

## EQUIPMENT IN SCANDINAVIAN COUNTRIES

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### ABSTRACT

Several Scandinavian countries have been experimenting with new and highly promising techniques and systems which have lead to substantial savings in de-icing chemicals without sacrificing the level of roadway service during the winter. Some of these techniques required the development and utilization of equipment such as brine making plants, spreaders for applying liquid salt, and prewetted salt and slush plows. The equipment is summarized.

### INTRODUCTION

In recent years, a number of highway authorities in Scandinavian countries have been warned of the dangers inherent in the overuse of de-icing chemicals. These dangers include damage to the environment, and to vehicles, roads, and bridges. Historically, Scandinavian countries have applied a substantial amount of salt to their roadways to combat the frequent occurrences of black ice, frost, and roadway freezing after precipitation. A number of these countries have been experimenting with new and highly promising techniques and systems which have lead to substantial savings in de-icing chemicals without sacrificing the level of roadway service during the winter.

It has been demonstrated, in some countries, that salt usage can be reduced and the level of service maintained by applying salt quantities as small as  $5 \text{ g/m}^2$  (65 lb/lane-mile) to the roadway surface prior to the formation of a strong ice-pavement bond. Once a bond has developed, the ice is very difficult to remove. If a road is pre-salted, snow will not bond strongly to the surface. Typically, the brine formed at the beginning of a snowfall is absorbed by the salt as snow continues with very little free moisture. The snow can be removed by plowing without leaving a compacted snow-ice layer, but a slush that traffic may disperse.

Salt can be applied as a salt brine in liquid application or as prewetted salt. Grain size distribution of salt used by the various road administrations in the Scandinavian countries is much finer than the salt used in the United States. Based on reports from Sweden and Finland road administrations, most of the salt grain

size used in winter maintenance range from 0.16 to 3 mm (0.006 to 0.12 in) with a low percentage (maximum 5%) below 0.16 mm (0.006 in) and between 3 and 5 mm (0.12 and 0.2 in).

Some of these new and highly promising techniques required the development and utilization of new kinds of equipment such as brine making plants, spreaders for applying liquid salt, and pre-wetted salt and slush plows.

### BRINE PRODUCTION UNITS

With the advent of prewetting salt and using liquid brine, the road authorities had to develop simple brine manufacturing equipment that could operate without any malfunction. There are two types of brine solution plants currently in use for the preparation of the saturated brine. Simple units for a temporary or small scale production can be built from used tanks. Production involves filling a tank with salt and pumping water through the salt until a saturated brine solution is obtained. The production capacity is generally  $8 \text{ m}^3$  (2,113 gal) of solution at a time. The same container is used for production and storage.

For a high capacity production, more efficient units were developed. The road administrations working with private enterprises designed a plant where water is forced under pressure through a bed of salt in a large tank. In Finland, they use compressed air with the water. The saturated solution is then allowed to flow over to a  $10\text{-m}^3$  (2,642-gal) storage receptacle. Manufacturing of brine solution is a continuous process and the amount of salt and water is metered automatically.

The Swedish National Road Administration has developed a set of standard specifications for brine manufacturing plants. Three production rates are contained in the specifications ( $2 \text{ m}^3/\text{hr}$  (528 gal/hr),  $5 \text{ m}^3/\text{hr}$  (1,321 gal/hr), or  $10 \text{ m}^3/\text{hr}$  (2,642 gal/hr)). All these units can load trucks at the rate of 211 gal/min.

When specifying brine manufacturing plants, the road administration recommends that the following items be considered:

- Plan for additional capacity,
- Adequate sources of water,

- Plant site requirements,
- Adequate pump capacity,
- Possible use of earth heat, and
- Tank overflow control.

There are several brine plant manufacturers in the Scandinavian countries. In Sweden, there are two companies and in Norway, four companies manufacture brine plants. In Finland, there are several prototype plants designed by the road administration in addition to manufactured plants. One of the more known manufacturers is Ab Hanson & Möhring of Stockholm. They manufacture module plants. Their most common plant has a production rate of 10 m<sup>3</sup>/hr using a production tank of 8-m<sup>3</sup> (2,113-gal) and a storage tank of 13-m<sup>3</sup> (3,434-gal).

