

ROAD SALT AND SNOW AND ICE CONTROL

This is a primer for the public on the need and standard techniques for the use of road salt to maintain safe roadway travel in Canada. TAC has also produced a comprehensive Guide on the Management of Road Salt, and a series of Syntheses of Best Practices related to the effective management of road salt use in winter maintenance operations.



WHAT'S AHEAD

This Primer includes the following:

- Introduction
- Importance of Road Transportation to Canada's Economy
- The Role of Winter Maintenance in Maintaining Safe and Efficient Road Transportation
- The Role of Salt in Winter Maintenance
- Road Salt and the Environment
- Alternatives to Road Salt
- Reducing the Adverse Effects of Road Salt
- The Future

INTRODUCTION

Although there is ongoing research in the use of alternative chemicals to road salt in winter road maintenance, salt continues to be the de-icer of choice in Canada.

This primer is intended to help the public understand the role of road salt in maintaining Canada's road system. It is also an introductory guide for use by road authorities in finding ways to more effectively manage their salt use, and provide the public with the safe efficient road systems they expect while minimizing the adverse effects that road salt can have.

Road Salt: In this primer, the term "salt" refers to sodium chloride (NaCl). Road salt is mined from natural deposits in the ground. This is the same material that makes up table salt.

Although some of the statistics used in this *Primer* is dated, they are still relevant. A greater discussion of all of the matters covered in this *Primer*, can be found in TAC's *Road Salt (NaCl) Management Guide*.

IMPORTANCE OF ROAD TRANSPORTATION TO CANADA'S ECONOMY

Canada has close to one million kilometres of roads. This extensive network provides a safe, efficient, and affordable means of surface transportation, and supports a wealth of economic and social activities.

The Canadian Household

In 1995, Canadians relied on private motor vehicles to travel 475 billion passenger-kilometres, and public transit for another 8 billion. The average Canadian household spends about \$5,000 annually on road transportation, largely to purchase and operate private motor vehicles.

Spending on Road Transport ~ Per Household ~

Spending Item	Spending (\$)
Private Vehicle Purchases	\$2,519
Insurance / Repairs / Fuel	\$2,415
Urban Transit	\$125
Intercity Transit	\$51
Taxi	\$42
Total	\$5,152

Source: Transport Canada (1996), *Transportation in Canada 1996 - Annual Report*.

The Canadian Economy

The direct and indirect effects of road-related transportation is important to Canada's economy. Economy-wide, spending on road transportation totalled over \$90 billion in 1995. Half of this spending was on private motor vehicles, which had substantial benefits for the Canadian steel, petroleum, and insurance sectors.

Spending on Road Transport ~ Aggregate Economy ~

Spending Item	Spending (\$M)
Private Motor Vehicles	\$48,400
Passenger Carriers	\$4,800
Freight Carriers	\$12,500
Private Trucking	\$15,500
Government Spending	\$9,400
Total	\$90,600

Source: Transport Canada (1996), *Transportation in Canada 1996 - Annual Report*.

Our roads also directly support the activity of passenger and freight carriers (generating over \$32 billion in revenues in 1995). Government spending added another \$9 billion in revenues to the road construction sector.

Beyond this direct spending, our roads further play an indirect yet essential role in supporting other major transportation-dependent industries, such as tourism, agriculture, petroleum, pulp and paper, chemicals, and many others.

Other Social Benefits

Roads provide Canadians with increased mobility to pursue a range of social activities (e.g. visiting friends and family, recreational pursuits, getting to and from work). Emergency and security services (e.g. fire protection, ambulance, police services) which protect our safety and well-being could not function without Canada's road network.

Roads play essential and irreplaceable roles in supporting the high standard of living enjoyed by Canadians.

THE ROLE OF WINTER MAINTENANCE IN MAINTAINING SAFE AND EFFICIENT ROAD TRANSPORTATION

Safe and efficient road traffic is essential to the Canadian way of life. We rely on our road network for transport to the workplace and other economic uses, for recreation and leisure activities, and for emergency and security services. A strong Canadian economy is built on an efficient road transportation system. The safety, efficiency, and beneficial uses of our roads are sometimes compromised by snow and ice accumulation.

The Costs of Snow and Ice Accumulation

Snow and ice accumulation can result in a number of highly visible consequences. Not the least of these is reducing the safety which is normally afforded to the Canadian motoring public.

Increased accident rates result in corresponding damages to human health, property, and wildlife. Snow and ice accumulation can also result in a wide range of other, less obvious, adverse impacts. These include impacts on:

- individual motorists (e.g. through increased travel times and costs, and greater travel anxiety);
- the economy (e.g. economic losses as a result of inability of employees to reach the workplace or consumers to reach the marketplace); and
- society (e.g. the inability of emergency and security services to operate efficiently, restricted mobility, and inaccessibility of some locations).

