AN EVALUATION OF WINTER MAINTENANCE MATERIAL METERING AND PLACEMENT EQUIPMENT

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FINAL REPORT

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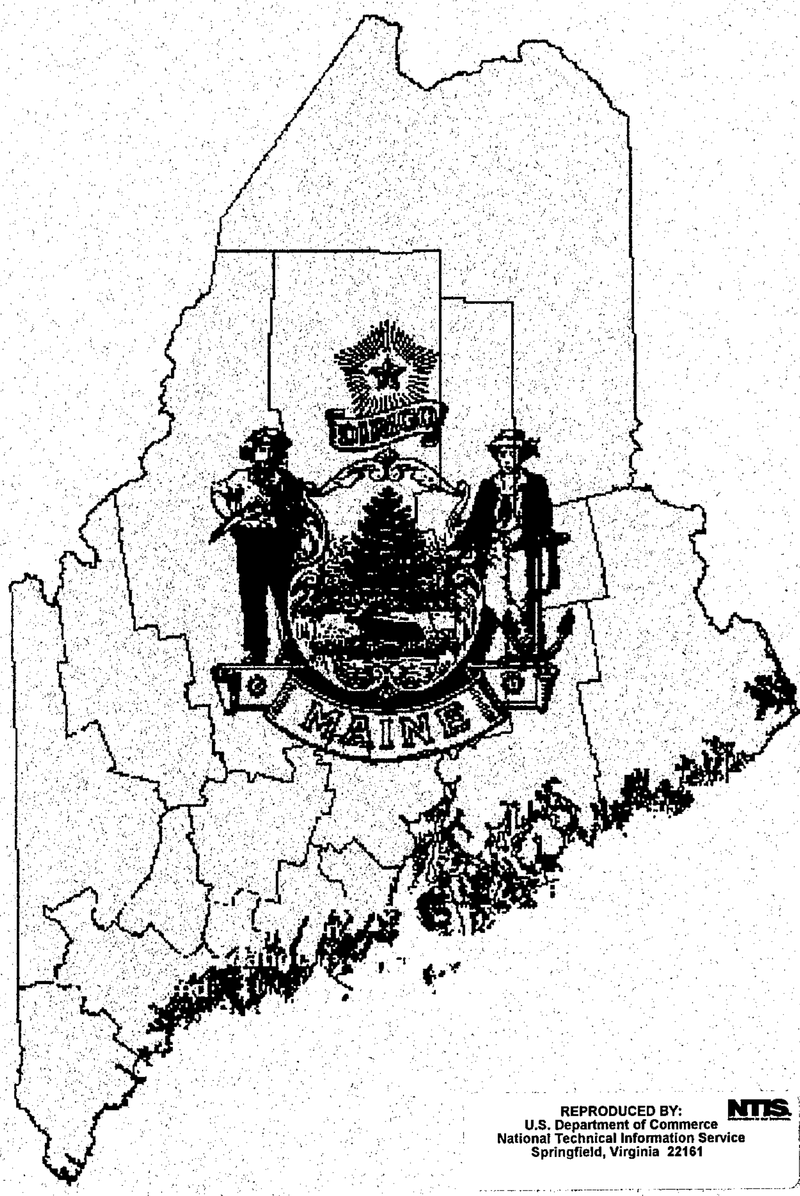
Research



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Abstract

Beginning in January, 1997, an evaluation process was undertaken by the Maine Department of Transportation (MDOT) in an effort to determine if developing technologies in the winter maintenance field might be viable and cost effective additions to MDOT's current fleet of snow fighting equipment. This process included the evaluation of the following equipment: Case-Tyler Zero Velocity System, Swenson Precision Placement System, Compu-Spread Ground Speed Control System and the Dickey-john Ground Speed Control System.

Data collected in both field and controlled settings indicate a savings in material is possible when utilizing some form of material metering equipment.

Testing performed for purposes of material placement using Zero Velocity and Precision Placement systems also shows promise in producing material savings.

Realization of these savings will require a significant commitment to equipment calibration and maintenance. It will also require a high level of coordination and cooperation between all personnel involved.

In addition to the equipment evaluation, this report briefly discusses the Department's experience with salt as a primary material for treating highways in winter related conditions.

Acknowledgments

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We would like to thank all who participated in this effort and acknowledge that without their hard work and commitment, this research project would not have been possible.

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Introduction

Beginning in January, 1997, an evaluation process was undertaken by the Maine Department of Transportation (MDOT) in an effort to determine if developing technologies in the winter maintenance field might be viable and cost effective additions to MDOT's current fleet of snow fighting equipment. The initial scope of this evaluation included three Case-Tyler Zero Velocity Systems. Since its inception, the following equipment has been added to this research: Compu-Spread Ground Speed Control, Dickey-john Ground Speed Control and the Swenson Precision Placement System.

Several states, including Pennsylvania, New York, Minnesota, Wisconsin and Missouri, have experimented with the Zero Velocity System (ZVS) technology. Pennsylvania has moved beyond the experimentation stage and purchased over 250 units. Ground Speed Control (GSC) technology has been in use for many years in a majority of the snow fighting states. The Swenson Precision Placement System (PPS) is new to the winter maintenance arena.

For years, MDOT has used sand as its primary material for treating highways in winter conditions. Increasing prices, depleting reserves, and poor quality of available sand has caused the Department to rethink its material of choice. This report will briefly discuss the Department's experience using salt as a primary material during the winter of 1998-1999.

In addition to this research, MDOT has been involved with several other efforts to improve and modernize their winter maintenance procedures. In the spring of 1998, the Departments' Bureau of Maintenance and Operations Quality Council established a Process Action Team (PAT) to evaluate the Department's experience, along with that of other DOT's, with the above mentioned technologies. Pavement temperature sensors, and any other new technology or technique, intended to improve chemical and abrasive application were also included as part of the PAT's evaluation. The PAT's findings and recommendations were presented to the Council in the fall of 1998 in the form of a report titled Improved Control of Chemical/Abrasive Application.

Anti-icing techniques have been tested on a limited basis in Division #3 using the product "Ice-Ban". Many of MDOT's winter maintenance vehicles have also been retrofitted with liquid pre-wetting systems. The Department is also in the process of establishing a Road Weather Information System (RWIS) in the Yarmouth - Freeport area of Division #6. This site is scheduled to be operational in the fall of 1999.

Description of Equipment

Basic Technologies
Compu-Spread Ground Speed Control (Models 220, 230)

The Compu-Spread Ground Speed Control System meters material using a sensor located on the shaft of the bed chain to count revolutions. A signal from the speedometer is used to determine the speed of the vehicle and distance traveled. Using these two signals, a microprocessor meters material in pounds, at one of ten programmable settings. Settings can be established for up to four material types. Each of these four settings can be programmed with specific material labels. Data stored in the control box includes: pounds of material applied (to nearest pound), miles of material applied (to nearest 0.01 miles), time of material application (to nearest minute), pounds of material applied in "blast" mode, miles applied in "blast" mode and time in "blast" mode. These totals are available for each storm and also as a season total. This data (logged data) and calibration data can be transferred to an office computer using the supplied "Calipromptor". The caliprompter uses infrared technology and allows the operator to simply point the calipromptor at the control box in the vehicle and "up-load" the desired information. Office software (Windows based), which allows analysis of storm data, is provided. In addition to storm data, the Compu-Spread stores events (time and date stamped) that occur during the storm cycle. Equipment errors, changes in application rates, predetermined maximum speed exceeded, and blast on-off histories are available. The system will automatically change to "open loop" or manual mode operation in the event of a sensor failure. A pre-wetting system can be adapted which applies liquid material on a gallons per ton of granular material applied basis. Gallons of liquid material applied is currently not a logged data item. The Compu-Spread model 230 is Global Positioning System (GPS) compatible using the manufacturers Global Tracking System (GTS). This optional system will allow remote data transfer and mapping technology that has the potential of being a significant tool in documenting plow history and planning future storm strategies.

The MDOT is currently operating 14 of these units at various maintenance facilities in Division #6 and six units at facilities in Division #1.

DICKEY-john
Control Point Ground Speed Control

The Control Point Ground Speed Control System utilizes a sensor located on the bed chain shaft to count revolutions. It obtains a signal from the speedometer to determine ground speed and distance traveled. These two signals enable the Control Point to distribute material at a set range of application rates for up to 4 granular materials. Current settings being utilized by MDOT are as follows: Salt - 100 to 800 pounds with 50 pound incrementing, Sand - 1,000 to 2,000 pounds with 100 pound incrementing. The Control Point will also meter liquid pre-wetting material using ground speed. Data stored in the control box includes: tons of granular material applied (to nearest 0.1 ton), miles of material applied (to nearest 0.1 miles), time of material application (to nearest 0.1 hour), tons of material applied in "blast" mode (to nearest 0.1 ton), miles of material application in "blast" mode (to nearest 0.1 miles), and time operated in "blast" mode (to nearest 0.1 hour). This information is available on a per storm basis and also as season totals. Data can be read directly from the data totals screen, or an optional "data logger" device can be attached using an RS232 interfacing cord. The Control Point also stores events (time and date stamped) that occur during the storm cycle. These events include: truck on-off, change in application rates, equipment errors, predetermined maximum speed exceeded, automatic and manual mode operation, and "blast" mode activation. The Control Point system uses menu driven programming and is very user friendly.

The Department is currently operating four units at the Plymouth Maintenance Facility in Division #3.

Case-Tyler Zero Velocity System

The Case-Tyler Zero Velocity System uses ground speed technology to meter granular and liquid pre-wetting material. Unlike either of the ground speed systems evaluated for this research, the Case Tyler system receives its metering signal from a sensor located on the shaft of an auger mechanism. This mechanism supplies material to a "venturi" located approximately 10 inches off the roadway at the left or right side of the truck. A high speed fan introduces air to the venturi to propel material out the rear of the truck at the same speed the truck is traveling forward. This effectively negates the speed of the truck and minimizes "bounce and scatter" of material applied. The venturi can also be positioned (from inside the cab) to accommodate material placement left or right of the centerline. This positioning will allow the operator to direct the material where it is needed most and still minimize the loss of material due to "bounce and scatter". Liquid pre-wetting material is introduced near the air output, creating a mist that effectively coats each particle of granular material. Storm data stored in the control box includes: pounds of material applied (to nearest pound), miles of material applied (to nearest mile), gallons of liquid pre-wetting material applied (to nearest gallon), pounds of material applied in "blast" mode and miles of application in "blast" mode. These totals are available for each storm and also as a season total. Data can be read directly from the data total screens.

The MDOT is currently operating three of these units from its Bangor Maintenance facility located in Division #3.

Swenson Precision Placement System

The Swenson Precision Placement System (PPS) utilizes a Swenson Controller manufactured by DICKEY-john for material metering. The addition of a highspeed shrouded spinner (controlled by ground speed) enables the operator to place material near the centerline of the roadway in a confined windrow. This technology creates the same effect of negating forward vehicle speed as the Case-Tyler system. The shroud can also be lifted enabling slow and left broadcasting of material. This feature has proven effective on interstate on and off ramps. Material is supplied to the spinner with a diagonal sloping chute. Storm data and events are stored in the same format as the Control Point ground speed control unit.

The Department is currently operating one of these units from its Division #3, Bangor facility.

Equipment Installation/Durability

Basic Technologies
Compu-Spread Ground Speed Control (Models 220,230)

Beginning in the fall of 1996, six of the model 220 Compu-Spread units were installed at the Motor Transport Services (MTS) facility in Augusta. Two representatives from Basic Technologies, the manufacturer of the Compu-Spread model, were present for the first installation. These installations took approximately 1-2 days to complete with no specific installation problems reported. Since the first series of installations, an additional 14 model CS230 units have been installed at MTS, Augusta.

To date, the replacement of several granular application sensors has been the primary durability issue. Several problems have been encountered that are believed to be a function of the limited hydraulic systems on the vehicles, and not a function of the Compu-Spread equipment.

DICKEY-john
Control Point Ground Speed Control

Installation of the four DICKEY-john Ground Speed Control units located in Division #3 began in early January, 1998 at MTS Augusta. A representative of Swenson Spreader, a supplier for the Dickey-john corporation was present one day of the first installation. Dickey-john is the manufacturer of the Control Point System.

The first truck installed at MTS needed several modifications to its hydraulic system to accommodate the Control Point System. This truck was equipped with an electronic speedometer which also needed modifications once the unit was placed in service. This installation took approximately two weeks.

The "Ice Storm of 1998" caused potential scheduling problems at MTS and it was determined that the second unit should be installed at H.P. Fairfield in Skowhegan, Maine. H.P. Fairfield is the representative for Swenson Spreaders and Dickey-john. Hydraulic compatibility problems were also encountered during this installation. A technician was sent from Dickey-john to assist H.P Fairfield personnel with these problems. This vehicle was equipped with a manual speedometer and once again modifications were necessary for proper operation of the Control Point unit. This installation also took approximately two to three weeks to complete.

The installation of unit three was completed at MTS Augusta, but not without similar problems related to the compatibility of the hydraulic system and the GSC unit. Modifications to the manual speedometer signal were once again necessary. This installation was completed in about three weeks.

After several discussions between Dickey-john, H.P. Fairfield and MTS personnel, the decision was made to install the fourth and final unit on a newer truck. A 1995 Ford was selected for this installation. No serious problems were encountered during this installation at MTS, which took less than one week to complete.