## SPREADERS

There are a number of companies that manufacture spreaders for liquid brine and prewetted salt. In addition, the road administrations have either designed liquid brine spreaders or worked with manufacturers in designing spreaders. For effective preventive treatments, spreaders should apply small controlled quantities of liquid brine and/or prewetted salt with precise control of spreading or spraying patterns. The following manufacturers are only the large companies. There are a number of smaller companies that manufacture equipment for the road administrations.

### Salon in Finland

Salon Terästyö Oy in Salo, Finland, is a highway equipment manufacturing company that produces spreaders and snow plows. Their equipment spreads liquid solution, prewetted salt, and dry salt and sand. The liquid solution spreader, which is mounted on the rear of a truck using a quick mounting system, is a standard for the Finnish National Road Administration. The unit has two liquid spinners that can be adjusted manually to control the asymmetric/symmetry of the spread pattern. The spread width is 2 to 8 m (7 to 26 ft). The liquid is pumped from the supply tank with two hydraulically operated solution pumps. The pumps are controlled with electric clutches and can deliver 520 l/min (145 gal/min). The supply tank is typically a skid-mounted slide-in tank. Salon employs a unique design for the supply tanks, consisting of a two-wall construction of fiberglass, separated by approximately 5 mm (0.2 in) of polyurethane. This design provides for a very strong

tank. The Salon company uses electric remote controls, which are manufactured by Bucher Hydraulik of Klettgau, Germany. These controls, which are custom-designed for the client, provide for ground-speed orientation.

The company also manufactures a combination unit, which can spread either liquid brine or prewetted salt. This unit features a spreading width from 2 to 8 m (7 to 26 ft) and has only one spinner. The liquid pumps discharge up to 260 l/min (68 gal/min) and discharge salt at a rate of 5 to 40 g/m<sup>2</sup> (65 to 520 lb/acre-mile). The unit has a tank capacity of 5-m<sup>3</sup> (6.5-yd<sup>3</sup>). The entire system is a slide-in model that can be loaded and operational within 15 minutes. Hydraulic power for the unit is supplied by the truck. The company also manufactures dry chemical spreaders, which are tailgate-mounted on a dump box. Salon works closely with the Finnish National Road Administration in providing and developing equipment for snow and ice operations.

### Epoke in Denmark

Epoke in Vejle, Denmark, has been manufacturing spreaders for 65 years and has distribution companies in Germany, Sweden and the United States. This company uses a patented metering and delivery system in all their solid-material spreader equipment. All Epoke's bulk spreaders feature hopper boxes where the bottom is closed off with two rubber flaps. One of the bottom flaps is positioned against the delivery roller by adjusting springs. The delivery roller is equipped with replaceable cams, which allow material to pass between the delivery roller and the rubber flap. The cam size can be adapted for all material types and dosage rates. The tightness of the bottom flap is controlled by springs adjusted with a manual crank at the rear of the machine. A scale with sequential markings for continuous increments of spring base tension shows the relative tension. The delivery roller pushes material out of the hopper and onto a rubber conveyor belt located underneath the hopper. An impeller with spring steel paddles located above the delivery roller, is used to pulverize all lumps, distribute the spreading material in the hopper, and feed it to the delivery roller at a constant rate. The conveyor is geared to the speed of the delivery roller so the quantity of material on the conveyor remains the same regardless of the spreading quantity. The impeller, the feed roller, the conveyor belt, and the spinner are all powered by the road wheel. The drive wheel features a piston-type hydraulic pump, which is mounted directly. The drive wheel is under a downward pressure to prevent sliding on icy surfaces. The amount of downward pressure

exerted is controlled automatically by hydraulics according to the power demanded by the spreading function. On spreaders with three- and seven-step gear boxes, the spread width is stated in meters, and the spread quantity is adjusted by change of the stated gears. The spread quantity is also displayed on the control box in grams per square meter. On spreaders with a synchron/9-step gear box, the control box has functions that control both quantity and width. The dosage varies from 5 to 40 g/m<sup>2</sup> (65 to 520 lb/acre-mile) in increments of 5. The spread width can vary from 2 to 12 m (7 to 39 ft) in 1-m (3 ft) increments.