These adverse impacts of snow and ice accumulation affect all Canadians, and generally result in direct and indirect costs and a lower standard of living if left unchecked.

The Benefits of Winter Maintenance

Winter maintenance activities, including the use of road salt, can mitigate or eliminate the adverse economic and social impacts resulting from snow and ice accumulation. Winter maintenance can:

- lower accident rates through safer roads;
- lower associated insurance and liability claims;
- generate time savings from faster (and safer) travel;
- generate fuel savings as a result of better traction and less congestion;
- reduce productivity losses due to late days and absenteeism by employees;
- reduce productivity losses due to unavailability of material inputs to production;
- help to avoid lost sales due to inaccessibility of finished goods to the marketplace;
- help to avoid lost sales due to inaccessibility of the customer to the marketplace;
- reduce the cost of commodities by reducing the transportation component of costs;
- ensure that emergency and security services can operate efficiently; and
- ensure mobility for Canadians to engage in social activities.

A number of attempts have been made to measure the net benefits to society resulting from the performance of winter maintenance activities. These studies explicitly recognize that the use of road salt results in costs to the road authority, and sometimes in unintended costs to road users and other non-users. For example, road salt has purchase and application costs, and may result in vehicle corrosion, damage to bridge decks, degradation of water supplies, and impacts on the natural environment.

The studies also estimate that the social benefits conveyed through the use of salt in winter maintenance outweigh these costs. Estimates of the ratios of societal benefits to costs of salting roads range from 2.0:1 to 18.1:1. These benefit/cost ratios suggest that *at least* two dollars in benefits tend to result from each dollar spent on winter maintenance activities through the avoidance of the adverse impacts of snow and ice accumulation, and the restoration of the beneficial uses of roads.

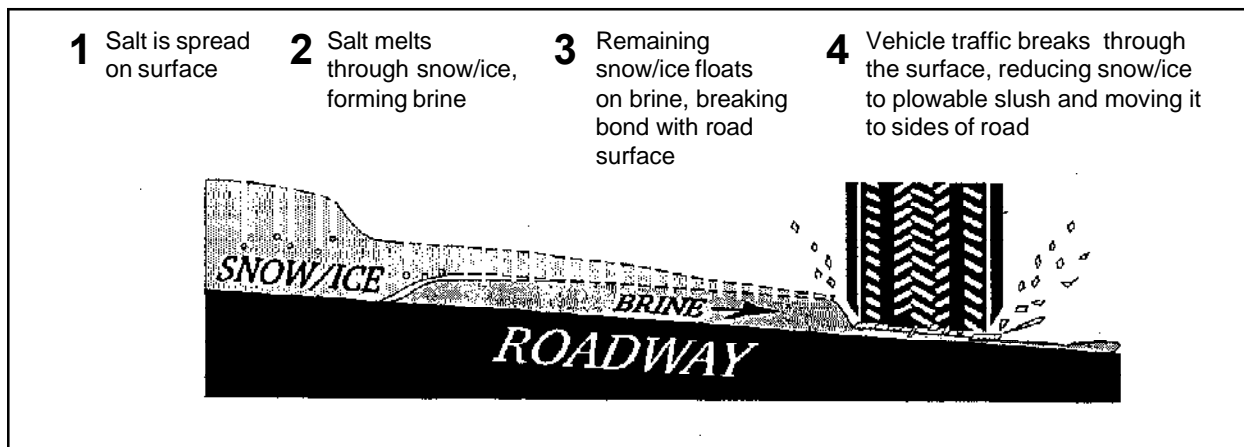
THE ROLE OF ROAD SALT IN WINTER MAINTENANCE

Safe roads in the winter depends upon maintaining sufficient traction between the vehicle's tires and the road to prevent skidding during vehicle operation and braking. Slippery conditions result from moisture freezing on the road during periods of fog, rain or snowfall when the road temperatures are below freezing.

As snow accumulates on the road and is compacted by traffic, it forms a bond with the pavement, making it difficult to remove with plows. In these situations, salt is needed to break through the snow to prevent this bond from forming. Figure 1 illustrates this deicing process. The salt reacts with moisture to create a layer of salty water - called brine - between the snow or ice layer and the road. This brine layer has a freeze point below zero degrees Celsius, and breaks the bond, permitting the snow and ice to be plowed from the road.

A clear trend to achieving more efficient salt use and safer road conditions is to apply the salt at the beginning of the storm to create a road condition that will prevent the initial freezing and the formation of the snow/road bond. This proactive and preventative approach requires less road salt

Figure 1 – The Role of Salt in Ice Removal



Source – Salt Institute

than that which is required to de-ice the road once the snow/ice pack has formed. It also helps keep the road ice-free throughout the storm. This is why we often see trucks spreading salt immediately after the storm has started. Rock salt should never be applied to bare pavement. The early application of salt is often referred to as “anti-icing”.

