—Overview and analysis of accident investigation cases—

# Japan Transport Safety Board DIGESTS

JTSB (Japan Transport Safety Board) DIGESTS

Number 46 (issued in November, 2024)

Railway Accident Analysis Report

# Preventing railway accidents caused by snow



## 1. Introduction

Railway routes are laid out across Japan and serve as an indispensable means of transportation even under various adverse weather conditions. During snowfall and snow accumulation, necessary arrangements, such as that for snow removal, are taken according to the characteristics of each route, and in recent years planned train service cancellations have also been implemented.

From October 2001 through March 2024, the former Aircraft and Railway Accidents Investigation Commission and the Japan Transport Safety Board (JTSB) have published a total of 404 accident investigation reports regarding railway accidents and serious incidents (hereinafter referred to as "accidents") investigated by them. Of accidents reported in these reports, 34 cases of accidents were attributed to snow or snowmelt, and looking at occurrences by cold-season-centered year (the period from August 1 of the preceding year to July 31 of the reference year), there is a tendency for the number of accidents to increase in regions hit by record or near-record heavy snowfall. Furthermore, under similar conditions, accidents also occurred in regions that do not usually experience much snow.

Some of these accident investigation reports point out human factors and organizational factors, indicating that responses by individuals or organizations to the rare situation of snow were not sufficient.

This digest aims to contribute to the prevention of accidents caused by snow, and introduces classifications and characteristics of situations where accidents caused by snow occurred, human and organizational factors, and specific countermeasures based on individual accident investigation cases. We hope this digest will be useful for understanding the nature of accidents during snowfall and snow accumulation and for considering route-specific organizational arrangements.

The left photo shows an unplowed track (level crossing) as seen from a train. Ruts where vehicles have passed through the snow on the road can be seen from the left toward the center of the photo. (From a railway accident investigation report)
The right photo shows the same level crossing without snow as seen from the road.

## 2. Situations where accidents caused by snow and snowmelt occurred

### (1) Classification of causes of accidents due to weather, etc.

As mentioned above, from October 2001 to March 2024, a total of 404 accident investigation reports have been published. Of accidents covered by these reports, 87 cases were caused by weather or related factors, accounting for about 20% of the total. Looking at the breakdown of weather-related factors, etc. (Figure 1), snow and snowmelt (hereinafter referred to as "snow, etc.") accounted for a total of 34 cases, accounting for about 40%, indicating that these phenomena have a major impact on railway operations and require attention. In addition, other factors include rain (23 cases: rockfalls and slope collapses due to rain, rise in river water levels, etc.), weathering (12 cases: rockfalls and slope collapses, etc.), and earthquake (10 cases). Wind-related factors are relatively few, totaling six cases for strong winds and gusts such as tornadoes.

In the 10-year period from 2013 to 2022, the total number of accidents investigated was 168 cases, of which 27 cases were attributed to weather or related factors, accounting for about 16% of the total, which is relatively few. However, looking at the breakdown of weather-related factors, etc., those caused by snow, etc., totaled nine cases, remaining the most common, followed by rain with eight cases.

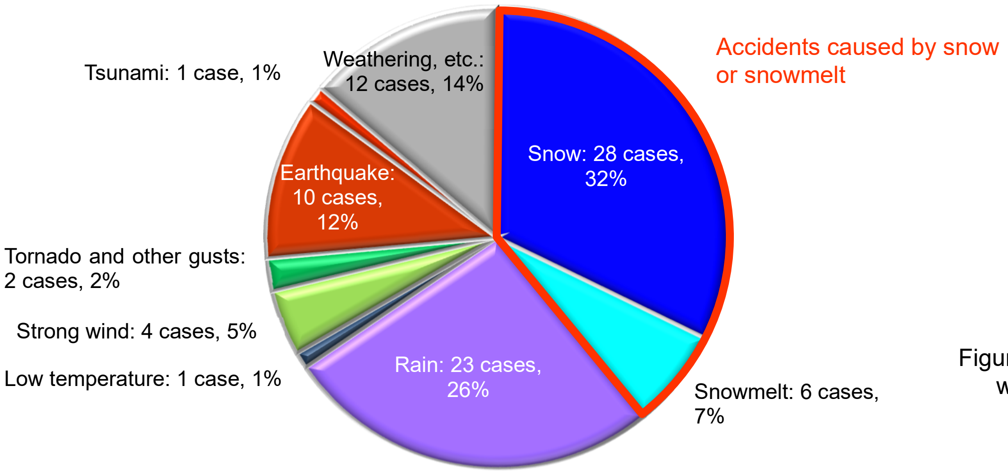


Figure 1: Breakdown of weather-related factors, etc.

### (2) Classification of situations where accidents caused by snow, etc. occurred

Looking at the breakdown of accidents caused by snow, etc., by accident type (Figure 2), about 90% were train derailments, and, for the causes of train derailment accidents (Figure 3), 90% were due to flange climbing. The objects that were climbed up (Figure 4) were most frequently caught snow (snow accumulated around bogies and underfloor equipment after accumulating on the track and being picked up by the running train) and compacted snow at level crossings (compacted snow in flangeways, gaps between closely adjacent rail heads through which wheel flanges pass, of a level crossing), both of which fall under the factor of "snow" in Figure 1.