To date, one granular application sensor has needed replacement on the Control Point units. Speed sensors on each of the two vehicles equipped with manual speedometers have required one replacement.

This equipment has also shown limitations believed to be a function of inadequate hydraulic systems.

Case-Tyler Zero Velocity System

In January and February 1997, installation of the three Case-Tyler Zero Velocity systems was completed at the MTS facility in Augusta. A representative from Case-Tyler, the manufacturer of the ZVS system, was present during the installation of the first unit. The two subsequent installations were completed by MTS personnel. Unit one was installed on a front dumping - 6 wheel truck, while units two and three were installed on rear discharge hopper units mounted in 10 wheel trucks. Installations went relatively smooth with one exception. Hydraulic systems on each of the trucks had to be enhanced with an additional pump to supply adequate hydraulic pressure to run the ZVS system. Installation time for each unit was approximately two weeks.

The Zero Velocity Systems have been in service for approximately three winters. Overall, the service provided by these systems has been very good. Three granular application sensors have been replaced during this time.

Swenson Precision Placement System

In late December, 1998, the Swenson (PPS) unit was installed on a 10 wheel 1995 Ford truck at H.P. Fairfield Company. The installation of this equipment went smoothy and was completed in less than three days. A representative from the Swenson Spreader Company was present during installation. During initial calibration, it quickly became apparent to the Swenson representative that hydraulic limitations of the vehicle were going to limit performance of the PPS system. After conversations with Division #3 personnel, it was determined that the PPS system would be operated and evaluated with the existing hydraulic system for the winter of 1998-1999.

To date, the PPS system has been in service for one year. The primary problem encountered during operation was the plugging of the chute that supplies material to the spinner. This plugging occurred almost exclusively with the use of sand. Some plugging did however occur with the use of salt. It is believed the use of "very fine or powdery" salt was the cause of this plugging. As stated above, the inadequate hydraulic system caused material application errors when material application rates in excess of 450 pounds were requested, and vehicle speeds exceeded 30 miles per hour.

Equipment Calibration

Calibration procedures are similar for each piece of equipment evaluated in this research. For the Compu-Spread and Dickey-john Ground Speed Control units, and the Swenson PPS unit, gate settings are established for salt and sand and a "catch test" is performed. These gate settings are critical to the accurate metering of material. The Case-Tyler Zero Velocity system meters material with an auger and is not dependent on gate settings for accurate calibration and material distribution.

A complete calibration must be performed for each type of material used.

The "catch test" involves distributing material with the equipment in calibration mode until such time that approximately 100 pounds of material has been dispensed. The dispensed material is caught and weighed and that weight is used to calculate the calibration factor in pounds per revolution of the shaft on the bed chain or auger.

The Compu-Spread system can also be calibrated in automatic calibration mode. With this procedure, the truck to be calibrated is driven onto six portable truck scales, weights are recorded and the total weight is entered into the controller. Material is then dispensed for approximately 15 minutes, or until such time that approximately 2500 pounds of material has been distributed. Weights are again recorded and the ending weight is entered into the controller. The controller then automatically calculates and stores the new calibration factor.

The Dickey-john and Swenson PPS systems can also be calibrated in a similar fashion as the Compu-Spread automatic calibration mode. The only variation being, the difference of the beginning and ending weight is calculated and then entered into the controller. The controller then calculates and stores the new calibration number.

The Case-Tyler system can also be calibrated using the method described above.

Calibration of conventional units was also performed using the "catch test" method. Table I presents calibrated application rates for two of the conventional units used in this research.

TABLE I
Conventional Settings

	Spreader Setting	Lbs./Mile 20 MPH	Lbs./Mile 25 MPH	Lbs./Mile 30 MPH
Veh. No T01-088	1	320	256	213
	2	374	300	250
	3	507	406	338
Veh. No T01-432	1	319	255	212
	2	511	409	341
	3	636	508	424

Both methods of calibration have been performed on each piece of equipment in this research. Based on the data collected, the method requiring approximately 2500 pounds of material distribution is considered to be more accurate.

Proper calibration of all metering equipment is critical to insure accurate data.

Field Testing/Data Collection

What began in January of 1997 as an evaluation of the Case-Tyler Zero Velocity systems in Division #3 Bangor, was quickly expanded to include the Compu-Spread ground speed control systems being utilized in the Department's Division #6 Scarborough area. The significant distance separating these two locations, as well as climatic differences required that the data collection portion of this research be completed as two separate efforts.

The unsuccessful attempt to distribute sand with the Case-Tyler units resulted in no valid data being collected for the 1996-1997 winter season. It was determined at that time, that beginning in the fall of 1997 the Case-Tyler system would be used exclusively for salt applications.

Several problems associated with the Compu-Spread systems during this first year of operation also resulted in no accurate data collection for 1996-1997. Representatives from Basic Technologies returned to Maine in the fall of 1997 and met with MDOT personnel associated with the GSC equipment. Questions and concerns related to the operation and repair of the systems were addressed in preparation of the 1997-1998 winter season.

For the winter of 1997-1998, it was proposed that data collection be performed on 500 miles of material application using four of the Compu-Spread GSC units and two conventional spreaders as control units. The same process was proposed using the two hopper mounted ZVS units along with two corresponding control units. Once installed, the four Dickey-john GSC units would also be evaluated using the same procedure.

Using portable scales on loan from the Maine State Police, each unit was to be weighed fully loaded, and then again after material application to determine the actual pounds of material applied. For the Zero Velocity and Ground Speed units, this total would then be compared to the reading on the control box to determine the level of material metering accuracy. Additional information including miles applied, gallons of liquid applied, weather conditions and road conditions were also scheduled to be collected (see Appendix A).

The data collection effort in Division #6 encountered several problems during the winter of 1997-1998.

As stated in the description portion of this report, the Compu-Spread system does not display material application totals on the screen of its controller. To compare weights, personnel had to download information from each unit and then transfer this data to a computer for viewing. This made it difficult to make comparisons after each load. When comparisons were made, significant differences in actual weight of material applied and readings from the Compu-Spread units were noticed. After several conversations with the manufacturer, it was determined that the units had not been properly calibrated before data collection began. Very little snowfall occurred after the completion of these new calibrations. This problem, coupled with snow, slush and ice buildup on the trucks which caused inaccurate weight comparisons, resulted in no valid data being collected during the 1997-1998 winter season. Data collection was not performed in Division #6 during the 1998-1999 season, therefore no field data is available for presentation in this report.

For Division #3, it was considered critical that data be collected under similar climatic conditions for each unit and location. This required that the Dickey-john installations be completed before data collection could begin. The problems encountered during these installations, and the scarcity of winter weather conditions in February and March allowed for no valid data collection during the winter of 1997-1998.

Field data collection was continued in Division #3 for the winter of 1998-1999. In the fall of 1998, Division #3 administrative personnel determined that Interstate 95 from Route #100 in Newport to Route #16 in Alton would become a "Salt Priority" area. This priority simply states; "when the weather conditions are considered conducive to salt only application, sand will not be used". This decision impacted the roadways treated by the experimental equipment and made it impossible to compare sand and salt application and resulting road conditions. Data collection to determine material metering accuracy was completed only when this "salt priority" policy was in effect.

Storm related data was collected for five storms at the Plymouth and Bangor maintenance facility locations. Overall data collection went relatively smooth with a few exceptions. As stated earlier, gate settings on all of the equipment included in this research with the exception of the Case-Tyler unit, are critical to accurate material metering. Several times these settings were changed resulting in lost data. The accumulation of snow, slush and ice also caused problems. An attempt was made to negate the effect of this accumulation by simply adding 200 pounds to the total salt applied for the first "cycle" of application. It became apparent that this attempt was not effectively eliminating the impact this accumulation was having on the results. By weighing one of the trucks included in this research, then removing the slush that had accumulated and re-weighing the truck, a total of 1,275 pounds of slush was identified. Field data presented in this report has not been adjusted for this accumulation.

A material spilling problem with the Case-Tyler System was identified during data collection and to date has not been corrected. This problem significantly impacts the results presented for the Case-Tyler System and these results should not be considered representative of the systems material metering accuracy.

The DICKEY-john and Swenson PPS systems display the granular totals to the nearest 0.1 ton. All data presented for these units has the potential of an error of this magnitude for each cycle of data collection.

Table II lists the vehicles used for the Division #3 field data collection.

Table III summarizes the field results collected. A more detailed review of this data (by vehicle) is available in Appendix B.

TABLE II
Vehicle Summary (1998-1999)

Vehicle No	Make	Model	Year	Spreader Type
T01-432	Ford	LT9000	1995	Conventional
T01-094	Volvo	White-WG64	1991	Conventional
T01-463	Ford	LT9000	1995	DICKEY-john
T01-067	GMC	Brigadier	1989	DICKEY-john
T01-046	GMC	Brigadier	1989	DICKEY-john
T01-087	Volvo	White-WG64	1991	DICKEY-john
T01-450	Ford	LT9000	1995	Swenson - PPS
T01-414	Ford	LT9000	1995	Case-Tyler - ZVS

TABLE III
Material Application Summary

Vehicle No.	Spreader Type	Total Miles Applied	Total Salt Applied (Actual Lbs.)	Target Salt Applied (Lbs.)	Percent Difference From Target
T01-432	Conv.	304	106293	97452	9.1
T01-094	Conv.	247	90190	82992	8.6
T01-463	D-john	147	42283	41605	1.6
T01-067	D-john	187	51945	53400	-2.7
T01-046	D-john	183	49240	45669	-7.8
T01-087	D-john	305	72506	85260	-15.1
T01-450	Sw - PPS	202	78665	86080	-8.6
T01-414	C-T - ZVS	91	55328	41200	34.3*

* MDOT has identified a material spilling problem with this unit. These results do not represent the anticipated level of accuracy once this problem is corrected.

When reviewing the "Percent Difference" column in Table III, it is interesting to note the impact snow and slush buildup would have on these values. A positive percentage would be adjusted further away from zero percent, while a negative percentage would be adjusted closer to zero. Considering this, a majority of the metering equipment would actually be closer in accuracy, while the conventional vehicles would be missing targeted rates by an even greater value than is displayed.

An "F and T" analysis was also performed on the storm data to compare the conventional spreaders with the metering equipment. The results of this analysis indicate a significant statistical difference exists. These results are included in Appendix B.

Controlled Testing/Data Collection

Material Metering

With the numerous variables that were encountered during the field data collection portion of this research, it was determined that additional testing in a more controlled setting was necessary. The first phase of this testing focused, once again, on the metering accuracy of the equipment.

Re-calibration of the equipment included in this testing was completed the week of April 12, 1999. To eliminate potential errors in calibration, a representative from each manufacturer was present to verify recommended calibration procedures were adhered to. Table IV lists the vehicles and equipment included in this testing.

TABLE IV
Vehicle Summary

Vehicle Number	Spreader Type
T01-414	Case-Tyler Zero Velocity
T01-431	Conventional
T01-099	Compu - Spread
T01-424	Compu - Spread
T01-046	DICKEY-john
T01-067	DICKEY-john
T01-450	Swenson - PPS

To accommodate this material metering test, a 1.1 mile "test track" was established at a discontinued airport facility located in the town of Winterport.

Material application rates of 250 and 350 pounds per mile were selected and each truck was scheduled to complete 10 trips around the track for each application rate. The conventional truck targeted the closest calibrated application rates available (212 and 323 lbs/mile).

Trucks were weighed before and after each of the two salt applications to determine the actual amount of salt applied. Data from the control boxes were recorded and this metered result was compared to the actual salt applied total.

It is important to note that in addition to the spilling problem addressed in the Field Testing/Data Collection portion of this report, the Case-Tyler System also had a malfunctioning switch during this testing which allowed a significant amount of material to spill from the vehicle without being metered. Results presented for the Case Tyler System should not be considered representative of performance, and are included for purposes of data continuity only.

Results of this testing are available in Appendix C.

Material Placement

When applying salt as a de-icing agent, it is recommended the salt be applied in a windrow at the centerline of the roadway. This concentrated application will allow a "brine" to form and further melt snow and ice that has accumulated on the pavement. Centerline application also introduces the material at a location away from the roadway shoulder. By applying salt at the centerline, even material that "bounces and scatters" will stay in the travel way and benefit melting.

This portion of our testing evaluated the Case-Tyler Zero Velocity System, Swensons' Precision Placement System, an in-house manufactured salt chute and a conventional spinner applicator. The objective of this testing was to determine where material comes to rest after application.

A section of the Winterport airport was again used to complete this testing. A 24 by 40 foot tarpaulin was secured to the pavement in a location that would allow trucks to reach a maximum speed of 40 miles per hour. This tarpaulin was segmented into 3 foot lanes to create a total of eight lanes (see Figure I). Each piece of equipment dispensed salt onto the tarpaulin at 25, 30 and 40 miles per hour. Each operator was instructed to target the center of the tarpaulin with their respective applicator. After each pass, the distributed salt was swept from each lane and weighed to determine the percentage of salt that stayed in that lane.