Following the initial salt application, plowing can proceed to remove continuing snow accumulations. Additional salting is only required to ensure sufficient traction and an ice-free surface.

Therefore, a chemical such as road salt, is critical to restoring safe road conditions where snow and ice conditions occur.

ROAD SALT AND THE ENVIRONMENT

Although road salt is critical to maintaining safe winter road conditions, excessive use can have negative impacts on the environment. It is important therefore to only apply as much salt as is necessary to achieve the safe driving objectives. Some of the environmental effects are identified below.

Surface and Groundwater - Salt that goes into the ground will dissolve in the water in the soil and can increase the amount of salt in well water. In high concentrations this can affect the taste of the water. Heavy salt loading to streams during sensitive periods of the year can adversely affect fish. However, most of the loadings are in the spring during high flow periods when dilution is high and watercourse sensitivities are low.

Vegetation - High concentrations of salt in soil, groundwater and salt spray from roadways can damage roadside vegetation such as trees, shrubs and grass. Some species of plants are more tolerant of high salt concentrations and therefore should be used near roadways.

Soil Impacts - The sodium in road salt can react with soil and cause increased hardness, increased pH and reduced permeability for some soil types. These characteristics in the roadside soils can adversely affect the fertility of the soils and their ability to grow plants. This is another reason for being selective in the type of plants used in roadside landscaping.

Wildlife - Some wildlife have a need for salt in their diets in the spring due to reduced salt diets over winter. These animals are often attracted to the roadside where there is a high spring salt concentration. The presence of wildlife near roadways is always a potential hazard and one that the driving public must be alert to.

Vehicle and Structural Corrosion - Road salt contributes to the corrosion of vehicles and structures (e.g. bridges, parking garages etc.). Technological improvements in materials and paints have reduced the corrosive effects of road salt.

ALTERNATIVES TO ROAD SALT

There has been considerable research into the use of alternative de-icing chemicals. These chemicals have different properties and in many cases have reduced environmental impacts.

Also, some of the alternatives work at lower temperatures than does road salt (NaCl). Many road authorities have tried these alternatives but usually return to road salt because of its significantly lower cost, its routine handling characteristics and its predictability in achieving a safe driving condition.

Research is continuing in hopes of finding a cost-effective alternative to road salt. However, in the mean time the best way to ensure appropriate salt use and therefore reduce the amount of salt being used, is through better forecasting about when salt is needed, better handling practices and improved technology for placing salt.

REDUCING THE EFFECTS OF ROAD SALT

There are many initiatives being evaluated and/or used to reduce the amount of salt that is needed to maintain a safe bare-pavement road. These involve:

- Reducing the accumulation of snow and ice on the roads, therefore eliminating the need for salt;
- Better predicting when and where salt needs to be applied;
- Improving the accuracy with which salt is placed on the road to achieve the best results;
- Reducing the amount of salt lost to the road-side shoulders and ditches before it has had a chance to work; and
- Improving the storage and handling of salt at the maintenance yards.

Each of these techniques is discussed briefly below.

Reducing the Amount of Snow on the Road - It is clear that if less snow is allowed to collect on the road, less plowing, sanding and salting will be required. Snow drifting occurs when the winds that are carrying snow are slowed down to the point that the snow drops onto the ground. This slowing of the winds can be caused by an obstruction such as trees, shrubs, posts, guiderails, etc., or a change in the terrain such as a ditch. This can cause snow drifts - or areas where un-

usual amounts of snow accumulate. Even parts of the road itself can create this snow drifting problem. For example if the road is divided by a median, and the upwind lanes are higher than the downwind lanes, drifting can occur on the downwind lanes. Also, bridges and interchanges can create drifting problems around the piers and abutments for the bridge.

It must be understood that dry pavement will allow the snow to blow clear, and that salt can make the road wet, causing blowing snow to stick and accumulate.

By taking care when designing roadways and through strategic placement or clearing of roadside vegetation, it is possible to reduce the number of areas where drifting will affect the roadway. Standard snowfences or living-snowfences - trees, shrubs, agricultural crops or stubble - are valuable tools in reducing snow drifting problems. These snowfences actually cause drifting off of, rather than on, the roadway. Innovative agreements are being developed with farmers to leave strategically placed rows of crops or stubble to trap the snow in the fields and prevent it from drifting onto the roads.

Vegetative clearing to reduce shading, and innovative pavement designs to ensure proper drainage are other techniques being used to prevent the formation of ice and therefore reduce the need for salt.

