

SNOW CLEARANCE ON RAILWAYS

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ABSTRACT. The prevention of snow accumulation on the tracks of railways in Great Britain. Various methods of removal, once lines have been blocked, are discussed in the light of the comparatively small snowfalls in the British Isles.

ZUSAMMENFASSUNG. Das Verhindern von Schneeanhäufungen auf Eisenbahngleisen in Grossbritannien. Es werden verschiedene Methoden besprochen, um blockierte Eisenbahnlinien von Schnee zu reinigen im Hinblick auf den verhältnismässig geringen Schneefall in Grossbritannien.

It can hardly be doubted that snow clearance on British railways would be more efficient if the climate were more severe. In northern Scotland, where snow is usual every winter, the staff are trained to deal with it and to prevent blockage of lines. Consequently, there is usually less trouble and delay in the north than in England where a severe winter is a rare event.

The equipment in Scotland is fairly adequate; it is operated by an experienced staff, and operating methods are modified to suit conditions as soon as snow begins to fall. In England, equipment is only adequate for an average winter and is insufficient to deal with a heavy fall. Normal operating methods are often continued too long after the commencement of a snowfall, consequently stalled trains and blocked lines ensue in conditions which would not hold up traffic in the Highlands. This is not due to the greater stupidity of the English, as Scotsmen may think, but rather comes from inexperience. When snow ploughs and the like are called out they may be operated by staff unused to the job and unable to obtain the service of which the equipment is capable. Furthermore, these conditions militate against the provision of more plant. Its supply would be uneconomic, and, if provided, the lack of experienced operators would be severely felt.

Professor D. Brunt, in a paper entitled "Winter Conditions and the Civil Engineer, Meteorological Aspects" read before the Institution of Civil Engineers on 20 January 1948, pointed out that in the past 100 years only eight winters had two consecutive months with mean temperatures of 35° F. (1.7° C.) or lower at Greenwich, and only fifteen winters with one month having a mean temperature of 35° F. or lower. The number of days with the lower temperatures varied from 17 to 60 per winter.

The number of winters in a century in which at least 20, 30, 40, 50 or 60 days had had a mean temperature of 35° F. or lower was as follows:

Days below 35° F.	20	30	40	50	60
Frequency	19	14	10	6	1

Thus, one winter in seven has 30 or more very cold days, and about one in five has as many as 20 very cold days.

It is not always the coldest years which give the heaviest snowfall. Mr. L. C. W. Bonacina analysed the winters of the 60 years 1876–1935 and classified 24 as snowy, 18 as ordinary and 18 as snowless. It appears that about one winter in three is liable to be snowy in some part of Great Britain and about one in four is liable to be snowy in England. The recurrence of snowy winters is very irregular. Six of the last eleven winters have been snowy. Of the snowy years, only three appear among the eight winters with two consecutive months of very cold weather, and in addition four snowy winters occur in the fifteen with one month having a mean temperature of 35° F. or less.

Snowfall can be classified by the railway engineer under three main headings:

- (i) Fall without drifting
- (ii) Fall with drifting
- (iii) Fall adhering to wires, etc. (glazed frost or "silver thaw")

(i) Snowfall without drifting is the least harmful and causes least delay to traffic. The fall is

rarely more than a few inches in depth and if switches can be kept clear, little interruption to traffic occurs except for slow running during the period of fall, when delays may be caused like those due to fog. The permanent way staff are at their fogging posts, signalling trains by flag and detonator, and thus informing the driver of the position of the fixed signals he cannot see. Until the end of the fall, therefore, there may be difficulty in finding manpower to keep points clear, but there is rarely much delay, and when the fall ceases conditions rapidly become normal.

As this type of snowfall is frequently damp, melting is accelerated and manpower saved by the use of salt or large blow lamps, which melt the snow on the slide chairs and keep the switches working freely. On parts of the system liable to heavy snowfall, special slide chairs support the switches. These contain a recess filled from time to time with a non-freeze compound. The movement of the switch blade across the recess smears the composition on the slide and this in turn prevents snow accumulating. Several thousand of these chairs were in use on the L.M.S. before nationalization.

