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EXPERIMENTAL CONSTRUCTION
97-7
AN EVALUATION OF WINTER MAINTENANCE MATERIAL METERING AND PLACEMENT EQUIPMENT
FINAL REPORT

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.

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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	Miles Applied	Total Salt Applied (Actual Lbs.)	Total 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 form 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.

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