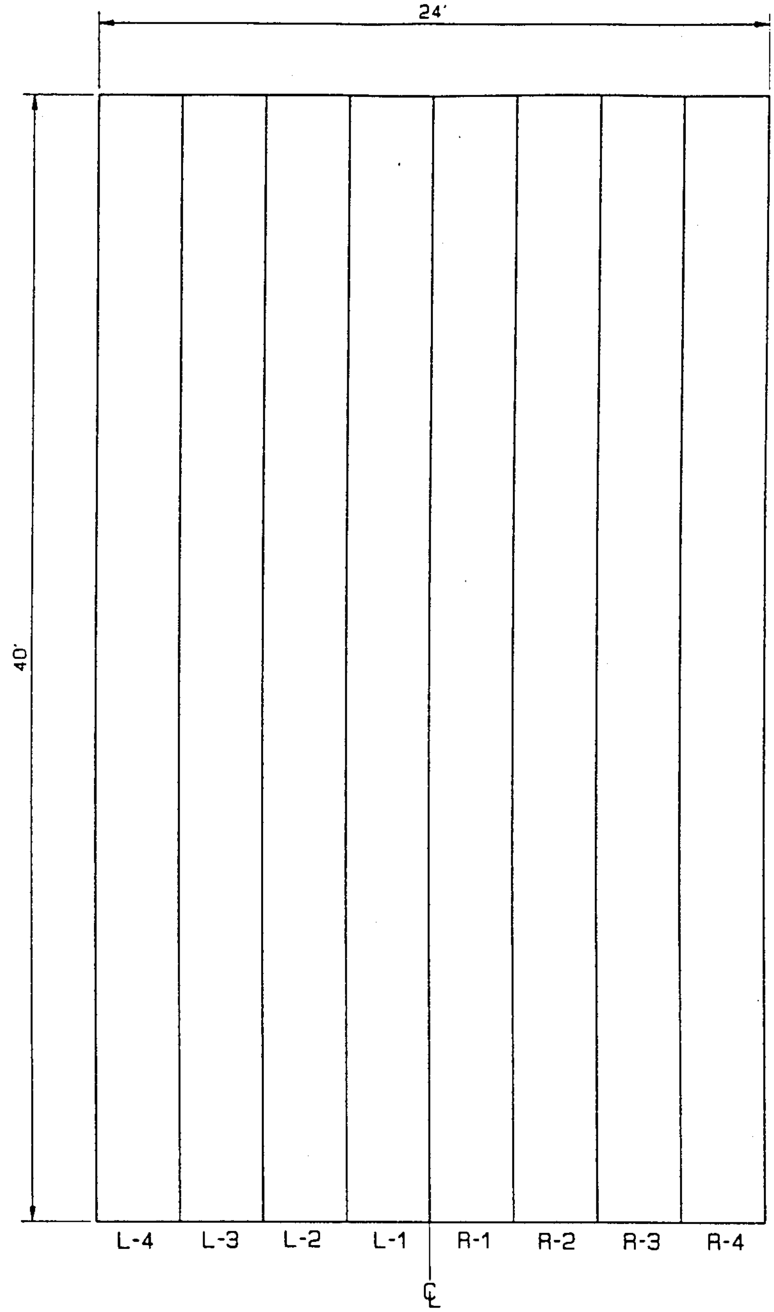


FIGURE I
View of Tarpaulin

Although it would be impossible to apply material at the centerline with the conventional spinner because of traffic flow, it too targeted the center of the tarpaulin. Considering that under normal operation the spinner is dropping material at approximately the center of the lane being traveled in, any material collected in lanes R-3 and R-4 would be in the shoulder area or off the roadway and would not benefit melting in the travel way.

Data summarized in Table V represents the percentage of salt remaining in the lanes directly left and right of the targeted centerline for each speed.

This data is available in detailed form in Appendix C.

TABLE V
Material Placement Summary
(Lanes R-1 and L-1 Only)

Equipment Type	% at 25 MPH	% at 30 MPH	% at 40 MPH
Conventional Spinner	67	61	48
Salt Chute	44	48	40
Swenson PPS	94	91	44
Case-Tyler ZVS	80	76	32

Sand Vs Salt Usage

As mentioned earlier, during the winter of 1998-1999 some initial efforts were undertaken to utilize salt as the primary material for treating a section of Interstate 95 in Division #3. This section started at the Route #100 interchange in Newport and ended at the Route #16 interchange in Alton. Overall, Division #3 management personnel considered this effort successful. As with any change in procedure, some resistance was present.

Sand, by nature of its color, allows both the operator and traveling public visual results on the treated roadway. Many studies completed throughout North America and Europe indicate that sands usefulness as an abrasive is quickly deteriorated after application. Several of these studies suggest that any advantage in frictional properties is lost after 15 or less vehicles have passed over the treated section. Any melting that occurs during a sand application is a function of the salt or other chemical applied during the stockpiling procedure. Likewise, melting that occurs during a pre wetting application of Calcium Chloride, Salt Brine, etc., is a result of that chemical application.

Sand application also requires extensive clean-up. Sweeping, shoulder cutting and ditching operations represent a significant portion of the Departments maintenance budget. One estimate developed by the Director of Maintenance and Operations put the price tag of ditching alone at $11,000 per ditch mile (ditches on both sides). Assuming 300 ditch miles per year could be accomplished, a total cost per year of $3,300,000 would be realized.

Although it was not possible to compare sand with salt use on the "salt priority" section of Interstate 95, data was collected on two sections of secondary roadway as part of the National Highway Cooperative Research Program (NCHRP) project 6-13, Guidelines for Snow and Ice Control Materials and Methods. Several states and provinces, including Maine, assisted in collecting data to determine if a higher level of service can be achieved at a lower cost with chemical usage instead of abrasive application. This data has not yet been finalized, but preliminary results indicate significant savings in material, personnel and equipment are possible when employing a chemical priority policy.

Results of this cooperative research will be made available as soon as data analysis is complete.

A Salt Application Rate table was developed by the Bureau of Maintenance and Operations Process Action Team and is available in Appendix D.

Crew Supervisor and Driver Questionnaire

Throughout this research, crew supervisors and drivers voiced many concerns, suggestions and opinions. These personnel are the “front line” users of the equipment evaluated in this research and their views are considered critical to the successful implementation and utilization of any metering equipment.

In an effort to document each of these views, a questionnaire was developed and distributed to each driver and crew supervisor. Questions pertaining to equipment performance, potential material savings and salt versus sand use were included. Response was very good with only one questionnaire not being returned.

In summary, the primary equipment problems encountered by the operators were the positioning of wiring, plugs and hydraulic hookups. With one exception, supervisors and operators believed a savings in material could be realized using some form of metering equipment. Each respondent believed that salt worked well when temperatures were above 15 degrees Fahrenheit. They also stated that based on their experience, the Department could save money using salt.

Completed questionnaires were printed verbatim and are included in Appendix E.

Conclusions/Recommendations

This research quickly evolved into several evaluations of equipment and procedures associated with winter maintenance activities. What was first viewed as a negative, actually had a positive effect on the overall research effort. These additions allowed research personnel a "first hand look" at how things are accomplished during a storm event.

Material metering data collected during the winter of 1998-1999 indicated that a savings in material is possible when utilizing some form of metering equipment. In addition to this savings, it is important to recognize other potential advantages associated with the use of this equipment. Once operators become comfortable with this equipment, their responsibilities should become less difficult. Changes in spreader settings as their vehicle speed fluctuates are no longer necessary to assure an even distribution of material. As crews become more proficient in salt usage, the equipment will allow a much tighter range of application rates. Drivers of conventionally equipped trucks must maintain a constant speed and are limited to the manual settings on their spreaders when attempting to apply material at a targeted rate. Metering equipment does not require a constant speed to accurately distribute material and targeted application rates can be established with as little as 10 pound increments.

Storm by storm and seasonal material usage totals should also be much more accurate, enabling a more effective process for ordering salt as stockpiles become depleted and for annual budgeting purposes. These totals will also enable the Department to more accurately address environmental questions and concerns in respect to material usage.

The field data for this research was collected on interstate highways. It is believed that an even greater savings potential exists for vehicles equipped with metering devices that operate on secondary roads because of more significant variations in travel speed.

The material placement testing completed in a controlled setting also suggests that some form of Zero Velocity or Precision Placement shows promise in producing material savings. Based on the limited results obtained from this testing, the Precision Placement System performed best in maintaining material concentration at the centerline.

It should be noted, the Zero Velocity and Precision Placement systems are designed for salt application. Any effort to distribute sand with either of these units, as presently designed, is not recommended.

As stated earlier, the decision to employ a salt priority policy on the interstate section maintained by the metering equipment made it impossible to evaluate the effects of sand versus salt. Results from testing performed on two secondary highways in Division #3 as part of the NCHRP Project #6-13 will address this subject and should be available late summer, 1999.

Before any purchases are completed, trucks to be retrofitted should be evaluated to assure they are equipped with adequate hydraulic systems. This evaluation should include representatives from the Departments' Motor Transport Division, Bureau of Maintenance and Operations, and a representative from the supplier.

For all new truck purchases, hydraulic requirements should also be determined.

Training in the operation of this equipment, and the proper use of salt are critical to the success of this effort.

As the Department continues toward implementation of its "salt priority" policy, it is recommended that a review of current plowing strategies be completed. With the increased use of salt, it becomes more important to clear each lane of excess snow and slush before salt is applied. This clearing may best be accomplished by having plow vehicles operate closer together than is currently practiced. A spacing of approximately 0.5 mile to allow safe passing of traffic with the following truck applying salt would enable this clearing and also eliminate any salt being plowed from the travel way before it has an opportunity to work.

In conclusion, although data collected does not allow a specific percentage of savings to be calculated, material savings combined with the other advantages stated above, make purchasing some fotm of material metering equipment advisable.

Successful implementation of any of the equipment reviewed as part of this research will demand a significant commitment to calibration and maintenance. It will also require a high level of coordination and cooperation between all personnel involved.

Prepared By:

Stephen Colson

Reviewed By:

Dale Peabody
Transportation Research Division

Appendix A

'ruck No. ________ Driver ____________ Documented by ____________________

CYCLE # ______

MATERIAL ______________

		FULLY LOADED			AFTER MATERIAL APPLICATION	
xle #1 (a)	________		(e) ________	(i) ________		(m) ________
xle #2 (b)	________		(f) ________	(j) ________		(n) ________
xle #3 (c)	________		(g) ________	(k) ________		(o) ________
ıb Total (d)	________ (a+b+c)		(h) ________ (e+f+g)	(l) ________ (i+j+k)		(p) ________ (m+n+o)
ıtals		________ (d+h)			________ (l+p)	

ıte Weighed ________ Air Temp. ________ Date Weighed ________ Air Temp. ________

me Weighed ________ Surface Temp. ________ Time Weighed ________ Surface Temp. ________

ɔdometer Reading (beginning this cycle). ________ Odometer Reading (ending this cycle). ________

iles of Material Application This Cycle (from odometer). ________ Gallons of Calcium Applied This Cycle. ________

iles Plowed This Cycle (plow in down position). ________

ɔtal Estimated Depth of Snow. ________ Gallons of Fuel Used This Cycle. ________

ɔad Conditions (beginning this cycle) ________ Weather Conditions (beginning this cycle) ________

Road Conditions.

Bare and Dry
Bare and Wet
Snow Covered
4) Ice Covered
5) Slush Covered

Weather Conditions

1) Clear
2) Partly Cloudy
3) Cloudy
4) Raining
5) Freezing Rain
6) Sleet
7) Light Snow
8) Heavy Snow

ƆR ZERO VELOCITY AND GROUND SPEED UNITS ONLY (Equipment Readings)

ʼanular Application Rate. ________ Liquid Application Rate (if used). ________

ʼanular Material Applied This Cycle. ________ Gallons of Liquid Applied This Cycle. ________

iles of Material Application This Cycle. ________

ɔmments Specific To This Cycle.