On London Transport lines in the open, which carry intensive traffic, many slide chairs are heated by the circulation of hot oil warmed by an electric current. Experiments with electric heating of slide chairs have been made on the L.M.S., but it is doubtful if a case can be made for this except on electrified lines.

On railways in Canada and the United States, it is regular practice to install switch rail heaters, consisting of long-burning lamps, the flame of which heats the switch and stock rails and melts adjacent snow. The fuel in the heaters is replenished from time to time.

(ii) Snowfall accompanied by drifting is the type most dreaded by railway engineering and operating staff. It is the usual condition accompanying the heavier falls and may lead to serious interruption of traffic. Snow may drift in such large quantities as to overpower the special devices mentioned for keeping the switches clear, so that points have to be swept before each movement.

A railway is seldom constructed on the natural ground level for any distance and a cutting is liable to be blocked by snow. Shallow cuttings generally remain clear if the slopes are flattened to, say, 10 to 1; but this is seldom permissible in Great Britain owing to the large additional area of land required, apart from the increase in the quantity of excavation. In European countries, with a more severe climate than here, it is standard practice in cuttings up to a depth of 1 to 2 metres.

In Russia, particularly in the flat steppe country, railways are frequently constructed on low banks, 2-3 ft. (0.6-0.9 m.) in height, to obtain wind scour and to obviate snow drifts across the formation. The slopes in shallow cuttings are flattened as mentioned above. Russian engineers definitely stated, in the days when information from Russia was available, that deep cuttings of, say, 20 ft. (6 m.) become filled very slowly and that those of 30 ft. (9 m.) or over very rarely become blocked. On a number of lines, such cuttings are not protected by snow fences. This is not our experience in Great Britain, where it is difficult to keep cuttings of all depths free of snow. The difference may be due to the snow here being more moist and heavier and possibly not driven by high winds.

To keep the line open at places where experience has shown that drifts occur, the provision of a snow fence is standard practice. The L.M.S. maintained almost 35 miles (56 km.) of these structures. Originally, they were made of second-hand sleepers removed from the track, erected vertically with spaces of 1 or 2 in. (2.5-5.0 cm.) between each sleeper. When timber became scarce, the construction was modified into one of vertical sleepers spaced 8 to 14 ft. (2.4-4.3 m.) centres and carrying two timber horizontal rails, to which in turn were nailed "backs," offcuts from tree trunks converted into scantlings at saw mills. The "backs" may be edged or in some cases cut parallel, and spaced 1 to 2 in. apart as before. Sheep passes, 2 ft. 9 in. (83 cm.) square, are provided through the fence as required. The fence should be erected at least 50 ft. (15 m.) from the top of the slope of the cutting and preferably at a distance of 100 ft. Close boarded fences accumulate snow on the windward side till completely filled and thus have to resist considerable

lateral thrust. But the provision of spaces permits part of the drifting snow to filter through the fence to leeward, thus increasing its storage capacity and reducing lateral pressure upon it. On the open moorland in the Highlands, permission to erect such fences outside the railway boundary can usually be obtained at reasonable cost, as their presence does not diminish the value of the land. In areas under cultivation it is as a rule only possible to erect the snow fence on the railway boundary, which is nearly always too near the cutting slope to give adequate protection.

Snow fences are usually erected in a line roughly parallel to the railways but approaching closer to the line towards the ends of the cutting where the fence is also diminished in height. Some fences have been laid out with a serrated plan, the side of the serration being say 14 ft. (4.3 m.) long, and its depth at right angles to the general line of the fence being about 4 ft. 6 in. (1.4 m.). Some experienced engineers consider this design more efficient and stronger.

It is interesting to note that the most southerly snow fence on the L.M.S. system is at Crewe station.