When the spreader is equipped for prewetting, it can apply liquids directly to the material being spread. The system automatically adjusts the flow rate of liquid so that the liquid-to-solid ratio remains constant regardless of change in truck speed, spread quantity, or pattern width. The prewetting system is also equipped with hydraulic controls that automatically reduce the material quantity exiting the conveyor belt by 30% when the liquid system is engaged. Epoke manufactures liquid spreaders incorporating nozzles on a spreading boom. The liquids are sprayed from a low height above the roadway, so that there is negligible influence from air currents or turbulence behind the vehicle that can cause the liquid to blow away. Epoke's SW 2000 model is a tow-behind liquid spreader similar to their TK 12 series truck-mounted liquid spreader. The SW 2000 is designed to be towed by a truck with an existing liquid tank. As the spreader is powered by its own traction-driven wheel, it is road-speed controlled. It can be operated at speeds up to 60 km/hr (37 mph).

Liquid flows by gravity through a clear 75-mm (3-in) plastic hose from the tank to the spreader, where two liquid pumps provide liquid chemical to each nozzle. These two pumps, which are a diaphragm type featuring six diaphragms each, share a common inlet filter. The main spray bar, which is 2,264-mm (89-in) long, is equipped with six nozzles -- three large and three small. The spray bar's main nozzles can achieve 3.5 m (11.5 ft) of spraying coverage. At low speeds, the smaller nozzles are engaged. As the truck's speed increases and the need for liquid increases, the smaller nozzles disengage and the larger nozzles are engaged without a break in spray pattern. As the truck slows, the reverse process occurs and the smaller nozzles engage again. Three additional stainless steel nozzles mounted on the left end of the main spray bar are adjustable so that a spray pattern in the left lane can be maintained. With the side nozzles engaged, a spraying width of 7 m (23 ft) can be obtained. Each side nozzle is pressure regulated for a smooth and even flow, even at slow speeds.

To provide the liquid spreader with a maintenance-free environment, the liquid pumps, valving and electrical components are housed in a steel enclosure. The top covers, which open to provide for inspection and service, are rubber gasketed to prevent contaminants from entering. Also, the steel members of the spreader are sandblasted, zinc dust-primed, second-primed, and surface-coated with two-component polyurethane paint.

### Kupper-Weisser in Germany

Kupper-Weisser, one of the three leading manufacturers of winter maintenance spreader equipment in Europe, is controlled by Kellner (KG), a holding company. Kupper-Weisser has designed and manufactured spreader equipment using modular systems. Because of the multiple capabilities of this system, they can accommodate all multi-use vehicles including trucks, LVDs, Unimogs, narrow-track vehicles and trailers to towed vehicles. Kupper-Weisser manufactures highway chemical spreader equipment (dry, prewetted, and liquid material), pumps and controls for mixing salt brine, and modular diesel engine with hydraulics. The typical winter maintenance spreader sizes that are manufactured by Kupper-Weisser are salt hopper boxes (6 to 9-m<sup>3</sup> (8 to 12-yd<sup>3</sup>)) and liquid salt tanks (2,500-l (660-gal)). The size of the spinner is based on the desired spread width: 12 m (39 ft) spread needs an 800-mm (32-in) disk; and, 2 to 6 m (7 to 20 ft) spread needs a 600-mm (24-in) disk. If chemical is to be applied to three lanes (16 m (53 ft)) at once, dual spinners are required. Material is metered by a large, open steel helical auger. Parallel to the auger is another shaft with fingers to break up lumps. The material is delivered to a chute at the rear where it is dropped onto a spinner disk. The patented spinner has a series of three different radii that give the disk an almost triangular configuration. This shape provides different lengths of curved vanes or fins that control spread patterns on the roadway. The chute and spinner assembly is rotated to change the direction of the pattern.