DOCUMENTATION

WORKSHEET

	MATERIAL APPLICATION		PLOWING	
	BEGIN	END	BEGIN	END
ODOMETER	________	________	________	________
ODOMETER	________	________	________	________
ODOMETER	________	________	________	________
ODOMETER	________	________	________	________
ODOMETER	________	________	________	________
ODOMETER	________	________	________	________
ODOMETER	________	________	________	________
ODOMETER	________	________	________	________
ODOMETER	________	________	________	________
ODOMETER	________	________	________	________

Appendix B

Salt Application
Summary by Storm
Vehicle T01-094 (Conventional)

Vehicle Number	Date	Spreader Type	Lane	Cycle Number	Driver Cycle Start Time	Target Application Rate	Actual Total Salt Applied	Miles of Application	Actual Pounds Applied Per Mile	Difference Lbs./Mile Actual-Target	Percent Difference From Target
T01-094	01/06/99	Conventional	P	1	08:45 PM	336	7223	19	380.2	44.2	13.1
T01-094	01/06/99	Conventional	P	2	11:00 PM	336	8173	19	430.2	94.2	28.0
T01-094	01/09/99	Conventional	P	1	02:20 AM	336	6173	19	325	-11	-3.3
T01-094	01/09/99	Conventional	P	2	04:30 AM	336	7473	19	393	57	17.1
T01-094	01/09/99	Conventional	P	3	07:00 AM	336	6123	19	322	-14	-4.1
T01-094	02/02/99	Conventional	P	2	07:30 PM	336	7473	19	393	57.32	17
T01-094	02/25/99	Conventional	P	1	08:30 PM	336					
T01-094	02/25/99	Conventional	P	2	09:40 PM	336	12443	38	327	-8.55	-3
T01-094	02/25/99	Conventional	P	3	12:35 AM	336					
T01-094	02/25/99	Conventional	P	4	03:00 AM	336	12068	38	318	-18.42	-5
T01-094	02/25/99	Conventional	P	5	05:30 AM	336					
T01-094	02/25/99	Conventional	P	6	07:25 AM	336	15293	38	402	66.45	20
T01-094	03/05/99	Conventional	P	1	08:45 PM	336	7748	19	408	71.79	21

Salt Application
Summary by Storm
Vehicle T01-432 (Conventional)

Vehicle Number	Date	Spreader Type	Lane	Cycle Number	Driver Cycle Start Time	Target Application Rate	Actual Total Salt Applied	Miles of Application	Actual Pounds Applied Per Mile	Difference Lbs./Mile Actual-Target	Percent Difference From Target
T01-432	01/06/99	Conventional	T	1	08:45 PM	212	3973	19	209.1	-2.9	-1.4
T01-432	01/06/99	Conventional	T	2	11:00 PM	341	7623	19	401.2	60.2	17.7
T01-432	01/09/99	Conventional	T	1	03:00 AM	341					
T01-432	01/09/99	Conventional	T	2	04:30 AM	341	17493	38	437	96	28.2
T01-432	01/09/99	Conventional	T	3	07:00 AM	341					
T01-432	01/09/99	Conventional	T	4	08:30 AM	341	15043	38	376	35	10.3
T01-432	02/02/99	Conventional	T	1	02:30 PM	341	8323	19	438	97.05	28
T01-432	02/02/99	Conventional	T	2	06:00 PM	319					
T01-432	02/02/99	Conventional	T	3	08:00 PM	319	10083	38	265	-53.66	-17
T01-432	02/25/99	Conventional	T	1	08:30 PM	319					
T01-432	02/25/99	Conventional	T	2	09:40 PM	319	14293	38	376	57.13	18
T01-432	02/25/99	Conventional	T	3	12:35 AM	319					
TO1-432	02/25/99	Conventional	T	4	03:00 AM	319	12668	38	333	14.37	5
TO1-432	02/25/99	Conventional	T	5	05:30 AM	319					
TO1-432	02/25/99	Conventional	T	6	07:25 AM	319	11343	38	299	-20.50	-6
T01-432	03/05/99	Conventional	T	1	08:45 PM	319	5451	19	287	-32.11	-10

Salt Application
Summary by Storm
Vehicle T01-046 (Dj-GSC)

Vehicle Number	Date	Spreader Type	Lane	Cycle Number	Driver Cycle Start Time	Target Application Rate	Actual Total Salt Applied	Miles of Application	Actual Pounds Applied Per Mile	Difference Lbs./Mile Actual-Target	Percent Difference From Target
T01-046	02/02/99	Dj - GSC	T	1	02:15 PM	200	4152	20.4	204	3.53	2
T01-046	02/02/99	Dj - GSC	T	2	03:55 PM	200	4102	22.2	185	-15.23	-8
T01-046	02/02/99	Dj - GSC	T	3	06:45 PM	200	3152	20.6	153	-46.99	-23
T01-046	02/25/99	Dj - GSC	T	1	07:45 PM	400	8023	20.4	393	-6.72	-2
T01-046	02/25/99	Dj - GSC	T	2	09:30 PM	300					
T01-046	02/25/99	Dj - GSC	T	3	12:15 AM	300	12061	41.3	292	-7.97	-3
T01-046	02/25/99	Dj - GSC	T	4	04:55 AM	300	6017	23.9	252	-48.24	-16
T01-046	02/25/99	Dj - GSC	T	5	06:00 AM	200	2226	13.8	161	-38.70	-19
T01-046	03/05/99	Dj - GSC	T	1	08:45 PM	300	5936	20.4	291	-9.02	-3

Salt Application
Summary by Storm
Vehicle T01-067 (Dj-GSC)

Vehicle Number	Date	Spreader Type	Lane	Cycle Number	Driver Cycle Start Time	Target Application Rate	Actual Total Salt Applied	Miles of Application	Actual Pounds Applied Per Mile	Difference Lbs./Mile Actual-Target	Percent Difference From Target
T01-067	01/06/99	Dj - GSC	P	1	08:00 PM	300					
T01-067	01/06/99	Dj - GSC	P	2	09:30 PM	300	9646	34.4	281.2	-18.8	-6.3
T01-067	01/09/99	Dj - GSC	P	1	02:30 AM	275					
T01-067	01/09/99	Dj - GSC	P	2	03:30 AM	275	9267	31.6	293	18	6.6
T01-067	01/09/99	Dj - GSC	P	3	07:30 AM	300	6383	17.3	369	69	23.0
T01-067	02/02/99	Dj - GSC	P	1	02:00 PM	200	2276	14.8	154	-46.22	-23
T01-067	02/02/99	Dj - GSC	P	2	04:00 PM	200	2231	11.7	191	-9.32	-5
T01-067	02/02/99	Dj - GSC	P	3	06:00 PM	200	2082	10.7	195	-5.42	-3
T01-067	02/25/99	Dj - GSC	P	2	09:00 PM	400	7250	18.1	401	0.55	0
T01-067	02/25/99	Dj - GSC	P	3	11:30 PM	300	4771	18.3	261	-39.29	-13
T01-067	02/25/99	Dj - GSC	P	4	02:00 AM	300	3551	14.8	240	-60.07	-20
T01-067	03/05/99	Dj - GSC	P	1	09:00 PM	300	4488	15.3	293	-6.67	-2

Salt Application
Summary by Storm
Vehicle T01-087 (Dj-GSC)

Vehicle Number	Date	Spreader Type	Lane	Cycle Number	Driver Cycle Start Time	Target Application Rate	Actual Total Salt Applied	Miles of Application	Actual Pounds Applied Per Mile	Difference Lbs./Mile Actual-Target	Percent Difference From Target
T01-087	01/06/99	Dj - GSC	P	1	08:30 PM	300					
T01-087	01/06/99	Dj - GSC	P	2	10:00 PM	300	11967	44.4	270.1	-29.9	-10.0
T01-087	01/09/99	Dj - GSC	P	1	02:30 AM	300	4846	21.4	226	-74	-24.5
T01-087	01/09/99	Dj - GSC	P	2	04:30 AM	300	5930	24.8	239	-61	-20.3
T01-087	02/02/99	Dj - GSC	P	1	02:15 PM	300	6602	20.9	316	15.89	5
T01-087	02/02/99	Dj - GSC	P	2	03:55 PM	300	5352	23.1	232	-68.31	-23
T01-087	02/02/99	Dj - GSC	P	3	06:30 PM	300	5715	20	286	-14.25	-5
T01-087	02/02/99	Dj - GSC	P	4	07:40 PM	300	5223	18.3	285	-14.59	-5
T01-087	02/25/99	Dj - GSC	P	3	10:15 PM	300					
T01-087	02/25/99	Dj - GSC	P	4	12:15 AM	300	11360	48.5	234	-65.77	-22
T01-087	02/25/99	Dj - GSC	P	5	04:55 AM	300					
T01-087	02/25/99	Dj - GSC	P	6	06:00 AM	300	10286	42.6	241	-58.54	-20
T01-087	03/05/99	Dj - GSC	P	1	08:45 PM	300	5225	20.2	259	-41.34	-14

Salt Application
Summary by Storm
Vehicle T01-463 (Dj-GSC)

Vehicle Number	Date	Spreader Type	Lane	Cycle Number	Driver Cycle Start Time	Target Application Rate	Actual Total Salt Applied	Miles of Application	Actual Pounds Applied Per Mile	Difference Lbs./Mile Actual-Target	Percent Difference From Target
T01-463	01/09/99	Dj - GSC	T	1	02:15 AM	325					
T01-463	01/09/99	Dj - GSC	T	2	03:10 AM	325	8936	29.4	304	-21	-6.5
T01-463	02/02/99	Dj - GSC	T	1	02:00 PM	200	2424	15.3	158	-41.57	-21
T01-463	02/02/99	Dj - GSC	T	2	04:00 PM	200	3422	17.6	194	-5.57	-3
T01-463	02/02/99	Dj - GSC	T	3	06:00 PM	300	3776	14.8	255	-44.86	-15
T01-463	02/25/99	Dj - GSC	T	2	09:00 PM	300	6518	20.3	321	21.08	7
T01-463	02/25/99	Dj - GSC	T	3	11:30 PM	300	5699	16.2	352	51.79	17
T01-463	02/25/99	Dj - GSC	T	4	02:00 AM	300	6896	18.1	381	80.99	27
T01-463	03/05/99	Dj - GSC	T	1	09:00 PM	300	4612	15.5	298	-2.45	-1

Salt Application
Summary by Storm
Vehicle T01-450 (Swenson -PPS)

Vehicle Number	Date	Spreader Type	Lane	Cycle Number	Driver Cycle Start Time	Target Application Rate	Actual Total Salt Applied	Miles of Application	Actual Pounds Applied Per Mile	Difference Lbs./Mile Actual-Target	Percent Difference From Target
T01-450	01/06/99	Swenson-PPS	T	1	10:30 PM	400	11801	28.5	414.1	14.1	3.5
T01-450	01/07/99	Swenson-PPS	T	2	05:30 AM	400	8758	24.3	360.4	-39.6	-9.9
T01-450	01/09/99	Swenson-PPS	B	1	02:00 AM	400	7757	22.9	339	-61	-15.3
T01-450	01/09/99	Swenson-PPS	B	2	05:30 AM	400	8760	21.1	415	15	3.8
T01-450	02/02/99	Swenson-PPS	B	1	03:00 PM	400	7108	22.7	313	-86.87	-22
T01-450	02/02/99	Swenson-PPS	B	2	05:45 PM	400					
T01-450	02/02/99	Swenson-PPS	B	3	07:00 PM	400	9107	28.2	323	-77.06	-19
T01-450	02/25/99	Swenson-PPS	B	1	08:30 PM	500	10258	23.2	442	-57.84	-12
T01-450	02/25/99	Swenson-PPS	B	2	05:00 AM	500	15116	30.8	491	-9.22	-2

Salt Application
Summary by Storm
Vehicle T01-414 (Tyler-ZV)

Vehicle Number	Date	Spreader Type	Lane	Cycle Number	Driver Cycle Start Time	Target Application Rate	Actual Total Salt Applied	Miles of Application	Actual Pounds Applied Per Mile	Difference Lbs./Mile Actual-Target	Percent Difference Actual vs. Target
T01-414	02/02/99	Tyler - ZV	B	1	03:15 PM	400	16652	30	555	155.07	39
T01-414	02/02/99	Tyler - ZV	B	2	06:00 PM	400	6160	13	474	73.85	18
T01-414	02/25/99	Tyler - ZV	B	1	08:30 PM	500	15412	22	701	200.55	40
T01-414	02/25/99	Tyler - ZV	B	2	05:20 AM	500	17104	26	658	157.85	32

* M.D.O.T. has identified a material spilling problem with this unit. Therefore, these results don't represent the anticipated level of accuracy once this problem is corrected.

mparison of Population Variances for Conventional and Experimental

mple sizes = 20 and 48
andard deviations = 13.9689 and 16.3807
riances = 195.129 and 268.328
tio of variances = 0.727204

.0% confidence interval for ratio of variances: [0.358048,1.67617]

test
----
ll hypothesis: ratio = 1.0
t. hypothesis: not equal
mputed F statistic = 0.727204
value = 0.454622
not reject the null hypothesis for alpha = 0.05

atistical Interpreter
----
is table displays the result of an F test performed to test the null pothesis that the ratio of the variances of the populations from ich the two samples come equals 1.0 versus the alternative pothesis that the ratio is not equal to 1.0. Since the P-value for is test is greater than or equal to 0.05, we cannot reject the null pothesis at the 95.0% confidence level. Also shown is a 95.0% nfidence interval for the ratio of the population variances. In peated sampling, 95.0% of all such intervals will contain the true tio.

PORTANT NOTE: the F-test and confidence interval shown here depend the samples having come from normal distributions. To test this sumption, select the Stats tab and check the standardized skewness d standardized kurtosis values.