In Great Britain, a fence of the type described, 6-7 ft. (1.8-2.0 m.) in height, is usually sufficient. In other countries with greater snowfall, higher barriers are provided. These vary from stone walls 5 metres high in Hungary, to long continuous sheds through which the trains run in Norway and the Alps.

In a number of countries snow is kept off the line by special plantations of trees or bushes parallel to the track, or in echelon if the snow-drifting wind is at an acute angle to the railway. The old-fashioned quick-thorn hedge was a reasonably efficient snow screen, but usually could not be grown in country very exposed to drifting snow.

Other countries, for example Denmark, developed a portable snow fence which was erected each year outside the railway boundary to check drifting snow, and removed in the spring when field work on the farmland began. In Russia, this idea was developed further; after the fence had collected a drift to about its own height and before it had become buried, it was lifted to the top of the drift that had formed and a fresh cycle of accumulation began. In exposed sites, seven or eight settings are possible, and as this type, which resembles an ordinary slatted fence, is from 3 ft. 6 in. to 5 ft. (1.1 to 1.5 m.) in height, a very large quantity of snow is collected.

The foregoing precautions are taken to prevent snow from lying on the track. To free the track from snow which has drifted upon it, the usual tool is the plough, either attached direct to a locomotive or built as a separate vehicle.

On the L.M.S. all engines running over the Grampians north of Perth are fitted with a small nose plough attached to the front buffer plank at the beginning of winter. This ensures that all trains can do a certain amount of clearance, and a double-headed train with a load reduced by, say, 50 per cent. can run steadily through snow 2 ft. (60 cm.) deep with a nose plough.

A larger plough is also used. This, too, is bolted to the engine front, but slopes up to approximately the top of the boiler. This is run separately to keep the line open when snow is drifting, and the plough engine is backed up with one or two additional locomotives as pushers. Two engines with this equipment can plough steadily through 5 ft. (1.5 m.) of snow and up to 12 ft. (3.6 m.) by charging the drift at speed. It is essential to charge drifts at speeds of 35-45 m.p.h. (56-72 km.) in order to obtain the maximum kinetic energy and lift and throw the snow. At low speeds the snow is merely compressed.

Rock cuttings with steep sides are almost impossible to clear by ploughing alone. The snow must be cross-trenched and may have to be dug out by hand.

A deep cutting partially filled generally has a snow cornice overhanging to leeward. As, in that case, the resistance to a plough would be all, or practically all, on one side, derailment would occur if the drift were charged; the snow, therefore, has to be dug out. The cornice may render it dangerous to do this by hand and mechanical navvies have been used to cut off the cornice as well as to assist in loading up the main body of the drift.

As a result of experience gained during the winter of 1946-47, modifications of the design of snow ploughs have been suggested, and after the next severe snowfall I expect British Railways will endeavour to work out standards on a system-wide basis.

For medium and large ploughs used to clear drifts, the outer edges of the ploughing surface should be of retractable or flap design for a width of 6 in. (15 cm.). This would ease extraction of the plough by reversing after sticking and not cause a "fall in" of the snow which frequently causes a block if not a derailment. Ploughs operating back to back should run with the trailing plough retracted.

Lubrication of the plough face would be valuable. Snow in certain conditions adheres to the steel face plate, but if oil could be steam sprayed over it it would prevent adhesion.

Extensive trials have been made of the use of aeroplane jet engines to blow snow off the line. With dry snow the results were good, but snow which had thawed and re-frozen could not be handled with any reasonable speed and the performance generally was inferior to ploughs and the cost of operation much greater.

The use of rotary ploughs is always advocated after a heavy snowfall and what is said to be American experience is cited. These tools work best in dry snow, which is not the usual British type. In Canada and the United States rotaries are not used where the snow tends to be wet and heavy. Their use in Great Britain would be uneconomic as the machines are extremely costly and the infrequency of their use, if they were available, would also militate against their performance.