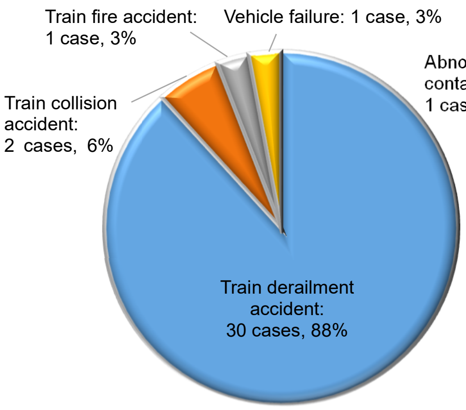


Figure 2: Breakdown of types of accidents

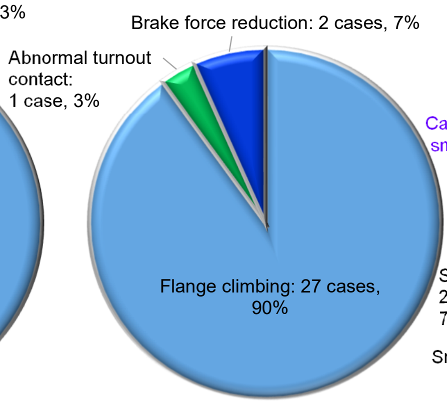


Figure 3: Breakdown of causes of derailment accidents

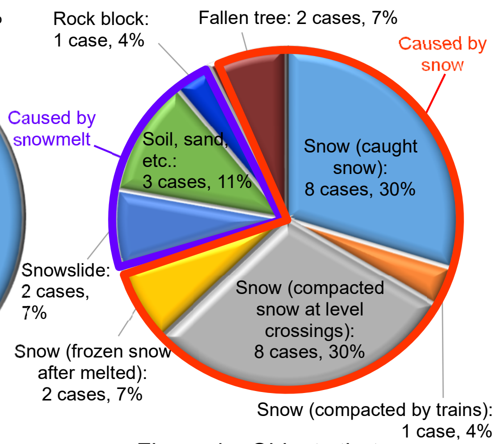


Figure 4: Objects that were climbed up

## (3) Situations where accidents occurred by cold-season-centered year and by month

Looking at the number of accidents caused by snow, etc., (34 cases in total) by cold-season-centered year (Figure 5), there is a tendency for the number of accidents to particularly increase in years with heavy snowfall. During the 2006 heavy snowfall (the heavy snowfall from December 2005 to early January 2006), which brought record-breaking heavy snow over a wide area, accidents occurred in many places from Hokkaido to the Hokuriku region. In addition, in the cold-season-centered year of 2012 when Hokkaido experienced heavy snowfall, accidents were concentrated in the areas that had heavy snow, including areas outside Hokkaido. Looking at the classification of situations where accidents occurred, although since the cold-season-centered year of 2014, there have been no accidents caused by caught snow, accidents due to compacted snow at level crossings account for about 30% of all accidents, and the most recent occurrence was in 2022 (see page 6 for compacted snow at level crossings).

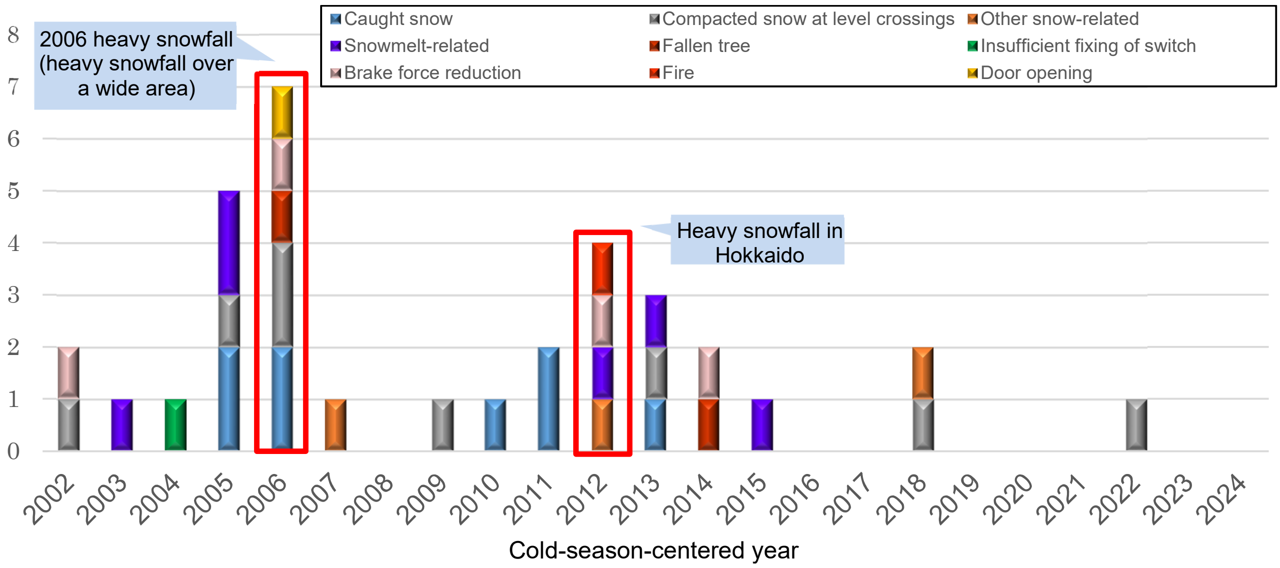


Figure 5: Situations where accidents caused by snow, etc. occurred by cold-season-centered year

As for the number of accidents by month (Figure 6), accidents caused by snow occur frequently in January and February, while accidents caused by snowmelt are concentrated in March and April. Since accidents caused by compacted snow at level crossings begin to occur in December, caution is required from early in the snowfall season.

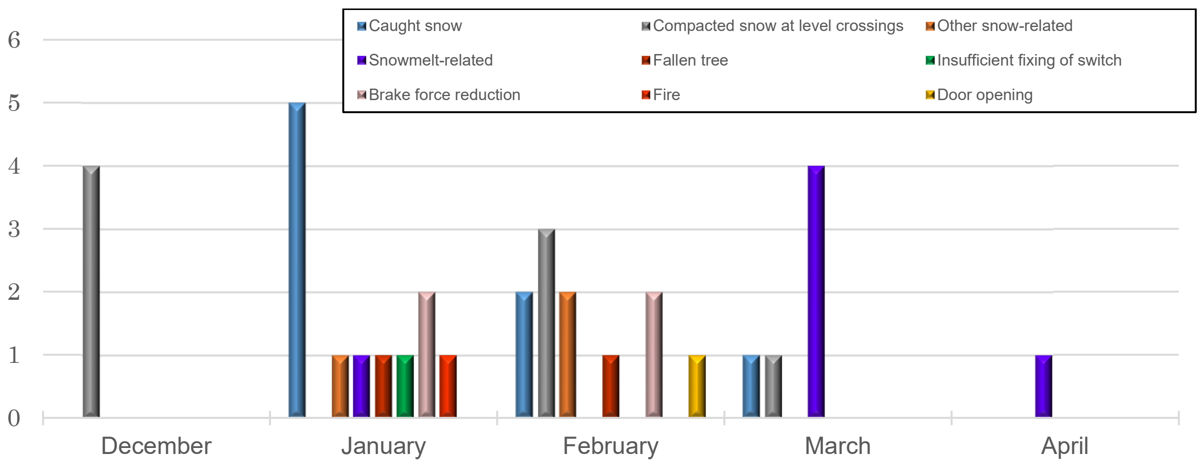


Figure 6: Situations where accidents caused by snow, etc. occurred by month

## (4) Locations, situations, etc. where accidents occurred

About 90% of the accidents caused by snow, etc., occurred in heavy snowfall areas or special heavy-snowfall areas (areas designated under the Act on Special Measures concerning Countermeasures for Areas of Heavy Snow, hereinafter referred to as "heavy snowfall areas, etc.") (Figure 7). Four accidents occurred even in areas other than heavy snowfall areas, etc. (hereinafter referred to as "low-snowfall areas"), and three of them occurred in areas that experienced record or near-record heavy snowfall from the day before to the day of the accident. In such areas, because accidents caused by snow, etc., are themselves rare, accidents that occurred in the past are considered to be important lessons for preventing recurrence in the future (see page 10).