Comparison of Population Means for Conventional and Experimental

Sample sizes = 20 and 48
Means = 8.68 and -4.01875
Difference of means = 12.6988

95.0% confidence interval for difference of means:
12.6988 +/- 8.35557 [4.34318,21.0543]

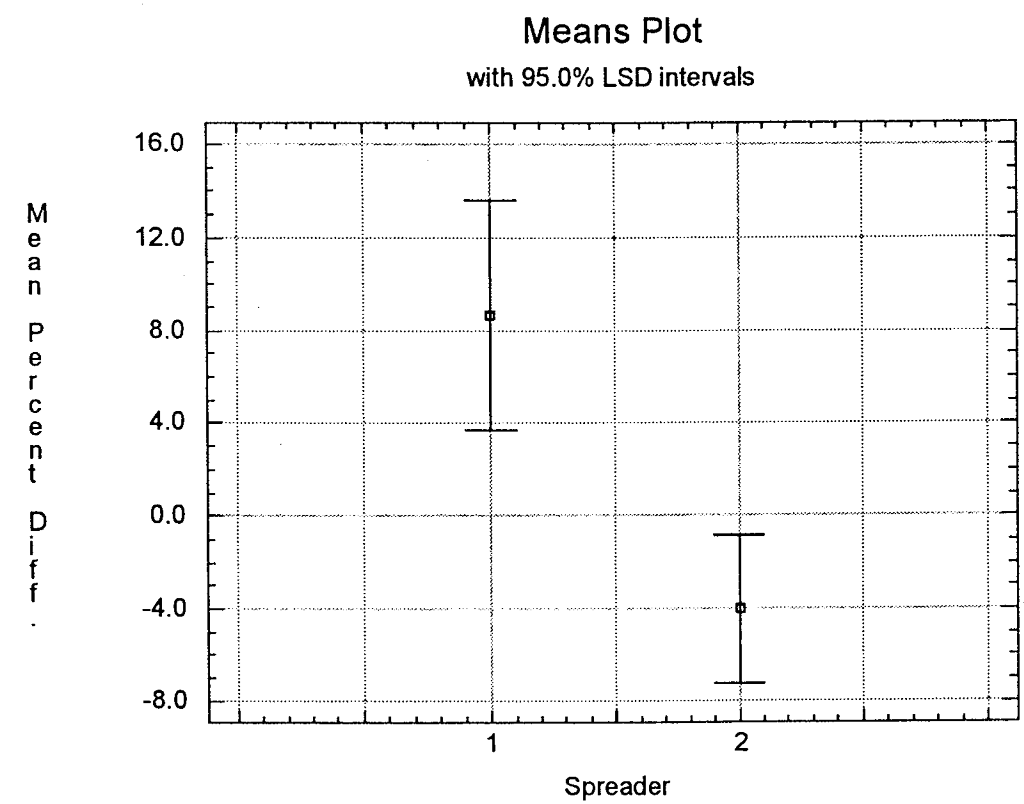
t-test

Null hypothesis: mu1-mu2 = 0.0
Alt. hypothesis: not equal
Computed t-statistic = 3.03437
P-value = 0.00344584
Reject the null hypothesis for alpha = 0.05

NOTE: equal standard deviations have been assumed.

Statistical Interpreter

This table displays the result of a t-test performed to test the null hypothesis that the difference between the means of the populations from which the two samples come equals 0.0 versus the alternative hypothesis that the difference is not equal to 0.0. Since the P-value for this test is less than 0.05, we can reject the null hypothesis at the 95.0% confidence level. Also shown is a 95.0% confidence interval for the difference between the population means. In repeated sampling, 95.0% of all such intervals will contain the true difference.



Spreader:
1 - Conventional 2 - Material Metering Equipment

Appendix C

Material Application Testing
April 27, 1999

Case Tyler Zero Velocity

Vehicle No.	Target Application Rate (Lbs./Mile)	Miles Applied	Actual Material Applied (lbs.)	Actual Applied Per Mile	Material Applied (Control Box)	Difference (Actual - Control Box)	Percent Difference (+-) Per Mile
T01-414	350	11	7850	714	3840	4010	104

Conventional Unit

Vehicle No.	Target Application Rate (Lbs./Mile)	Miles Applied	Actual Material Applied (lbs.)	Actual Applied Per Mile	Material Applied (Control Box)	Difference (Actual - Control Box)	Percent Difference (+-) Per Mile
T01-431	212	11	2810	255	-	-	20
	323	11	3830	348	-	-	8

Compu-Spread

Vehicle No.	Target Application Rate (Lbs./Mile)	Miles Applied	Actual Material Applied (lbs.)	Actual Applied Per Mile	Material Applied (Control Box)	Difference (Actual - Control Box)	Percent Difference (+-) Per Mile
T01-099	250	11	2055	187	2463	-408	-25
	350	11	2910	265	3448	-538	-24
T01-424	250	11	2660	242	2630	30	-3
	350	11	3765	342	3691	74	-2

Dickey-John

Vehicle No.	Target Application Rate (Lbs./Mile)	Miles Applied	Actual Material Applied (lbs.)	Actual Applied Per Mile	Material Applied (Control Box)	Difference (Actual - Control Box)	Percent Difference (+-) Per Mile
T01-046	250	11	2690	245	2600	90	-2
	350	11	3830	348	3800	30	-1
T01-067	250	11	2915	265	2800	115	6
	350	11	3850	350	3600	250	0

Swenson Precision Placement

Vehicle No.	Target Application Rate (Lbs./Mile)	Miles Applied	Actual Material Applied (lbs.)	Actual Applied Per Mile	Material Applied (Control Box)	Difference (Actual - Control Box)	Percent Difference (+-) Per Mile
T01-450	250	**8.8	1490	169	2200	-710	-32
	350	11	3260	296	3800	-540	-15

* MDOT has identified a material spilling problem with this unit and is attempting to correct it. A control switch used to turn the bed chain on and off also malfunctioned during this exercise causing additional spilling of material.

** Completed only 8 trips around test track

Conventional Spreader

25 MPH

Lane	Weight Per Lane	Percent Total Per lane
L-4	0.02	1
L-3	0.04	2
L-2	0.15	6
L-1	0.45	18
R-1	1.20	49
R-2	0.45	18
R-3	0.10	4
R-4	0.04	2
Total Weight	2.45	

30 MPH

Lane	Weight Per Lane	Percent Total Per lane
L-4	0.10	6
L-3	0.05	3
L-2	0.20	13
L-1	0.50	32
R-1	0.45	29
R-2	0.10	6
R-3	0.10	6
R-4	0.05	3
Total Weight	1.55	

40 MPH

Lane	Weight Per Lane	Percent Total Per lane
L-4	0.05	2
L-3	0.20	8
L-2	0.45	19
L-1	0.65	27
R-1	0.50	21
R-2	0.30	13
R-3	0.15	6
R-4	0.10	4
Total Weight	2.40	

Salt Chute

25 MPH

Lane	Weight Per Lane	Percent Total Per lane
L-4	0.05	2
L-3	0.25	12
L-2	0.70	34
L-1	0.55	27
R-1	0.35	17
R-2	0.10	5
R-3	0.04	2
R-4	0.02	1
Total Weight	2.06	

30 MPH

Lane	Weight Per Lane	Percent Total Per lane
L-4	0.10	4
L-3	0.25	10
L-2	0.75	31
L-1	0.90	38
R-1	0.25	10
R-2	0.05	2
R-3	0.05	2
R-4	0.04	2
Total Weight	2.39	

40 MPH

Lane	Weight Per Lane	Percent Total Per lane
L-4	0.05	2
L-3	0.30	12
L-2	0.70	27
L-1	0.70	27
R-1	0.35	13
R-2	0.30	12
R-3	0.10	4
R-4	0.10	4
Total Weight	2.60	

Swenson Precision Placement

25 MPH

Lane	Weight Per Lane	Percent Total Per lane
L-4	0.02	1
L-3	0.04	1
L-2	0.10	3
L-1	3.25	81
R-1	0.50	13
R-2	0.04	1
R-3	0.02	1
R-4	0.02	1
Total Weight	3.99	

30 MPH

Lane	Weight Per Lane	Percent Total Per lane
L-4	0.02	1
L-3	0.05	1
L-2	0.20	5
L-1	2.35	62
R-1	1.10	29
R-2	0.04	1
R-3	0.02	1
R-4	0.02	1
Total Weight	3.80	

40 MPH

Lane	Weight Per Lane	Percent Total Per lane
L-4	0.20	5
L-3	0.45	12
L-2	0.90	23
L-1	1.15	30
R-1	0.55	14
R-2	0.20	5
R-3	0.10	3
R-4	0.30	8
Total Weight	3.85	

Case Tyler Zero Velocity

25 MPH

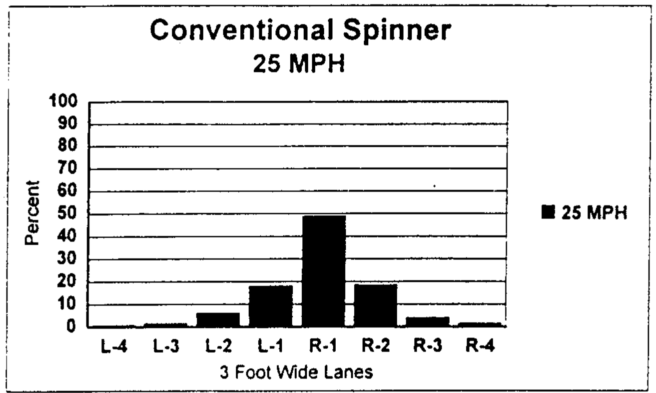
Lane	Weight Per Lane	Percent Total Per lane
L-4	0.02	2
L-3	0.04	3
L-2	0.10	8
L-1	0.55	42
R-1	0.50	38
R-2	0.04	3
R-3	0.04	3
R-4	0.02	2
Total Weight	1.31	

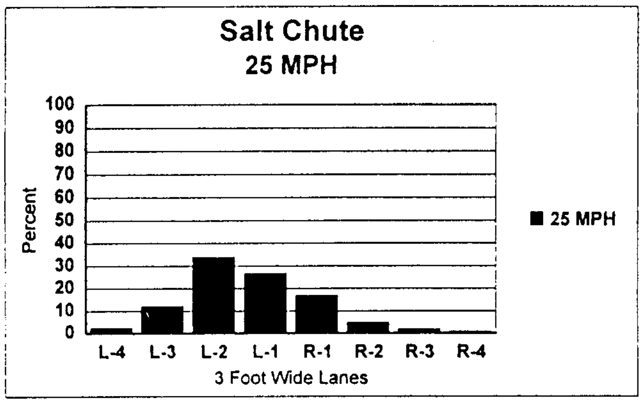
30 MPH

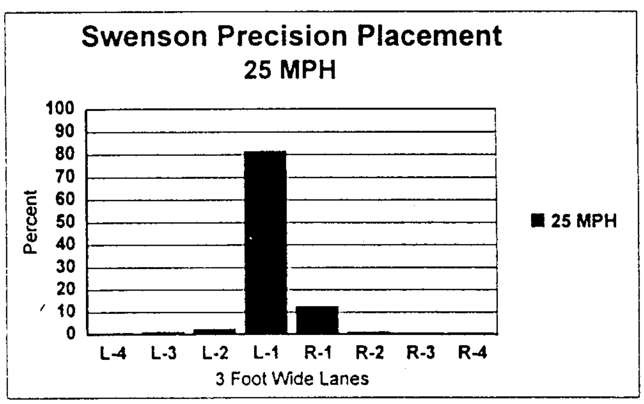
Lane	Weight Per Lane	Percent Total Per lane
L-4	0.04	1
L-3	0.10	3
L-2	0.60	17
L-1	1.60	45
R-1	1.10	31
R-2	0.05	1
R-3	0.04	1
R-4	0.02	1
Total Weight	3.55	

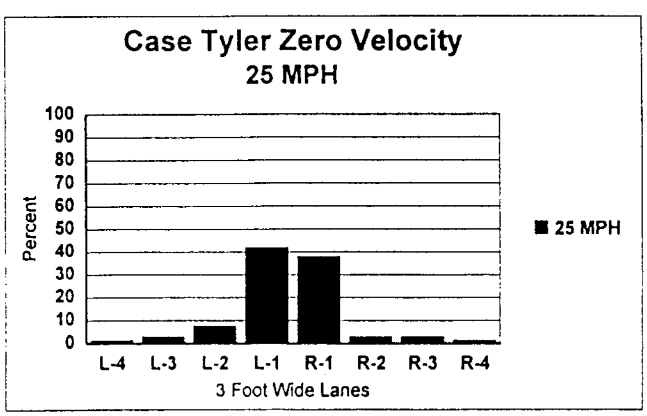
40 MPH

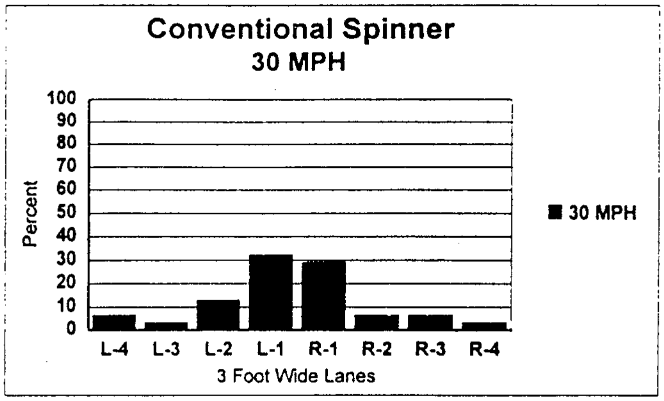
Lane	Weight Per Lane	Percent Total Per lane
L-4	0.10	6
L-3	0.40	23
L-2	0.55	31
L-1	0.40	23
R-1	0.15	9
R-2	0.10	6
R-3	0.04	2
R-4	0.02	1
Total Weight	1.76	


Conventional Spinner
25 MPH
Percent
100
90
80
70
60
50
40
30
20
10
0
L-4 L-3 L-2 L-1 R-1 R-2 R-3 R-4
3 Foot Wide Lanes
25 MPH

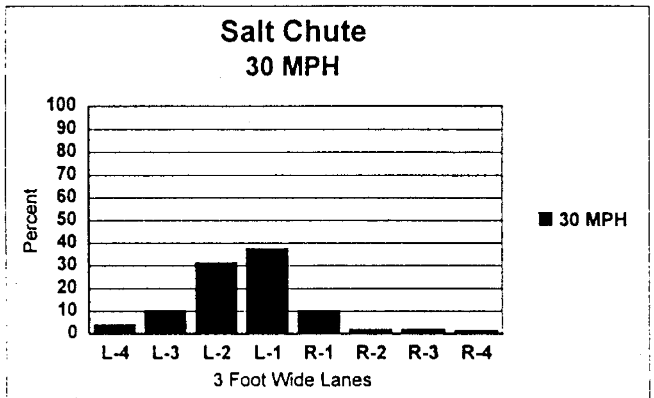

Salt Chute
25 MPH
Percent
100
90
80
70
60
50
40
30
20
10
0
L-4 L-3 L-2 L-1 R-1 R-2 R-3 R-4
3 Foot Wide Lanes
25 MPH