Air turbulence behind the spreader vehicle may cause drifts and swirls in the salt leaving the spinner disk. To address this problem, Kupper-Weisser has a patented wind deflector mounted just behind the hopper box and projecting above it. The slip stream is deflected onto the roadway behind the spreader vehicle. Besides spreaders that can prewet salt, the company offers a unit that can be switched from prewetting to spreading of liquid chemicals. This unit has a hopper box with a capacity of 6-m<sup>3</sup> (8-yd<sup>3</sup>) and two polyester tanks

mounted underneath the side walls of the hopper, with a total capacity of approximately 2,000-l (528-gal). The range of the spread density for liquid application is 10 to 15 g/m<sup>2</sup> (130 to 195 lb/acre-mile), and the spread width is 2 to 7 m (7 to 23 ft).

## SNOW PLOWS

There are many varieties of plows including one-way front plows, reversible plows, underbody plows, side wings and slush removal plows. All of the plows are hydraulically controlled. It takes only minutes to mount and unmount the plows using the quick-change buffer system. Hydraulically extendable plows have recently been developed in Finland. The width of the plow can be extended on the left or right-hand side, depending on the manufacture. These plows are best suited to roads that vary in width. The extendable plow allows width adjustment between 2.8 and 3.5 m (9.2 and 11.5 ft). Side wing plows can be attached to trucks and motor graders. The one-way front plow and the underbody plow can be used simultaneously with the side wing. The side wings are used when the width of the roadway is more than 7 m (23 ft). The side wing is also used for lowering snowbanks and for pushing the banks away from road surfaces.

Motor graders utilize a large variety of accessories such as side wing plows, snow cast extensions and smaller main blade extensions to cast snow over snowbanks, side ditch cleaning wings for lowering snow banks, bulldozer blades to clean intersections, snow blowers to cast the windrow over the snowbanks, snowstop flanges to prevent windrows at intersections and driveways, and blades for slush removal.

The Swedish National Road Administration tests and evaluates both front and side wing plows. They are tested by plowing snow depths of 30-cm (12-in), 60-cm (24-in) and 120-cm (47-in) at speeds varying from 20 to 40 km/hr (12 to 25 mile/hr) at temperatures of 0° C (32° F) and -2° C (28° F). The height and length of the throw are measured. Also, the plows are evaluated as to sound level, splash protection, handling, and ease of hooking up the plow to the unit.

## SLUSH PLOWS

During the winter months in these countries, they experience long periods when the sun hardly rises in the sky and the relative humidity stays between 93 and 99

percent. Under these conditions, the roadway tends to stay wet. When slush develops from salting and plowing, the slush does not dry and must be plowed. Therefore, the combination of the rutting of the roadway surface by studded tires and salting has made the slush plow very important. Roads with slushy conditions are more dangerous for the traveling public than bare and dry conditions. These conditions require slush removal equipment consisting normally of double blade and/or rubber blade plows. The double blade plows are very good when the consistency of slush varies from wet to dry. Rubber blades can only efficiently remove wet slush. The wetter the slush, the thicker the rubber blade can be. The slush blades are either spring loaded or hydraulically controlled to maintain pressure on the road surface regardless of the deep ruts. These plows cannot remove wet or compacted snow because the rubber edges cannot withstand the pressure. Normal plows, motor grader blades, and underbody blades can be equipped with rubber edges.

The Norwegian Public Road Administration has developed a slush trailer that is very effective in clearing slush from the roads. This trailer has been equipped with ice blades, slush blades, and a brush. The brush is powered from a diesel engine mounted on the trailer. This produces a clean road surface. Traditionally, slush removal was accomplished with front-mounted truck equipment. However, the results from this trailer are so effective they are now building additional units. Plans include the attachment of a rear salt sprayer fed from a tank on the trailer. The only negative aspect of this new type of slush plow is its size and that it needs plenty of room to turn. However, this equipment is primarily intended for use on highways where its size will not be a problem.

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