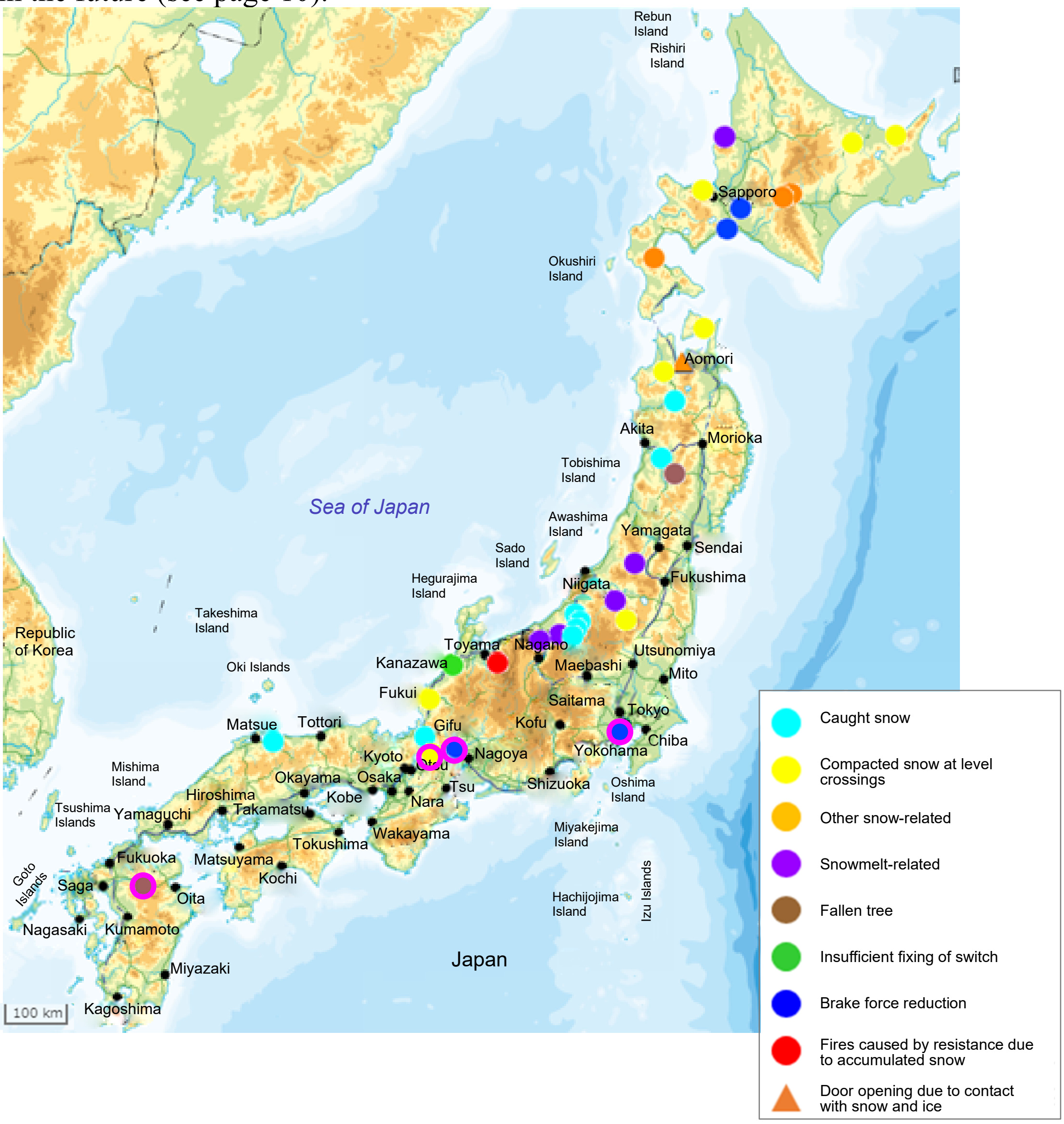


Figure 7: Locations where accidents caused by snow, etc. occurred

Created using the Geospatial Information Authority of Japan's GSI Maps (web maps).
Pink circles (○) indicate accidents that occurred in low-snowfall areas.

Among the accidents caused by snow, etc. (34 cases in total), there were cases in which human and/or organizational factors were also involved. To cite some examples, there were eight cases where human factors related to organizational problems in snow removal, decisions on its implementation, etc., were involved (see page 12), four cases related to slope inspections, measures against falling rocks, temporary slope inspections (enhanced train patrols, etc., when temperatures continue to rise when snow has been accumulated), etc., and three cases where human factors such as inappropriate use of snow brakes by a driver when the train was running (see pages 5 and 12) were involved.

## Column

# Measures for the prevention of railway operation accidents during snowfall and snow accumulation, etc.

Railway operators have made numerous efforts related to snowfall and snow accumulation to prevent railway operation accidents caused by snow. We spoke with East Japan Railway Company about their efforts, which are introduced below.

Major efforts at East Japan Railway Company

### (1) Efforts for safe and stable transportation during snowfall and snow accumulation

In the Tokyo metropolitan area, there is a risk that switches fail to operate after snow has accumulated in the gaps of switches during snowfall. To prevent this, trains are operated at regular intervals. In addition, after the last scheduled service, we run deadhead trains (freezing-prevention run: a temporary operation for such a purpose) and railway motor cars to prevent overhead contact lines from freezing and snow accumulating on rails. If heavier snowfall is expected, we make efforts to maintain safe and stable transportation by, for example, changing to temporary timetables that eliminate the need for switch operation or temporary timetables with reduced service frequency so that impacts of heavy snowfall are minimized.