Swenson Precision Placement
25 MPH
Percent
100
90
80
70
60
50
40
30
20
10
0
L-4 L-3 L-2 L-1 R-1 R-2 R-3 R-4
3 Foot Wide Lanes
25 MPH

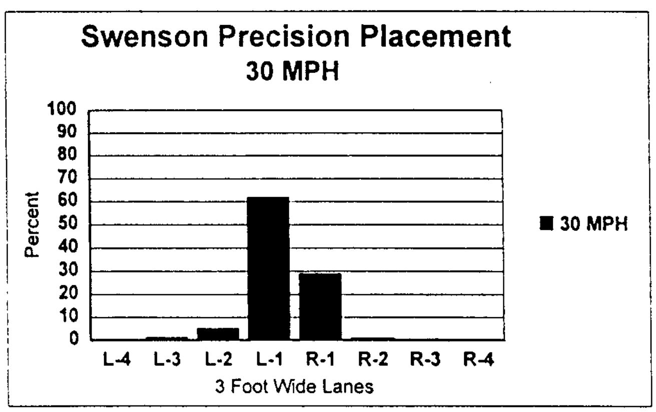

Case Tyler Zero Velocity
25 MPH
Percent
100
90
80
70
60
50
40
30
20
10
0
L-4 L-3 L-2 L-1 R-1 R-2 R-3 R-4
3 Foot Wide Lanes
25 MPH



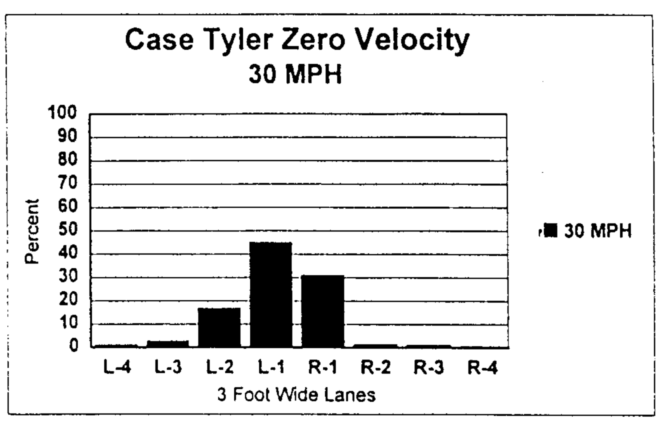
Conventional Spinner
30 MPH
100
90
80
70
60
50
40
30
20
10
0
Percent
30 MPH
L-4 L-3 L-2 L-1 R-1 R-2 R-3 R-4
3 Foot Wide Lanes



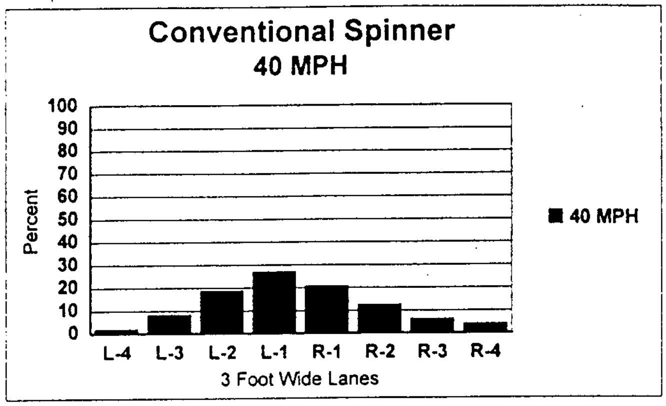
Salt Chute
30 MPH
100
90
80
70
60
50
40
30
20
10
0
Percent
30 MPH
L-4 L-3 L-2 L-1 R-1 R-2 R-3 R-4
3 Foot Wide Lanes

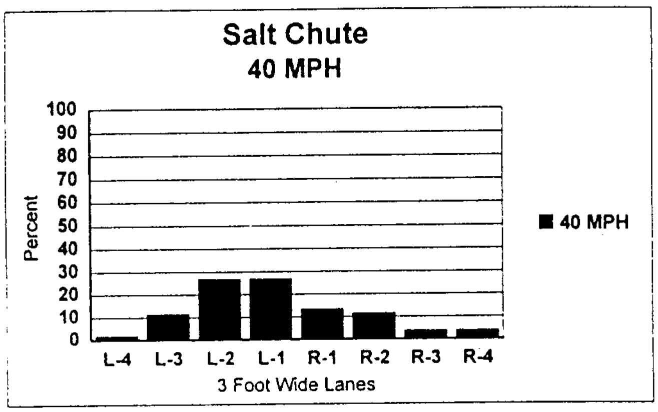


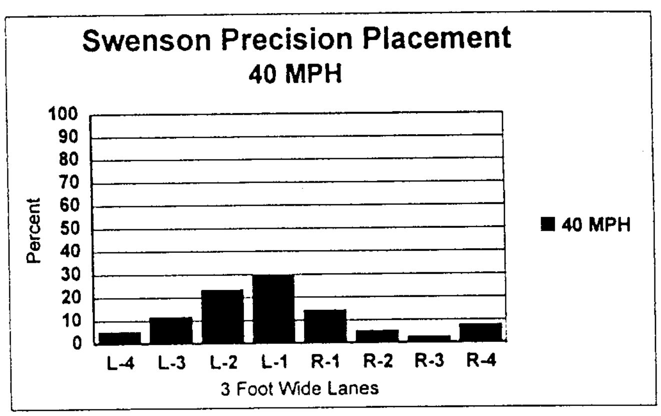
Swenson Precision Placement
30 MPH
100
90
80
70
60
50
40
30
20
10
0
Percent
30 MPH
L-4 L-3 L-2 L-1 R-1 R-2 R-3 R-4
3 Foot Wide Lanes

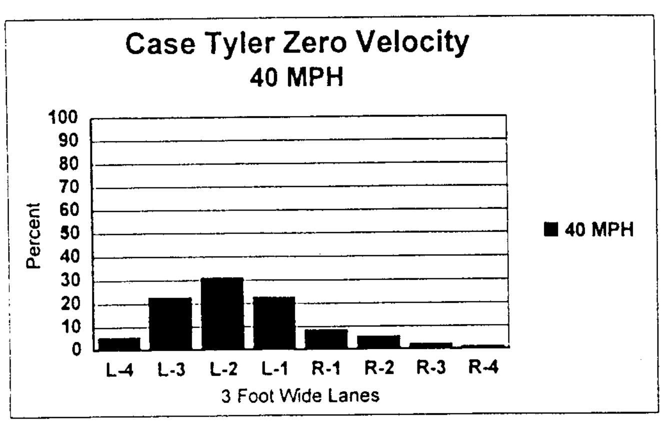


Case Tyler Zero Velocity
30 MPH
100
90
80
70
60
50
40
30
20
10
0
Percent
30 MPH
L-4 L-3 L-2 L-1 R-1 R-2 R-3 R-4
3 Foot Wide Lanes


Conventional Spinner
40 MPH
Percent
100
90
80
70
60
50
40
30
20
10
0
L-4 L-3 L-2 L-1 R-1 R-2 R-3 R-4
3 Foot Wide Lanes
40 MPH


Salt Chute
40 MPH
Percent
100
90
80
70
60
50
40
30
20
10
0
L-4 L-3 L-2 L-1 R-1 R-2 R-3 R-4
3 Foot Wide Lanes
40 MPH


Swenson Precision Placement
40 MPH
Percent
100
90
80
70
60
50
40
30
20
10
0
L-4 L-3 L-2 L-1 R-1 R-2 R-3 R-4
3 Foot Wide Lanes
40 MPH


Case Tyler Zero Velocity
40 MPH
Percent
100
90
80
70
60
50
40
30
20
10
0
L-4 L-3 L-2 L-1 R-1 R-2 R-3 R-4
3 Foot Wide Lanes
40 MPH

Appendix D

Table I

Salt Application Rates

Current Pavement Temperature Range (F)	Anticipated Pavement Temperature Change (Higher or Lower)	Precipitation Type/ Severity	Application Rate Pounds Per Two Lane Mile	Recommended Treatment	Comments
Above 32	Higher	1,3,5 / Light	None	-	Monitor Pavement Temperature
	Lower	1,3,5 / Moderate to Heavy	100 to 200	Initial Application, reapply as needed	Closely Monitor Pavement Temperature
25 to 32	Higher	2,3,4,5 / Light	200 to 300	Initial Application,plow and reapply as needed	No Pre-wetting necessary
	Higher	2,3,4,5 / Moderate to Heavy	200 to 300	Initial Application,plow and reapply as needed	No Pre-wetting necessary
	Lower	2,3,4,5 / Light	200 to 400	Initial Application,plow and reapply as needed	No Pre-wetting necessary
	Lower	2,3,4,5 / Moderate to Heavy	200 to 400	Initial Application,plow and reapply as needed	No Pre-wetting necessary
20 to 25	Higher	3,4,5 Light	300 to 500	Initial Application,plow and reapply as needed	Consider some Pre-wetting
	Higher	3,4,5 Moderate to Heavy	300 to 500	Initial Application,plow and reapply as needed	Consider some Pre-wetting
	Lower	3,4,5 Light	400 to 600	Initial Application,plow and reapply as needed	Consider some Pre-wetting
	Lower	3,4,5 Moderate to Heavy	400 to 600	Initial Application,plow and reapply as needed	Consider some Pre-wetting
15 to 20	Higher	4,5 / Light	500 to 700	Initial Application,plow and reapply as needed	Use Pre-wet System
	Higher	4,5 Moderate to Heavy	500 to 700	Initial Application,plow and reapply as needed	Use Pre-wet System
	Lower	4,5 / Light	* 700 to 800	Initial Application,plow and reapply as needed	Use Pre-wet System / Be prepared to switch to Sand
	Lower	4,5 Moderate to Heavy	* 700 to 800	Initial Application,plow and reapply as needed	Use Pre-wet System / Be prepared to switch to Sand
15 or Below	-	-	-	Apply sand and Plow as needed	Monitor Pavement Temperature Switch to Salt if Rising above 15 deg.

* If Snow is blowing off roadway and no hard pack exists, do not apply.

Appendix E

Maine Department of Transportation
Bureau of Planning, Research and Community Services

Winter Maintenance Questionnaire

(Optional)
Name: **Charles Bailey**
Truck No.: **Drive all trucks (alternate driver)**
Crew: **3532(Plymouth)**

Material Application Equipment

1) What type of sand and/or salt application equipment did you use for the winter of 1998-1999 (Tyler ZV, Dickey-john Ground Speed, Swenson PPS, Conventional)?
   Crew Supervisors please list all that apply to your crew.
   Dickey-John GSC
2) Please list any problems you encountered with the equipment for this past winter. For example: wiring, hydraulics, bed chain sensors, speedometer sensors, plugging, radio interference, etc.
   I had problems with the hydraulics and the speedometer sensors.
3) Do you think this equipment makes your job any less difficult?
   Yes, when it is working properly.
4) What suggestions do you have to make the use of this equipment easier for the operator? For example: plug wiring locations, hydraulic hookup locations, control box location in the cab, etc.
   Put the hydraulic hookup in a more convenient location.
5) Overall, do you think you were able to do a better job, as good a job, or a poorer job compared to your experience with just a conventional spreader control system.
   I think I did as good a job with the new equipment as I did with the old.
6) Do you think this equipment can save material?
   Yes, I do.
7) Do you think MDOT should pursue more purchases of this type of equipment?
   No, not until all of the problems are worked out.
8) Any additional comments.
   The crew needs to be putting out salt near the beginning of the storm to prevent a snow pack from accumulating on the road.

Sand vs. Salt usage

1) Did you apply both sand and salt this past winter?
   Yes, I did.
2) Overall, which worked better?
   The salt did.
3) Did you have any problems when using salt? (please explain)
   No, I didn't.
4) If you used Calcium Chloride, did it help you do a better job?
   Yes, it did.
5) What needs to change when we use salt instead of sand? For example: application rates, timing of application, call-outs, etc.
   The first application needs to be heavier.
6) Were there times this winter when salt did not work? (please explain)
   Yes, when there was hard packed ice and the temperatures were very low.
7) Do you think MDOT can save money by using salt more often?
   Yes, I do.
8) Any additional comments.
   No

Maine Department of Transportation
Bureau of Planning, Research and Community Services

Winter Maintenance Questionnaire

(Optional)
Name: **Ward Bond**
Truck No.: **T01-087**
Crew: **3532(Plymouth)**

Material Application Equipment

1) What type of sand and/or salt application equipment did you use for the winter of 1998-1999 (Tyler ZV, Dickey-john Ground Speed, Swenson PPS, Conventional)?
   Crew Supervisors please list all that apply to your crew.
   Dickey-John GSC
2) Please list any problems you encountered with the equipment for this past winter. For example: wiring, hydraulics, bed chain sensors, speedometer sensors, plugging, radio interference, etc.
   The electrical plug wires need to be located behind the cab.
3) Do you think this equipment makes your job any less difficult?
   Yes, it did.
4) What suggestions do you have to make the use of this equipment easier for the operator? For example: plug wiring locations, hydraulic hookup locations, control box location in the cab, etc.
   Change the electrical plug wires to a place behind the cab.
5) Overall, do you think you were able to do a better job, as good a job, or a poorer job compared to your experience with just a conventional spreader control system.
   I think I did as good a job with this equipment.
6) Do you think this equipment can save material?
   Yes, I do.
7) Do you think MDOT should pursue more purchases of this type of equipment?
   Maybe, I am not sure yet.
8) Any additional comments.
   Some of the small problems need to be worked out.