Flame throwers were tried but were only useful for small jobs, clearing switches, etc. It must be borne in mind that the melting of large quantities of snow on the line would raise acute problems of water disposal. The surface of the ground would probably be frost-bound, thus natural drainage would be impeded and if the formation were water-logged and subsequently frozen, heaving of the track might render it unsafe. An example is the trouble experienced in maintaining track in frosty weather alongside and near track troughs. In the winter of 1946-47, one set of L.M.S. troughs alone needed 100 men working day and night in an attempt to keep them usable. After some days of successful operation, the track was frost heaved by spillage to such an extent that trains had to be slowed to a low speed and were, therefore, unable to pick up water.

(iii) The third type of snowfall which adheres to wires or produces glazed frost affects the signal and telegraph engineer more than the civil engineer. In severe cases it breaks down signal, telephone and telegraph wires and causes serious interruption to communications. Railway operating depends more and more on the telephone and a breakdown has serious results. Other signalling troubles are caused by signal mechanisms which operate wires and rods freezing to the ballast or pulleys, thus rendering points and signals immovable. This may cause an accident if operators do not use good judgment in carrying out their duties. As a rule a fall of this kind is not heavy, so that frozen mechanism is soon released, but the repair of line wires may take months, especially if many poles are broken. Fortunately this is a relatively rare occurrence and if the railways are now permitted to develop wireless telephony and telegraphy they will be less dependent on their wire network.

This third type of snowfall is very serious to electric railways with third-rail current supply. Ice is an exceedingly good insulator and it must be kept off the rail head or other contact surface. When a fall of this kind occurs, special rail cleaning vehicles are kept running over the line with ice cutters or steel brushes. Recently London Transport has developed an apparatus whereby the current-collecting shoe makes contact with a ball or cylinder in a reservoir on the centre line of the live rail which contains an anti-freeze liquid. This is distributed along the live rail head by the shoes and thus prevents ice formation. It will be interesting to see if the extensive suburban electrification of the Eastern Region of British Railways with overhead current collection suffers from ice or snow incrustation. Existing installations at Manchester and Lancaster appear to be almost entirely free from trouble due to this cause.

DISCUSSION

The CHAIRMAN (Mr. W. H. Ward) opened the meeting for discussion.

Air-Commodore DAVID LUCKING (Ministry of Civil Aviation) asked what was the theoretical basis for setting a snow fence back from the permanent way and for determining its height.

Mr. WALLACE said that it was largely a matter of experience, but normally the fence would be erected about 50 ft. (15 m.) away. The fences were usually built from old sleepers and their height was 7 ft. (2 m.).

Mr. L. C. W. BONACINA said that Mr. Wallace had spoken of the relative infrequency of dry snow in this country, but he thought it should be realized that snow needed only to be slightly below the freezing point to be sufficiently dry and powdery to drift. This explained why so much trouble was experienced on the roads and railways. He thought, too, that road and railway engineers should have in mind the fact that snow was highly methodical in its manner of drifting. Accumulations tended to form at the same spots and to die hard at these points. If their surroundings were carefully studied in relation to windward and leeward obstacles, much knowledge and experience of practical value would be gleaned.

Mr. WALLACE replied that much information on the subject had been given at one of the international railway congresses by the Russians, but in their country the snow was very much drier than in this and remained dry, while here the chief troubles occurred with drifted wet snow. In this country the fences were usually erected where drifting was most frequent, but often after a succession of mild winters they fell into disrepair. Therefore with the sudden advent of a severe winter preparations were inadequate.