Drivers use snow brakes during snowfall and snow accumulation. A snow brake is a device that brings brake shoes and the wheel into contact in advance to prevent snow from entering the gap between them and causing the brake to fail to function properly. When using snow brakes, because they behave differently from normal brakes, drivers operate the brakes more cautiously than they would under normal conditions. Although the operation control center, for example, issues instructions to start using snow brakes, the specific timing is determined by each driver. In the case of heavy snowfall, drivers may be strongly informed and encouraged to use snow brakes. Furthermore, each year as the snowfall season approaches, during driver training we convey past snow-related accidents and their countermeasures, the importance of snow brakes, and other points to drivers to raise their awareness of accident prevention.

In heavy snowfall areas, snow-removal vehicles are used on a planned basis to remove snow so that train operations are not affected. Moreover, because snowslide may occur, locations at risk of snowslide are monitored for snow depth along the railway route using snow-depth gauges, and staff members riding in train cabs observe the snow surface for any cracks, to predict snowslide and take preventive measures to avoid accidents.

### (2) Structural countermeasures

The countermeasures implemented in response to past railway operation accidents caused by falling or accumulated snow have been extended to other necessary routes and locations. For example, following a train derailment accident caused by snow accumulating in the gaps of level crossing rails and being compacted by passing vehicles, we have installed snow-melting devices in the rail gaps of level crossings to prevent snow from being compacted. At level crossings prone to snowdrifts, snow-melting devices have also been installed in locations other than between rails to avoid similar accidents. In addition, at sites where slope collapses occurred because of rapid snowmelt, we have implemented grating crib works and other works. Not limited to snowmelt, we have been implementing works on slopes with a high risk of inflow of soil and sand, making efforts to reduce the risk of railway operation accidents.

Figure 8: Example overall view of a location where a level crossing snow-melting device has been installed. There is little snow on the road near the level crossing. (From the East Japan Railway Company website)

### (3) Relationship with other operators

We regularly exchange views with various railway operators across Japan and share efforts to prevent accidents and issues in maintaining safe operations. In some cases, we have adopted useful accident countermeasures used by other railway operators.

## 3. Characteristics of the accidents and incidents under focus and their investigation cases

In preceding chapters, the characteristics of accidents caused by snow, etc., have been presented. In this chapter, cases that may serve as references for taking recurrence prevention measures are introduced for types of accidents with a large number of cases.

### (1) Train derailment accidents caused by compacted snow at level crossings

As for the train derailment accidents caused by climbing up onto compacted snow at level crossings cited in Figure 4 on page 2 (eight cases in total), compaction of snow by vehicles passing over the level crossing was involved in every case.

If there has been snowfall from the day before to the day of the accident, the newly accumulated snow is compacted by vehicles, which becomes compacted snow. In many cases the snowfall from the day before amounted to 20 cm or more (Figure 9), and there were cases where snowdrifts had formed. In addition, because of train service cancellations, operation controls, etc., in six cases there was an interval of 10 hours or more after the previous train that passed the level crossing (Figure 10). In the two remaining cases, snowdrifts formed rapidly because of heavy snowfall.

The accident investigation reports introduced below pointed out issues such as snow removal not having been carried out for a long period of time, and that snow-removal arrangements should be reviewed. Two cases of typical types of accidents are introduced below.

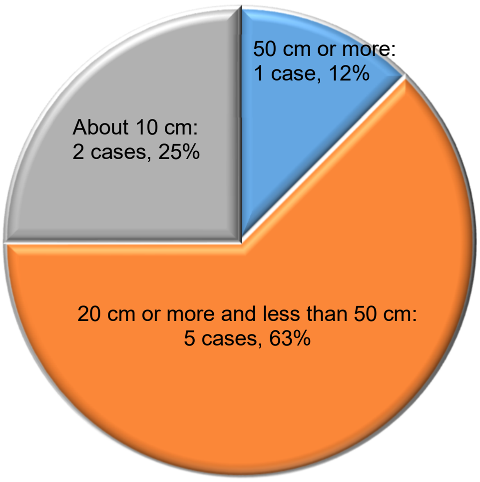


Figure 9: Snowfall from the day before (compacted snow at level crossings)

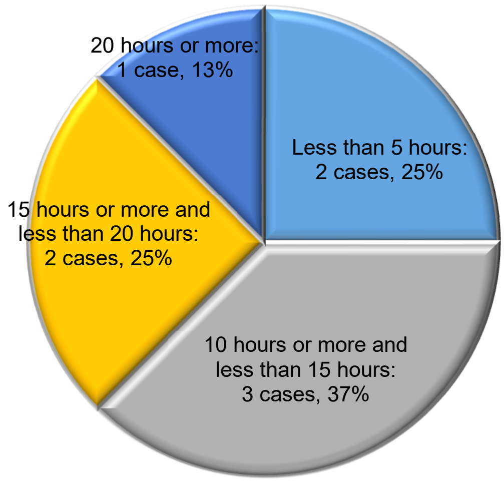


Figure 10: Interval after the previous train

### Case 1 (Train derailment accident: compacted snow at a level crossing) Occurred at about 8:30 on February 14, 2009

**Snowfall and compaction due to passing of heavy vehicles formed compacted snow on the level crossing in a short time, and the train climbed up onto it and derailed.**

**Outline:** A two-car train (internal combustion railcar) was operating at reduced speed en route because of strong wind. The train entered the level crossing while decelerating after passing a bridge. At around the point when the train had just passed the crossing, the driver felt an impact as if the car had come off the rails and applied the emergency brake, and the train stopped after running about 82 m from the crossing. When it was checked after stopping, both axles of the front bogie of the leading car were derailed to the left (the front, back, left, and right are based on the direction of travel of the train.). There were 21 passengers and the driver on board the train, and there were no fatalities or injuries. The snow plow (a snow clearing device installed on the leading car to eliminate snow on the track within the rolling stock gauge) and the auxiliary life guard of the first car of the train were damaged.

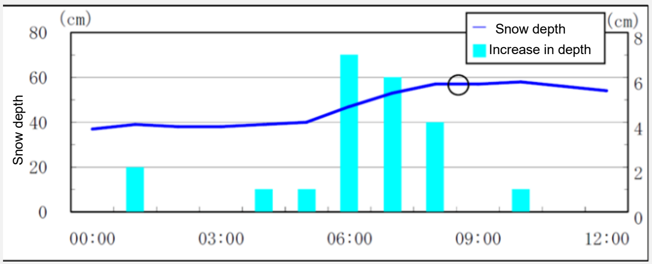


Figure 11: Snow depth and increase near the accident site (the circle indicates the time when the accident occurred.)