Sand vs. Salt usage

1) Did you apply both sand and salt this past winter?

Yes, I did.

2) Overall, which worked better?

Both salt and sand have there good points.

3) Did you have any problems when using salt? (please explain)

No, I didn't.

4) If you used Calcium Chloride, did it help you do a better job?

Yes, it did.

5) What needs to change when we use salt instead of sand? For example: application rates, timing of application, call-outs, etc.

The crew needs to be called out sooner and more salt used on the first application.

6) Were there times this winter when salt did not work? (please explain)

Yes, when it was too cold and when snow and ice were packed on the road.

7) Do you think MDOT can save money by using salt more often?

Yes, I do.

8) Any additional comments.

Maine Department of Transportation
Bureau of Planning, Research and Community Services

Winter Maintenance Questionnaire

(Optional)
Name: **Bruce Bragdon**
Truck No.: **T01-046**
Crew: **3532(Plymouth)**

Material Application Equipment

1) What type of sand and/or salt application equipment did you use for the winter of 1998-1999 (Tyler ZV, Dickey-john Ground Speed, Swenson PPS, Conventional)? Crew Supervisors please list all that apply to your crew.

Dickey John GSC

2) Please list any problems you encountered with the equipment for this past winter. For example: wiring, hydraulics, bed chain sensors, speedometer sensors, plugging, radio interference, etc.

Some problems encountered with this equipment during the winter were:

1. **The electrical plugs between the hopper and the truck.**
2. **Calcium control not responding, error occurred frequently.**
3. **The speed fluctuated 4-5 miles per hour due to wrong placement of sending unit.**

3) Do you think this equipment makes your job any less difficult?

. The equipment makes my job less difficult because it eliminates the need to adjust the speed of the bed chain as the truck speed or RPM's fluctuate.

4) What suggestions do you have to make the use of this equipment easier for the operator? For example: plug wiring locations, hydraulic hookup locations, control box location in the cab, etc.

Lengthen the hydraulic and plug wire connections so as they can be put in a better location.

5) Overall, do you think you were able to do a better job, as good a job, or a poorer job compared to your experience with just a conventional spreader control system.

I was able to do a better job with this equipment.

6) Do you think this equipment can save material?

Yes, I think it can.

7) Do you think MDOT should pursue more purchases of this type of equipment?

Yes, but decide on one brand so as all installations and operations will be the same.

8) Any additional comments.

Sand vs. Salt usage

1) Did you apply both sand and salt this past winter?

Yes, but mostly I applied salt.

2) Overall, which worked better?

Salt worked well when applied at higher rates 400 pounds per mile or more.

3) Did you have any problems when using salt? (please explain)

Application rates under 400 pounds per mile generally are not sufficient.

4) If you used Calcium Chloride, did it help you do a better job?

Yes it did. I would suggest that any material that is being applied be supplemented with calcium.

5) What needs to change when we use salt instead of sand? For example: application rates, timing of application, call-outs, etc.

We need to be called out sooner and using a higher initial application of salt. When it is extremely icy possibly an application of hot mix would work well.

6) Were there times this winter when salt did not work? (please explain)

Yes, at very low temperatures but this might have been due to low application rates.

7) Do you think MDOT can save money by using salt more often?

Yes, I do.

8) Any additional comments.

I think the initial application rate needs to be around 500 to 600 pounds per mile. One trip around at that rate results in less salt used then three trips at 300 pounds per mile.

Maine Department of Transportation
Bureau of Planning, Research and Community Services

Winter Maintenance Questionnaire

(Optional)
Name: **Barbara Charters**
Truck No.:**Crew Leader**
Crew: **3532(Plymouth)**

Material Application Equipment

1) What type of sand and/or salt application equipment did you use for the winter of 1998-1999 (Tyler ZV, Dickey-john Ground Speed, Swenson PPS, Conventional)?
   Crew Supervisors please list all that apply to your crew.
   Dickey-John GSC
2) Please list any problems you encountered with the equipment for this past winter. For example: wiring, hydraulics, bed chain sensors, speedometer sensors, plugging, radio interference, etc.
   The electrical plug is in the rear under the truck. This is a bad place for it to be.
3) Do you think this equipment makes your job any less difficult?
   I don't know, I haven't run one yet.
4) What suggestions do you have to make the use of this equipment easier for the operator? For example: plug wiring locations, hydraulic hookup locations, control box location in the cab, etc.
5) Overall, do you think you were able to do a better job, as good a job, or a poorer job compared to your experience with just a conventional spreader control system.
   We had no problems with the conventional spreader control system but some problems were encountered with the ground control unit.
6) Do you think this equipment can save material?
   Yes, I do.
7) Do you think MDOT should pursue more purchases of this type of equipment?
   If your talking ground control yes, zero velocity, no.
8) Any additional comments.

Sand vs. Salt usage

1) Did you apply both sand and salt this past winter?

Yes, we did.

2) Overall, which worked better?

Hard to say, when the conditions were right for each, either one worked fine.

3) Did you have any problems when using salt? (please explain)

4) If you used Calcium Chloride, did it help you do a better job?

Yes, it did.

5) What needs to change when we use salt instead of sand? For example: application rates, timing of application, call-outs, etc.

The crew needs to be called out sooner and more salt applied on the first application.

6) Were there times this winter when salt did not work? (please explain)

Yes, on occasions when the temperatures were very low or when a snow pack had accumulated on the road.

7) Do you think MDOT can save money by using salt more often?

Yes, If the salt was applied sooner and more put out on the first application.

8) Any additional comments.

The only problem I found was that all the trucks are not set up the same. Therefore, when drivers are rotated or switched they don't know how to operate the other truck.

Maine Department of Transportation
Bureau of Planning, Research and Community Services

Winter Maintenance Questionnaire

(Optional)
Name: **David C. Flannery**
Truck No.: **T01-450**
Crew: **3531**

Material Application Equipment

1) What type of sand and/or salt application equipment did you use for the winter of 1998-1999 (Tyler ZV, Dickey-john Ground Speed, Swenson PPS, Conventional)? Crew Supervisors please list all that apply to your crew.
   Swenson PPS
2) Please list any problems you encountered with the equipment for this past winter. For example: wiring, hydraulics, bed chain sensors, speedometer sensors, plugging, radio interference, etc.
   Some problems were encountered during the season and are listed below.
   - **A) The hydraulic hookups are too close together underneath the frame making it hard to work with them.**
   - **B) The radio is all static at the beginning of an operation plus when the radio mic is keyed it shuts the bed chain-spinner off.**
   - **C) Multiple cases of chute plugging up especially with sand, but also occasionally when the salt is wet.**
   - **D) The unit operates too slow to put out sand effectively. Unless it can be redesigned, sand should not be used with this unit.**
3) Do you think this equipment makes your job any less difficult?
   This equipment makes the job more difficult because there are so many variables which will be explained in future answers.
4) What suggestions do you have to make the use of this equipment easier for the operator? For example: plug wiring locations, hydraulic hookup locations, control box location in the cab, etc.
   - **A. The hydraulic hose hookups would be easier to use if they were mounted on the side of the truck. Also, it would be nice to eliminate some of the extra wire and cable in the cab.**
   - **B. The unit works better with granular salt instead of powdery salt.**

C. All the people involved in the research project need to keep an open mind until the research proves otherwise.

5) Overall, do you think you were able to do a better job, as good a job, or a poorer job compared to your experience with just a conventional spreader control system.

The work wasn't always completed in the same manner that it would've been done with a conventional unit. Therefore, it was hard to compare the results.

6) Do you think this equipment can save material?

The unit wasn't always used the way it was intended but if it had been, I think it would save material.

7) Do you think MDOT should pursue more purchases of this type of equipment?

A couple of things need to be addressed such as the chute design and the pump capacities. If corrected, then it most likely would be beneficial to purchase more of these units.

8) Any additional comments.

It takes too long to unload when sitting still. The unloading speed needs to be bumped up somehow. As it is now it takes thirty to forty minutes.

Sand vs. Salt usage

1) Did you apply both sand and salt this past winter?

Yes, but the unit didn't work very well with sand.

2) Overall, which worked better?

The salt worked the best.

3) Did you have any problems when using salt? (please explain)

A) The salt was somewhat powdery causing it to stick to the chute.

B) All the people involved in the research project need to be opened minded and make no judgment calls until they are substantiated by the results of the research.

4) If you used Calcium Chloride, did it help you do a better job?

Calcium chloride was used a few times but wasn't very effective due to inexperience. Learning how much to apply depending on road conditions will most likely enhance its usefulness.

5) What needs to change when we use salt instead of sand? For example: application rates, timing of application, call-outs, etc.

A) When using salt the first application needs to be on the heavy side, around 4 to 5 hundred pounds per mile.

B) When an extended snowfall is expected trucks should be put out early applying salt so as a snow pack doesn't accumulate on the roadway.

6) Were there times this winter when salt did not work? (please explain)

Yes there was. Sometimes we were not called in soon enough resulting in a buildup of snow and ice on the roadway. It seems more cost effective to come in a little earlier and keep the roadway bare rather than staying 4 or 5 hours after the storm is over to obtain the same result. Also, less salt would be needed.

7) Do you think MDOT can save money by using salt more often?

Yes, I do in the long run. This would eliminate most of the stockpiling of sand, sweeping the sand off the roadway in the spring and much of the ditching which needs to be done because of sand buildup .

8) Any additional comments.

Drivers should be shown respect and encouraged when they are doing a good job . Let them shoulder some of the responsibility as to what they feel needs to be done on their beat. Also, a driver shouldn't be expected to do someone else's beat unless his or hers is in good condition or there is an urgent situation.

Maine Department of Transportation
Bureau of Planning, Research and Community Services

Winter Maintenance Questionnaire

(Optional)
Name: **Jerry Hathaway**
Truck No.: **Supervisor**
Crew: **3532(Plymouth)**

Material Application Equipment

1) What type of sand and/or salt application equipment did you use for the winter of 1998-1999 (Tyler ZV, Dickey-john Ground Speed, Swenson PPS, Conventional)?
   Crew Supervisors please list all that apply to your crew.
   Dickey-John GSC
2) Please list any problems you encountered with the equipment for this past winter. For example: wiring, hydraulics, bed chain sensors, speedometer sensors, plugging, radio interference, etc.
   One problem I encountered was that the wiring that comes off the truck is way too long. It should be on the hopper.
3) Do you think this equipment makes your job any less difficult?
   Once everyone gets used to it, I think it will make my job easier.
4) What suggestions do you have to make the use of this equipment easier for the operator? For example: plug wiring locations, hydraulic hookup locations, control box location in the cab, etc.

5) Overall, do you think you were able to do a better job, as good a job, or a poorer job compared to your experience with just a conventional spreader control system.

6) Do you think this equipment can save material?
   Yes, if I can get the drivers to keep the settings low and not turn them up.
7) Do you think MDOT should pursue more purchases of this type of equipment?

8) Any additional comments.

Sand vs. Salt usage

1) Did you apply both sand and salt this past winter?
2) Overall, which worked better?
3) Did you have any problems when using salt? (please explain)
4) If you used Calcium Chloride, did it help you do a better job?
5) What needs to change when we use salt instead of sand? For example: application rates, timing of application, call-outs, etc.
6) Were there times this winter when salt did not work? (please explain)
7) Do you think MDOT can save money by using salt more often?
8) Any additional comments.

Maine Department of Transportation
Bureau of Planning, Research and Community Services

Winter Maintenance Questionnaire

(Optional)
Name: **Preston Hopkins**
Truck No.: **T01-463**
Crew: **3532(Plymouth)**

Material Application Equipment

1) What type of sand and/or salt application equipment did you use for the winter of 1998-1999 (Tyler ZV, Dickey-john Ground Speed, Swenson PPS, Conventional)? Crew Supervisors please list all that apply to your crew.
   Dickey-John GSC
2) Please list any problems you encountered with the equipment for this past winter. For example: wiring, hydraulics, bed chain sensors, speedometer sensors, plugging, radio interference, etc.
   None
3) Do you think this equipment makes your job any less difficult?
   Yes, I do.
4) What suggestions do you have to make the use of this equipment easier for the operator? For example: plug wiring locations, hydraulic hookup locations, control box location in the cab, etc.
   The hydraulic hock up needs to be put in a more convenient location.
5) Overall, do you think you were able to do a better job, as good a job, or a poorer job compared to your experience with just a conventional spreader control system.
   I think I did as good a job compared with the conventional spreader.
6) Do you think this equipment can save material?
   Yes, I do.
7) Do you think MDOT should pursue more purchases of this type of equipment?
   No, not until the problems have been worked out.
8) Any additional comments.
   None

Sand vs. Salt usage

1) Did you apply both sand and salt this past winter?
   Yes, I did.
2) Overall, which worked better?
   Salt did a better job at night.
3) Did you have any problems when using salt? (please explain)
   No, I didn't.
4) If you used Calcium Chloride, did it help you do a better job?
   Yes, it did.
5) What needs to change when we use salt instead of sand? For example: application rates, timing of application, call-outs, etc.
   The first trip should be a higher application.
6) Were there times this winter when salt did not work? (please explain)
   Yes, when we weren't called out soon enough causing the snow to pack on the road and when the temperatures were very low.
7) Do you think MDOT can save money by using salt more often?
   Yes, I do.
8) Any additional comments.
   No

Maine Department of Transportation
Bureau of Planning, Research and Community Services

Winter Maintenance Questionnaire

(Optional)
Name: **Glen A. Lebel**
Truck No.: **T01-414 Ford wheeler**
Crew: **3531 Bangor**

Material Application Equipment

1) What type of sand and/or salt application equipment did you use for the winter of 1998-1999 (Tyler ZV, Dickey-john Ground Speed, Swenson PPS, Conventional)? Crew Supervisors please list all that apply to your crew.