Mr. BONACINA said he agreed with Mr. Wallace that the Scots had, of necessity, to be more expeditious in snow clearing than the English and were thus less afraid of charging major drifts with snow ploughs, but on occasion conditions could be equally severe in the south. No experiences in the whole history of the British railways had been worse than those which resulted from the blizzard of dry snow which overwhelmed the south-west of England in March 1891. Scores of trains throughout Devonshire and Cornwall had been almost buried out of sight. A branch line train on the high moors near Princetown had been noticed by a passing farmer with its carriages filled to the hat-racks with snow, and only the timely arrival of horsemen had rescued the passengers from starvation. Similarly a main line express from Paddington had been marooned for nearly a week at the moorland station of Brent, between Exeter and Plymouth, and no news of the fact had reached London for some days owing to the collapse of the telegraph wires.

Mr. FRANKLIN B. STERN (U.S.A. and Oslo University) reminded Mr. Wallace that he had said that experience was one of the ways in which it was decided where to erect fences. He asked whether the number of locomotives used for hauling a train through snow drifts was also decided by experience or was there some correlation between the depth of snow and its density and the number of cars the locomotives were hauling.

Mr. WALLACE replied that in Scotland the permanent way staff lived in groups of houses all along the lines and they reported snow falls and drifts to the District Engineer at headquarters in Inverness. With these reports as to how much and what type of snow was likely to be experienced, it was decided on how much load and how many engines would be required, and also whether to send out snow ploughs.

Mr. N. S. ROBINSON (Railway Executive Headquarters Staff) said that Mr. Wallace had explained that in Russia open snow fences were erected to cause snow to be drifted in long heaped-up ridges. He had described how the fences were then lifted bodily to the top of a ridge, causing

the mound to be enlarged, eventually reaching a height of as much as 25 ft. (7.6 m.). This method had reminded the speaker of a paper on stabilization of sand dunes recently read at the Institution of Civil Engineers. A precisely similar process had been described for encouraging the formation of sand dunes in coast protection work.

Mr. A. J. WHITEN suggested that the system of growing plantations to act as snow barriers adopted in some European countries could usefully be extended to this country. Quite apart from the aesthetic point of view he considered it would be more efficient and economical in the long run, as it would be largely self-maintaining. Methods had also been described for the prevention of snow drifting across a railway cutting, but there seemed to be no protection against winds blowing along a cutting. This, though of rarer occurrence, would seem to present a more difficult problem.

Mr. WALLACE said that plantations if grown for protection purposes would often be on private property. The cost of maintaining them was high because of frequent fires in dry summers. He had never known snow to drift along a cutting.

Mr. A. MOSS (Signal and Telegraph Department, British Railways) agreed with the view that wet snow was particularly troublesome to the signal and telegraph engineers. The complete dislocation over a wide area of the communication system could have disastrous effects on the working of a railway. Most of the discussion had centred on the heavy falls of snow where drifts had completely blocked and filled up cuttings. He had experienced many such occurrences on the late West Highland and Great North of Scotland Railways and also in the border counties, all of which were particularly susceptible to snow blocks. Considerable trouble was caused by comparatively light falls of snow, particularly where there was a concentration of points. Perhaps Mr. Wallace could tell them whether the method used in other countries of fitting heaters in the switch slide chairs was an efficient way of dealing with this problem. He also asked what were the objections to the use of a rotary type of snow plough, as he could not recollect ever having seen one in use on British railways.

Mr. Wallace replied that heated switches had been tried on a certain line on high ground in Derbyshire, but it had been decided that they could not be justified economically. Instead they used chairs which had recesses in them filled with an anti-freezing mixture, "Killfrost" or some similar product. London Transport Executive had gone a great deal further with heating their slide chairs by hot oil circulation, but this would only be economic on lines with very dense traffic. In America they depended largely on long thin metal boxes with jet burners which heated the rails. With regard to rotary snow ploughs, Mr. Wallace said that these were very expensive and costly to run as they had to be driven by engines of about 150 to 200 h.p. The number of severe winters in this country had not as yet seemed to justify the expense. Also, it was very rare that the snow in this country was dry enough for a rotary plough. The Canadian Pacific and Canadian National Railways had told him that they did not like rotaries working in wet snow. In America these ploughs were used for clearing big motor roads in the Rocky Mountains and other high districts but not in the eastern states. On the New York Central Railway Russell ploughs were used. Rotary ploughs were used in Europe where the snow was drier and persisted for longer periods.