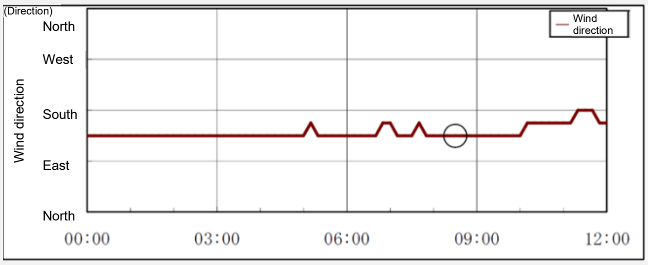


Figure 12: Wind direction near the accident site (the circle indicates the time when the accident occurred.)


Figure 13: Condition of the level crossing where the accident occurred and the southeast direction from it (the day after the accident)

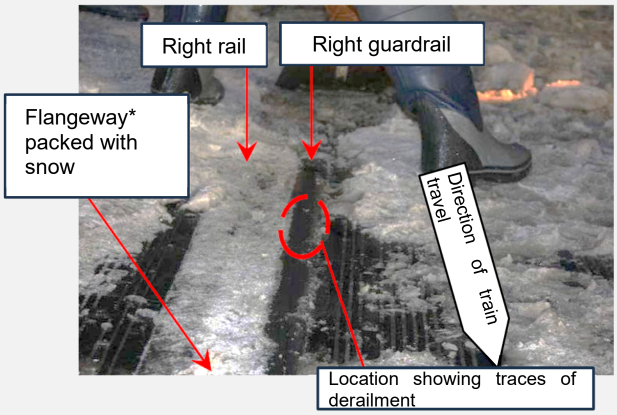


Figure 14: Condition of the level crossing where the accident occurred (photographed after removing snow at the location on the evening of the day of the accident)

* At the level crossing, although there is filler rubber at the bottom, it is not visible.

**Probable causes**: The JTSB concludes that it is probable that the accident was caused as the train climbed up onto compacted snow formed in the flangeways and on the rail surfaces at the level crossing and then moved to the left, resulting in a derailment.

As for the occurrence of the accident, it is possible that the rapid formation of compacted snow due to a combination of the following factors was involved: strong winds from the direction unobstructed near the accident site caused a snowdrift to grow quickly at the level crossing, which, together with snowfall earlier in the period before the accident, led to snow accumulating enough to bury the rails at the crossing; and many heavy vehicles passed over the crossing and compacted the accumulated snow in a short time.

## For the prevention of recurrence

### Required measures to prevent recurrence:

When strong winds are expected during snowfall in winter, depending on wind direction, drifts of unexpected amounts of snow can form in a short time; therefore, taking into account that the condition of a level crossing when a train is operated may differ greatly from the condition after snow removal, it is necessary to make efforts to appropriately ascertain the situation by, for example, riding on the train or patrolling the level crossing, and, when necessary, promptly consider carrying out snow removal at the level crossing so that, even if compacted snow forms in a short time, it can be dealt with.

### Measures taken by the railway operator after the accident:

(1) On level crossings on line sections with low train frequency where compacted snow may form in the flangeways because of frequent passing of heavy vehicles, the following measures have been implemented in weather conditions where snowdrifts may be formed by wet snow:
- Snow removal at the crossing and removal of snowdrifts at the crossing ends before the first train
- During time periods with long intervals between trains, repeated checks on snowdrift formation and the monitoring of flangeways by patrolling, and snow removal when necessary

(2) A camera was installed at the level crossing where the accident had occurred to monitor the condition of the crossing according to weather conditions.

(3) Efforts were continuously made to appropriately ascertain snowfall and accumulation conditions, and snow removal was carried out. In addition, for level crossings equipped with filler rubber, visual inspections and checks using a hammer, for example, were conducted to investigate whether soil and sand had accumulated in the hollow sections of the filler rubber. The operator has decided to check the conditions of filler rubber, remove soil and sand when necessary, and take measures to prevent the ingress of soil and sand before the winter season and, for locations where ingress is observed, to further strengthen the monitoring system.

The investigation report of this case is published on the website of the JTSB. (Published on November 27, 2009.)
https://jtsb.mlit.go.jp/railway/rep-acci/RA2009-9-1.pdf

## Case 2 (Train derailment accident: compacted snow at a level crossing) Occurred at about 5:31 on December 6, 2017

## Although compacted snow formed on the level crossing, it was not properly removed because the winter snow-removal arrangements had not yet started, and the train climbed up onto it and derailed.

**Outline:** The driver of a six-car, one-person-operated train on Line A, departing B Station for C Station, while coasting at a velocity of about 34 km/h on track E at D Station (a siding for inbound and outbound lines), detected an abnormal noise and noticed an indication of an abnormal condition on the cab monitor, and stopped the train by applying the emergency brake. Although the operation of the train was resumed after checking cars, the indication of the abnormal condition recurred, and therefore the train was taken out of service for the remainder of the trip and was transferred to F Depot. Because a car investigation at F Depot found evidence that the wheels of the first axle of the leading car's bogie had run derailed, an investigation of the D Station premises was carried out, and as a result, traces of derailment were found at the G level crossing, and traces of re-railing were also found at turnout H about 83 m toward C Station from that point. The train was a deadhead train with one driver on board, who was not injured.