Predicting When to Apply Salt - For decades, winter maintenance personnel have used their experience to make decisions about when and where to place salt. This is a challenging task and one that road maintainers have become very good at.

They are being helped with new advances in information technology. Anyone who has watched the snow melt from their paved driveway on a sunny day, even though the air temperature is well below freezing, knows that pavement temperatures can be significantly different from air temperatures. When it comes to the formation of ice on the road - it is the pavement temperature that is most important.

Hand-held infrared thermometers measure pavement temperatures to help the observer monitor pavement condition trends.

Road Weather Information Systems (RWIS) with pavement and atmospheric sensors are now providing up-to-the-minute information to the road maintainers about what is happening at the road surface. Pavement sensors embedded in the road surface, linked to mini weather towers, collect information that is sent to a weather service. Their experts can forecast when freezing pavement conditions are likely to occur similar to the way they forecast the weather. This provides an early warning to road maintainers to have their people and trucks ready. The patrol staff relate the forecast to the actual observed conditions and the real time pavement information coming from the sensors. If they see that there is going to be precipitation, and the road temperatures are below freezing then they know that they need to put salt down. However, if the pavement temperatures are above freezing and are likely to stay there, then salt is not needed.



A Typical Tower at an RWIS Installation

It is now common practice to place the salt on the road at the beginning of the storm event to prevent the formation of ice. By doing so, less salt is required to achieve the same end - safe roads.

Through tools and techniques such as these, the road maintainers can ensure the continued high degree of safety with just the right amount of salt.

Putting the Salt in the Right Place - Salt is placed through the use of spreaders. It is important that the right amount of salt is placed to achieve the objectives - not too much and not too little. New spreader technology is allowing the road maintainer to place exactly the right amount of salt in the correct location regardless of the operating speed of the spreader. Furthermore, electronic spreader controls permit a better understanding

of the amount of salt being used, so that proper applications are documented and wasteful practices can be identified and corrected.

Keeping it on the Road - Salt that is lost to the ditch is wasted. It cannot perform its function of dissolving and preventing the bonding of snow and ice to the road surface if it does not stay on the road. Several techniques are being used to reduce the loss of salt to the side of the roadway. Better distribution techniques such as windrowing on the crown of the road and more accurate spinners are being used. Experiments with zero-velocity spreaders are being carried out. These spreaders blow the salt out in the opposite direction as the vehicle is moving. The salt is discharged at the same speed as the vehicle. Because the salt is traveling in the opposite direction as the spreader, it is not moving in relation to the road. Therefore it is not prone to bouncing off the road. With refinements, these spreaders hold promise.

A more widely used technique for keeping the salt on the road and increasing the speed of the melt action is "Pre-wetting". Pre-wetting involves spraying liquid salt brine onto the solid salt as it is being spread. This has two benefits. The first is that it makes the salt sticky and therefore it stays on the road better. The second is that the salt is already wet and therefore starts to form the brine that is needed to break the ice-road bond more quickly. Studies in the USA show that pre-wetting can increase the retention of salt on the road to 96% as compared to about 70% with dry salt application. Some areas are also experimenting with the use of straight brine application.

Better Salt Handling at Maintenance Yards - Maintenance yards have a high potential for salt loss. This generally comes from unprotected salt or sand/salt piles and spillage during the handling of salt. Salt and sand/salt mixes must be covered to protect them from the elements. Not all road jurisdictions can afford to house all their stockpiles inside buildings. However, even where outside storage is necessary, these stockpiles should be placed on impermeable asphalt or concrete pads and covered with tarps.

Spillage of salt comes during handling operations such as:

- stockpiling the salt at the beginning of the winter;
- creating the sand/salt mixture;
- loading the spreaders;
- spilling salt from over-loaded spreaders;
- unloading residual salt from the spreaders at the end of their runs; and
- washing the spreaders following the storm.

Good housekeeping practices are being put in place by many road authorities to reduce the amount of salt lost during these storage and handling processes.

THE FUTURE

Considerable progress has been made in reducing the amount of salt that has to be used to maintain safe roadways. As more road authorities realize the benefits that can be achieved through improved techniques and technologies, the amount of salt needed to safely maintain a kilometre of road will continue to be optimized.

Research continues into alternative de-icers and there may be a time when other chemicals are cost-effective. In the mean time efforts continue to improve the way in which road salt is managed.

~ FOR MORE INFORMATION ~

More information on the effective management of Road Salt can be obtained from the Transportation Association of Canada at:

2323 Saint Laurent Blvd.
Ottawa, Ontario, Canada, K1G 4J8

Specifically look to the TAC Road Salt Management Guide and the series of Syntheses of Best Practice for Road Salt Management.

www.tac-atc.ca