Mr. G. SELIGMAN said that he had recently heard of a Canadian apparatus made on the principle of the rotary plough but having a set of knives revolving like a disk harrow and cutting the snow into slices and shooting it out by means of a fan. This seemed to be a cheaper contrivance than the ordinary rotary plough.

Mr. J. S. WILSON (Road Research Laboratory, West Drayton) said that for general road work, blade ploughs fitted with heavy duty trucks were preferred, since they could be run at speeds up to 45 m.p.h. and at this speed normally threw snow, 2-3 ft. deep, well clear of the roadway. Further, by repeatedly "slamming" the deep drifts they could nearly always force a break-through.

The blower ploughs, referred to by Mr. Seligman, could only be fed into the drifts at the speed at which the rotors could get the snow away. They were, however, used for clearing up work and for widening after a blade plough. More commonly they were used on airfields because they dispersed the snow and did not leave it in ridges which might encourage the formation of further drifts in a later fall. Certain models, fitted with easily controlled hoods for directing the blown snow, were popular in some cities for loading into lorries snow which had been swept into banks at the side of the streets by blade ploughs. With regard to the measurements which indicated that blower-type ploughs had a low mechanical efficiency, attempts had been made to offset this by increasing the engine horsepower of the blower rather than by considering the design of the blower mechanism itself. Modern machines of this type had engines of 200–250 h.p. to drive the blower units.

Mr. C. G. REDDINGTON (District Engineer, Ipswich) referred to excavators being used to cut away cornices obstructing the line and asked whether bulldozers had ever been used to clear away snow.

Mr. WALLACE said bulldozers had not been used, as a non-railborne vehicle was difficult to handle on a railway. What was required was for the snow to be lifted and thrown to one side, and this could not be done with a bulldozer. A great many methods of snow clearance had been suggested from time to time including schemes for melting the snow quickly, but it was extremely undesirable to have water lying about unable to drain away. In America they had used melters to remove snow from platforms in localities where quick drainage of the melt water was practicable. In New York City bulldozers were used to clear the snow into manholes and the water drained away into the sewers which never reached freezing point.

Dr. B. B. ROBERTS (Scott Polar Research Institute) asked whether there had been any application in this country of the principle of “funneling” the wind to produce an accelerated “blow-out” effect with suitably placed wind barriers. This method was said to be effective with encroaching sand dunes. Many cases had also arisen in Polar regions where it had been convenient to arrange for the wind to remove snow which would otherwise have drifted into sheltered positions, such as doorways or passages between houses.

Mr. WALLACE said that in the Highlands a sheeted “blower” fence had been tried, the theory being that the wind would blow the snow across and away. Unfortunately these fences often caught fire in the summer and during the war lack of timber prevented their replacement. An ordinary snow fence was found to be better.

F/Lt. R. TREWEEKS, R.A.F., asked whether, when dealing with dry snow, jet blowers were an economical form of snow clearance in preference to ploughs and what was the maximum depth of snow at which they could be used.

Mr. WALLACE said that in his experience the jet blowers did not clear more than 3–4 ft. (0.9–1.2 m.) of snow and often as a result of partial thaw and re-freezing the jets merely blew holes in the solid snow and did not clear it away. Jet blowers had no kinetic energy as had the snow plough and were not considered an economical form of clearance.

The CHAIRMAN, concluding the discussion, said that those who were interested in snow just for the sake of it would realize that engineers had some very difficult problems; clearly one of the most difficult was organizing the men and plant and transporting it all to the right place at the right time. He thanked Mr. Wallace for his instructive lecture which the discussion had shown to be of the greatest interest to members of the Society and to the many visitors representing the Railways and Civil Engineering groups.