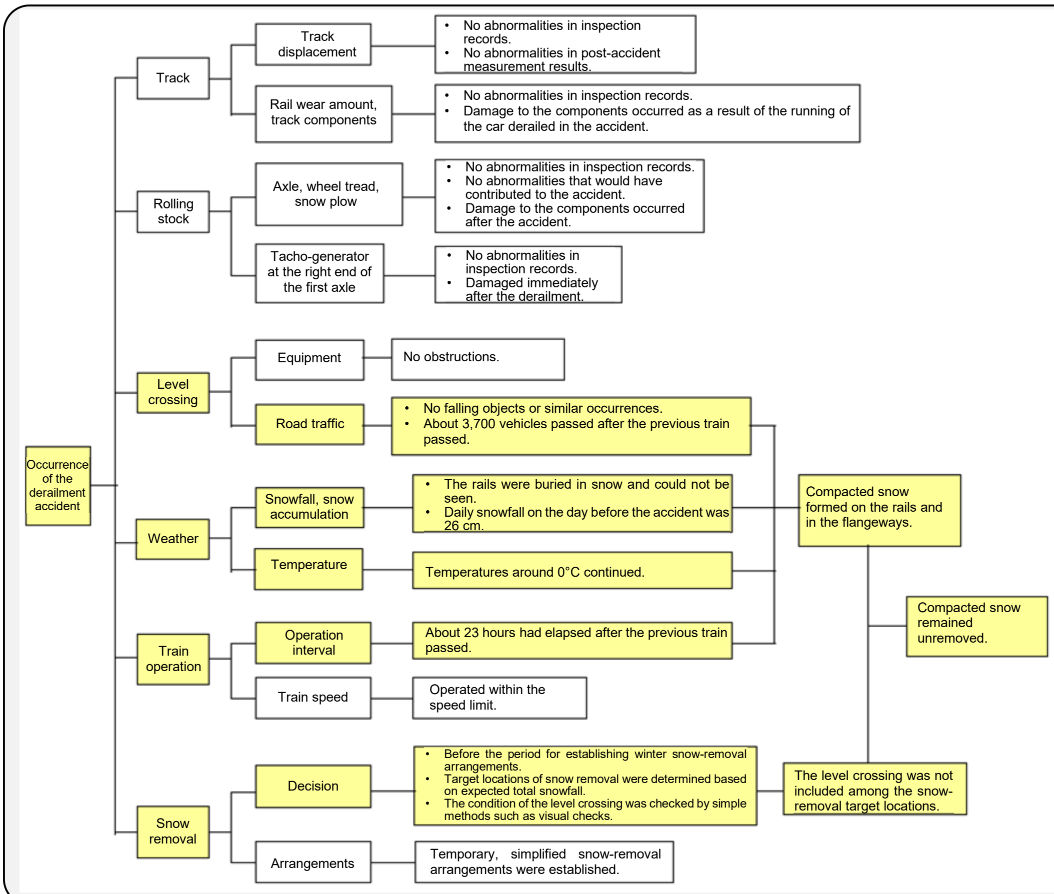

Figure 15: Factors involved in the train derailment accident (yellow boxes indicate factors that may have been involved in the occurrence of the accident.)

**Probable causes**: The JTSB concludes that the probable cause of the accident was, when the train was passing the level crossing located on the right-hand curve of the siding for inbound and outbound lines, which had not been used frequently, on the station premises, the left wheel of the first axle of the leading car's bogie climbed up onto the left rail (outer rail), resulting in a derailment to the left.

As for the derailment, it is possible that the wheel flange climbed up onto the compacted snow that existed on the rails and in the flangeways at the level crossing.

As for the presence of compacted snow at the level crossing, it is possible that heavy snowfall on the day before the accident, under the condition where temperatures around 0°C continued, and the continued compaction of snow by vehicles passing over the crossing during the long interval after the previous train contributed to its presence. In addition, it is possible that the compacted snow formed on the rails and in the flangeways remained unremoved, because no snow removal was performed up to when the train passed the crossing. As for the lack of snow removal, it is possible that the following factors were involved: it was before the period for establishing winter snow-removal arrangements; the condition of the level crossing was checked by simple methods such as visual checks; and the operation interval was not sufficiently considered in on-site checks and decisions about snow removal.

## For the prevention of recurrence

### Required measures to prevent recurrence:

(1) Appropriate snow-removal arrangements and designation of snow-removal target locations according to the situation

In the cases where a day with heavy snowfall, the passage of strong cold air at night, or other weather conditions requiring caution are expected, it is desirable to flexibly increase snow-removal personnel according to the situation even outside the planned period for the winter snow-removal arrangements. Furthermore, it is desirable to further enhance snow removal at level crossings depending on snowfall and accumulation conditions by, for example, appropriately designating snow-removal target locations taking into account the conditions of compacted snow ascertained through on-site checks and environment of the level crossings, such as train operation intervals and vehicular traffic volumes.

(2) Identification of locations requiring attention with consideration of the level crossing environment

Although the level crossing where the accident occurred had been designated as a location requiring attention under the winter snow-removal arrangements, it is desirable, also for other level crossings, to consider identification of locations requiring attention and specific countermeasures for snow removal.

When considering the above, it is necessary to take care that the measures are tailored to the equipment, etc., of each level crossing in order to appropriately implement snow removal that takes into account each level crossing's environment, such as level crossings on lines where trains do not pass for long periods and level crossings with high vehicular traffic.

### Measures taken by the railway operator after the accident:

(1) Bringing forward the winter snow-removal arrangements

Although the winter snow-removal arrangements (deployment of winter snow-removal personnel to carry out nighttime ice and snow removal, etc.) for 2017 at C Station had been planned to be established from December 15, 2017, the schedule was brought forward, and the arrangements were established from 0:00 on December 9, 2017.

(2) Cancellation of use of the sections where the accident occurred

It was decided that the sections in which trains exit track E at D Station to the A Line inbound mainline and in which trains enter track E at D Station from the A Line outbound mainline (both toward C Station) would not be used for train operations during the period from December 7, 2017 to March 31, 2018.

However, turnback trains using track E at D Station toward H Station (the same direction as toward B Station) were kept in their regular scheduled operation.

(3) Identification of locations requiring attention, bringing forward the winter snow-removal arrangements, review of work schedules, etc.

Thirteen level crossings on station premises (11 stations) with conditions similar to track E at D Station, such as tracks with two or fewer trains per day and level crossings with high vehicular (particularly truck) traffic, were newly designated as locations requiring attention. At the stations with such crossings, the winter snow-removal arrangements were brought forward, and the review of work schedules, etc., were implemented so that the crossings could be inspected before the entry of the first train.

In view of the driver having resumed the operation of the train without noticing damage to its snow plow, the operator instructed crew members on points of caution when checking cars that re-railed after a derailment and cars that experienced abnormal impact, in order to further enhance initial response measures.

The investigation report and materials of this case are published on the website of the JTSB. (Published on January 31, 2019.)

https://jtsb.mlit.go.jp/railway/rep-acci/RA2019-1-1.pdf (Report)

https://jtsb.mlit.go.jp/railway/p-pdf/RA2019-1-1-p.pdf (Materials)

In addition, examples of other measures to prevent recurrence of train derailments caused by compacted snow at level crossings are shown below:

- The importance of identifying level crossings in unusual situations by working with municipalities was shown, because the crossing concerned had been on a dump truck route for snow removal by a municipality.
- The necessity of removing snow while also paying attention to ice and snow deposited outside the track, taking into account the position of the side beams of freight car bogie frames, was shown.