   Tyler ZV

2) Please list any problems you encountered with the equipment for this past winter. For example: wiring, hydraulics, bed chain sensors, speedometer sensors, plugging, radio interference, etc.

   I had a couple of problems, one with the sensors on the back gate and the other problem was with the plug on the wiring.

3) Do you think this equipment makes your job any less difficult?

   Yes, it does when everything is working as it should.

4) What suggestions do you have to make the use of this equipment easier for the operator? For example: plug wiring locations, hydraulic hookup locations, control box location in the cab, etc.

   I would like to have the wire plug and the hydraulic hookup put between the cab and the dump body for easier access.

5) Overall, do you think you were able to do a better job, as good a job, or a poorer job compared to your experience with just a conventional spreader control system.

   I do a better job with this unit. I can do both lanes at once and put the salt where I want it.

6) Do you think this equipment can save material?

   Yes, and do a good job at the same time.

7) Do you think MDOT should pursue more purchases of this type of equipment?

   Yes, I do.

8) Any additional comments.

   I think we should go all salt.

Sand vs. Salt usage

1) Did you apply both sand and salt this past winter?
   Yes I did. I used salt mostly but I did put out two loads of sand.
2) Overall, which worked better?
   The salt works better and overall it saves money.
3) Did you have any problems when using salt? (please explain)
   No, I wish the department would go totally to salt.
4) If you used Calcium Chloride, did it help you do a better job?
   It did help under certain conditions , especially when the temperature was 22 degrees or below.
5) What needs to change when we use salt instead of sand? For example: application rates, timing of application, call-outs, etc.
   The Tyler ZV unit is made just for salt usage.
6) Were there times this winter when salt did not work? (please explain)
   No, salt always did a good job.
7) Do you think MDOT can save money by using salt more often?
   Yes, salt appears to save money and does a better job.
8) Any additional comments.
   I am sold on using all salt.

Maine Department of Transportation
Bureau of Planning, Research and Community Services

Winter Maintenance Questionnaire

(Optional)
Name: **Royce Mc Laggan**
Truck No.: **T01-067**
Crew: **3532 (Plymouth)**

Material Application Equipment

1) What type of sand and/or salt application equipment did you use for the winter of 1998-1999 (Tyler ZV, Dickey-john Ground Speed, Swenson PPS, Conventional)? Crew Supervisors please list all that apply to your crew.
   Dickey-John GSC
2) Please list any problems you encountered with the equipment for this past winter. For example: wiring, hydraulics, bed chain sensors, speedometer sensors, plugging, radio interference, etc.
   Problems encountered while using this equipment were with the speedometer sensor and interference with the radio.
3) Do you think this equipment makes your job any less difficult?
   Yes, When it is working correctly.
4) What suggestions do you have to make the use of this equipment easier for the operator? For example: plug wiring locations, hydraulic hookup locations, control box location in the cab, etc.
   The hydraulic hookup could be put in a more convenient location.
5) Overall, do you think you were able to do a better job, as good a job, or a poorer job compared to your experience with just a conventional spreader control system.
   I think I did a better job with this equipment.
6) Do you think this equipment can save material?
   Yes, if everyone does what he or she are told.
7) Do you think MDOT should pursue more purchases of this type of equipment?
   No, not until the problems are worked out.
8) Any additional comments
   I think the equipment will work if we get an early start on the storm.

Sand vs. Salt usage

1) Did you apply both sand and salt this past winter?

Yes, I did.

2) Overall, which worked better?

Salt, if we were called out early enough.

3) Did you have any problems when using salt? (please explain)

No, I didn't.

4) If you used Calcium Chloride, did it help you do a better job?

Yes, it did.

5) What needs to change when we use salt instead of sand? For example: application rates, timing of application, call-outs, etc.

The first application of salt should be heavier then the subsequent applications.

6) Were there times this winter when salt did not work? (please explain)

Yes, when the temperature was too low.

7) Do you think MDOT can save money by using salt more often?

Yes, I do.

8) Any additional comments.

No

Maine Department of Transportation
Bureau of Planning, Research and Community Services

Winter Maintenance Questionnaire

(Optional)
Name: **Neil Merrill**
Truck No.: **Supervisor**
Crew: **3531**

Material Application Equipment

1) What type of sand and/or salt application equipment did you use for the winter of 1998-1999 (Tyler ZV, Dickey-john Ground Speed, Swenson PPS, Conventional)? Crew Supervisors please list all that apply to your crew.
   A) Tyler ZV
   B) Regular Swenson Hoppers
   C) Front dump Spreaders
   D) Swenson PPS
2) Please list any problems you encountered with the equipment for this past winter. For example: wiring, hydraulics, bed chain sensors, speedometer sensors, plugging, radio interference, etc.
   Almost every storm there would be something happen to the hoppers on the wheelers plus the units caused interference problems on the two-way radios.
3) Do you think this equipment makes your job any less difficult?
   No, this equipment makes my job more difficult since we didn't have these problems beforehand.
4) What suggestions do you have to make the use of this equipment easier for the operator? For example: plug wiring locations, hydraulic hookup locations, control box location in the cab, etc.
   The hydraulic hookup needs to be changed and put behind the cab.
5) Overall, do you think you were able to do a better job, as good a job, or a poorer job compared to your experience with just a conventional spreader control system.
   I think the regular hoppers done a much better job from past years experience.
6) Do you think this equipment can save material?
   No, because we can turn the old hopper up or down for more or less material.

7) Do you think MDOT should pursue more purchases of this type of equipment?

No, because we have fewer problems with the old units.

8) Any additional comments.

Sand vs. Salt usage

1) Did you apply both sand and salt this past winter?

Yes, we did.

2) Overall, which worked better?

They both work good under certain conditions. Salt should be used at temperatures above 15 degrees and sand when they are below 15 degrees.

3) Did you have any problems when using salt? (please explain)

Yes, we did when the temperature was below 15 degrees.

4) If you used Calcium Chloride, did it help you do a better job?

Yes, it did if it was mixed with the sand and the air temperature wasn't too low.

5) What needs to change when we use salt instead of sand? For example: application rates, timing of application, call-outs, etc.

There are times for sand or salt but that depends on the roadway temperature.

6) Were there times this winter when salt did not work? (please explain)

Yes, there were when the temperature was down too low.

7) Do you think MDOT can save money by using salt more often?

That depends on the temperature, salt is fine for temperatures above 15 degrees but for temperatures lower then that you would need to use sand and calcium.

8) Any additional comments.

I don't think we should be using salt when the temperature is below 15 degrees.

Maine Department of Transportation
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Winter Maintenance Questionnaire

(Optional)
Name: **Raymond Moore**
Truck No.: **T01-094**
Crew: **3532(Plymouth)**

Material Application Equipment

1) What type of sand and/or salt application equipment did you use for the winter of 1998-1999 (Tyler ZV, Dickey-john Ground Speed, Swenson PPS, Conventional)?
Crew Supervisors please list all that apply to your crew.
Conventional (Skip to Sand vs. Salt Usage)
2) Please list any problems you encountered with the equipment for this past winter. For example: wiring, hydraulics, bed chain sensors, speedometer sensors, plugging, radio interference, etc.
3) Do you think this equipment makes your job any less difficult?
4) What suggestions do you have to make the use of this equipment easier for the operator? For example: plug wiring locations, hydraulic hookup locations, control box location in the cab, etc.
5) Overall, do you think you were able to do a better job, as good a job, or a poorer job compared to your experience with just a conventional spreader control system.
6) Do you think this equipment can save material?
7) Do you think MDOT should pursue more purchases of this type of equipment?
8) Any additional comments.

Sand vs. Salt usage

1) Did you apply both sand and salt this past winter?
Yes, I did.
2) Overall, which worked better?
The salt worked better.
3) Did you have any problems when using salt? (please explain)
Yes, I did. It was freezing up in the hopper.

4) If you used Calcium Chloride, did it help you do a better job?

Yes, it did.

5) What needs to change when we use salt instead of sand? For example: application rates, timing of application, call-outs, etc.

1) application rates

2) call outs

6) Were there times this winter when salt did not work? (please explain)

Yes, when it was to cold.

7) Do you think MDOT can save money by using salt more often?

Yes, I do.

8) Any additional comments.

Maine Department of Transportation
Bureau of Planning, Research and Community Services

Winter Maintenance Questionnaire

(Optional)
Name:
Truck No.: **T01-088**
Crew: **3521**

Material Application Equipment

1) What type of sand and/or salt application equipment did you use for the winter of 1998-1999 (Tyler ZV, Dickey-john Ground Speed, Swenson PPS, Conventional)? Crew Supervisors please list all that apply to your crew.
   Conventional (Skip to Sand vs. Salt Usage)
2) Please list any problems you encountered with the equipment for this past winter. For example: wiring, hydraulics, bed chain sensors, speedometer sensors, plugging, radio interference, etc.
3) Do you think this equipment makes your job any less difficult?
4) What suggestions do you have to make the use of this equipment easier for the operator? For example: plug wiring locations, hydraulic hookup locations, control box location in the cab, etc.
5) Overall, do you think you were able to do a better job, as good a job, or a poorer job compared to your experience with just a conventional spreader control system.
6) Do you think this equipment can save material?
7) Do you think MDOT should pursue more purchases of this type of equipment?
8) Any additional comments.

Sand vs. Salt usage

1) Did you apply both sand and salt this past winter?
   Yes, I did.
2) Overall, which worked better?
   It worked the best when I used a mixed load.
3) Did you have any problems when using salt? (please explain)
   It wasn't very effective when used at temperatures below 30 degrees.
4) If you used Calcium Chloride, did it help you do a better job?

Yes, it did.

5) What needs to change when we use salt instead of sand? For example: application rates, timing of application, call-outs, etc.

The foreman needs to call the truck drivers out when he gets called.

6) Were there times this winter when salt did not work? (please explain)

Yes, the storm that turned to freezing rain.

7) Do you think MDOT can save money by using salt more often?

Yes, I do.

8) Any additional comments.

No

Maine Department of Transportation
Bureau of Planning, Research and Community Services

Winter Maintenance Questionnaire

(Optional)
Name:
Truck No.: **T01-420**
Crew: **3531**

Material Application Equipment

1) What type of sand and/or salt application equipment did you use for the winter of 1998-1999 (Tyler ZV, Dickey-john Ground Speed, Swenson PPS, Conventional)?

Crew Supervisors please list all that apply to your crew.

Tyler ZV

2) Please list any problems you encountered with the equipment for this past winter. For example: wiring, hydraulics, bed chain sensors, speedometer sensors, plugging, radio interference, etc.

There were a couple of problems, one was the computer wouldn't record he number of gallons of calcium and the unit caused interference on the radio.

3) Do you think this equipment makes your job any less difficult?

There is no change, it isn't any more or less difficult.

4) What suggestions do you have to make the use of this equipment easier for the operator? For example: plug wiring locations, hydraulic hookup locations, control box location in the cab, etc.

Program an unloading mode into the computer so that the auger will turn when the vehicle is stationary.

5) Overall, do you think you were able to do a better job, as good a job, or a poorer job compared to your experience with just a conventional spreader control system.

. I didn't see any difference in the performance of either unit

6) Do you think this equipment can save material?

Yes, because of computerization.

7) Do you think MDOT should pursue more purchases of this type of equipment?

I want to use this unit a little more before making that decision.

8) Any additional comments.

Sand vs. Salt usage

1) Did you apply both sand and salt this past winter?

   Yes, I did.

2) Overall, which worked better?

   There was no difference, they worked about the same.

3) Did you have any problems when using salt? (please explain)

   There were frozen lumps of salt in some loads causing problems with the bed chain, door and switch.

4) If you used Calcium Chloride, did it help you do a better job.

   Yes, and it did help at temperatures above 15 degrees.

5) What needs to change when we use salt instead of sand? For example: application rates, timing of application, call-outs, etc.

   Salt should only be used at temperatures above 15 or 20 degrees. Sand should be used at temperatures below 20 degrees applying soon after the storm begins.

6) Were there times this winter when salt did not work? (please explain)

   Yes, when the temperature was below 15 to 20 degrees.

7) Do you think MDOT can save money by using salt more often?

   Yes, when used at temperatures above 15 degrees.

8) Any additional comments.

   No