An example of other measures taken by operators after accidents is shown below:

- Electric snow-melting devices were installed on the turnouts on train depot main routes to prevent delays when dispatching snow-clearing trains and the like. In addition, to prevent malfunctions of level-crossing obstacle detection devices caused by falling or accumulated snow, replacement, reviews of the detection range, etc., were implemented.

## (2) Accidents that occurred in low-snowfall areas

In Figure 7 on page 4, it was cited that four accidents caused by snow, etc., occurred in low-snowfall areas. These were all train derailment accidents, and the breakdown of causes consists of two cases of brake force reduction and two cases of flange climbing (compacted snow at a level crossing and a fallen tree), and the causes of the accidents are not greatly different from those in heavy snowfall areas, etc. This indicates that when a low-snowfall area is struck by heavy snow, accidents similar to those in heavy snowfall areas, etc., may occur, and that operators in low-snowfall areas also need to understand the nature of accidents in heavy snowfall areas, etc. Outlines of the causes mentioned above are as follows (see pages 6 and 8):

- Brake force reduction: Snow, ice, etc., enter between brake shoes and the wheel, reducing braking force.
- Flange climbing (compacted snow at level crossings): A long interval occurs between trains passing a level crossing, during which vehicles passing over the crossing make the fallen snow into compacted snow, which a train climbs up onto.
- Flange climbing (fallen tree): Tree uprooting caused by snow accumulation results in fallen trees that obstruct the track, which a train climbs up onto.

Furthermore, organizational and/or human factors were involved in all four cases of the accidents mentioned above. Although not limited to accidents in low-snowfall areas, there were accident cases in which insufficient individual or organizational preparation for events that are rare for the area, such as heavy snow and snowfall, was involved. Outlines are listed below:

- Driver’s misunderstanding of the criteria for using snow brakes
- Failure to implement early operation controls when a heavy snow warning was issued
- Failure to establish objective standards and conditions for determining the necessity of snow removal and the possibility of operations
- Insufficient measures for trees that could obstruct the track if they fell

An accident case occurred in a low-snowfall area that illustrates the need for preemptive measures for brakes and operation controls during snowfall and snow accumulation is introduced below.

### Case 3 (Train collision accident: brake force reduction)

**Occurred at about 0:30 on February 15, 2014**

**Dust and oil deposited on the brake shoes and other parts, which mixed with snow, were supplied between the brake shoes and wheels, and brake force was reduced.**

**Outline:** An eight-car train was running in the section between A Station and B Station, where snow had accumulated on the track, and was instructed by the operation control center to stop immediately in order to maintain distance from the preceding train, an eight-car train preparing to back up in order to correct its stopping position at B Station, the next station. Although the driver attempted to stop the train by applying the emergency brake, the train collided with the rear of the preceding train that was stopped at B Station. A total of about 140 passengers and four crew members were on the two trains, and 72 passengers were injured.

| Time | Facility C | | | Facility D | | |
|---|---|---|---|---|---|---|
| | Snowfall | Temperature | Snow depth | Snowfall | Temperature | Snow depth |
| 16:00 | Snow | -0.2°C | 20 mm | Snow | 0.6°C | 50 mm |
| 17:00 | Snow | -0.4°C | 35 mm | Snow | 0.1°C | 75 mm |
| 18:00 | Snow | -0.4°C | 50 mm | Snow | 0.1°C | 90 mm |
| 19:00 | Snow | -0.4°C | 70 mm | Snow | 0°C | 105 mm |
| 20:00 | Snow | -0.5°C | 95 mm | Snow | 0.1°C | 125 mm |
| 21:00 | Snow | -0.5°C | 110 mm | Snow | -0.2°C | 130 mm |
| 22:00 | Snow | -0.5°C | 120 mm | Snow | -0.4°C | 150 mm |
| 23:00 | Snow | -0.8°C | 155 mm | Snow | -0.7°C | 160 mm |
| 0:00 | Snow | -0.9°C | 170 mm | Snow | -0.7°C | 170 mm |

Figure 16: Observations of temperature and snow accumulation at two facilities near the accident site

Figure 17: Brake shoes of the train
Left: example with little deposit.
Right: example showing accumulated deposits (in the blue circle)

**Probable causes**: The JTSB concludes that the probable cause of the accident was, when the following train that was running on snowy track received an instruction from the operation control center to stop immediately for the overrun handling of the preceding train at B Station and attempted to stop using the emergency brake, the train could not produce required braking force and consequently collided with the preceding train that was stopped.

As for the inability for the following train to produce required braking force, it is probable that the coefficient of friction between the wheel tread and sliding surfaces of brake shoes of the air brake had greatly decreased when the emergency brake was applied and the brake shoes were pressed against the wheels. As for the decrease in the coefficient of friction, it is possible that the following factor was involved: snow accumulated on the track, oil remained on the wheel flanges, and dust deposited on the brake shoes were mixed together into a liquid, which was supplied between the wheels and the brake shoes.

## For the prevention of recurrence

### Required measures to prevent recurrence:

If accumulated snow reaches a height approaching the rail head surface, and there is a risk of contact with wheel flanges, it is necessary to review operation controls so that speed restrictions or cancellation of operations, for example, are implemented early during snowfall, taking into account that braking force (the coefficient of friction between a wheel and the brake shoes) will decrease. In addition, in order to prevent the reduction of braking force due to the decrease in the coefficient of friction during snowfall, it is necessary to periodically remove the deposits on brake shoes.

Regarding snow brakes, it is necessary to examine the brake-shoe force in order to further enhance their functioning. Furthermore, it is desirable to clarify the method and timing of use of snow brakes.

**Measures taken by the railway operator after the accident:**

(1) Measures in response to the train collision accident

i) Remove deposits on brake shoes during monthly inspections (about once every three months).

ii) Clarify operation controls (speed restrictions, cancellation of operations).

Implementation of speed restrictions:

- Operate at a speed of 60 km/h or less when further snowfall is expected under any of the following conditions: hourly snowfall is 2 cm or more or equivalent, or snow depth is 8 cm or more, or when the driver, etc., recognizes insufficient braking force by early brake application.
- Operate at a speed of 40 km/h or less (25 km/h or less on E Line, another route of the same operator) when further snowfall is expected under any of the following conditions: hourly snowfall is 3 cm or more or equivalent, or snow depth is 11 cm or more, or when the driver, etc., recognizes insufficient braking force even during the above speed restriction of 60 km/h or less.

Implementation of cancellation of operations:

Cancel operations if it appears difficult to continue operation because the forward visibility becomes 200 m or less, or the margin in braking force becomes insufficient, for example.

iii) Clarify the timing of use of snow brakes.

The driver on duty shall use snow brakes when snow accumulation on the track is observed. However, the head of the operation control center shall instruct all trains to use snow brakes even before snow accumulates, if a driver reports that braking force is insufficient during snowfall.

iv) Re-emphasize early brake application during snowfall and snow accumulation.

Re-emphasize that drivers must start brake application further before the application start point for rainy conditions to ascertain the condition of braking force if snow accumulation on the track is observed.

v) Implement operation adjustments to prevent, for example, prolonged stoppages between stations.

During snowfall, the operation control center shall manage operations by changing train service types, reducing the number of trains, and adjusting train intervals. This is intended to prevent, for example, prolonged stoppages between stations due to service cancellations or train schedule disruptions.

vi) Review the brake cylinder pressure setting values for snow brakes.

Change the average BC pressure setting for snow brakes from 50±20 kPa to 50 (−0, +20) kPa, which also raises wheel temperature through the friction between the wheel tread and the brake shoes' sliding surfaces.

(2) Other efforts to ensure safe transportation during snowfall season

Newly install snow-depth gauges and surveillance cameras along the route and implement measures such as real-time monitoring of snow accumulation conditions at the operation control center.

* Average BC pressure: Output air pressure of the brake cylinder that presses brake shoes, which is the average value for each car

The investigation report and materials of this case are published on the website of the JTSB. (Published on May 28, 2015.)

https://jtsb.mlit.go.jp/railway/rep-acci/RA2015-3-3.pdf (Report)
https://jtsb.mlit.go.jp/railway/p-pdf/RA2015-3-3-p.pdf (Materials)

In addition, there is another example of measures taken by an operator after an accident caused by the reduction in braking force: operation handling was changed by, for example, requiring trains to make a temporary stop before home signals during snowfall and revising the decision about the timing for using snow brakes, and brake shoes were replaced with sintered brake shoes.

## (3) Characteristics of human factors and organizational factors related to snow removal

In Figure 4 on page 2, the objects that were climbed up in derailments caused by flange climbing were classified. There were 19 cases where trains climbed up onto snow (caught snow, compacted snow at level crossings, etc.), and of accident investigation reports for these accidents, eight reports contained descriptions of human factors and/or organizational factors related to snow removal, etc.

The descriptions are summarized below. Either or both of **errors in situational judgment by individuals or organizations** or **deficiencies in rules, etc.,** are involved in these cases. Many situational judgment errors were based on subjective judgment, and there are many cases that are considered to have been avoidable by properly ascertaining the snow conditions. The case where rules had not been established, which led to a decision based on empirical practice and resulted in an accident, is introduced below.

- **Snow removal was not carried out appropriately because of insufficient checks of snow conditions, erroneous judgments based on empirical practice, etc.**
- **There were no objective standards and conditions for determining the necessity of snow removal and the possibility of operations in internal regulations.**
- Instructions to remove snow at level crossings and to cancel operations were not issued because of being too busy carrying out snow removal at many locations.
- A train was operated by suspending necessary snow removal because the timetable was prioritized.
- There were deficiencies in manuals (omission of snow removal locations, reporting and ascertaining of snow removal status, etc.).
- Snow removal was not carried out sufficiently, although the criteria for deciding to carry out snow removal were followed (The criteria were insufficient.).

## Case 4 (Train derailment accident: compacted snow at a level crossing)
**Occurred at about 13:46 on December 27, 2021**

**The train was operated, after thinking that the condition was the same as on the previous day when snow had accumulated, and derailed.**

**Outline:** Because of heavy snowfall, services on the route had been canceled from around 20:23 on the day before the accident in the section between stations including the level crossing where the accident occurred. However, since the snow stopped falling on the morning of the day of the accident, the train (two-car train) was operated as a test-run train before resuming operations. When the train was passing the crossing, the driver detected an abnormal noise and stopped the train by applying the emergency brake. After the train stopped, staff members got off the train to check the situation and found that the wheels of the first axle of the leading car's bogie had derailed to the left. One driver, four staff members for the snow removal of turnouts, three drivers who were to work at stations, etc., and two station staff members were on the train, and none were injured.

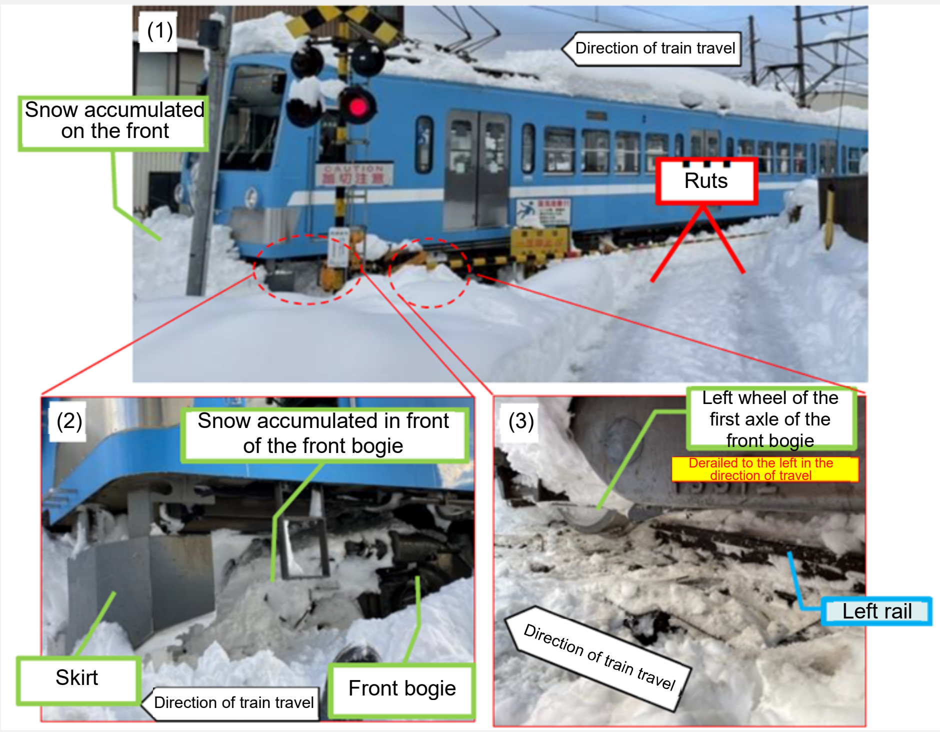


Figure 18: Conditions at the accident site

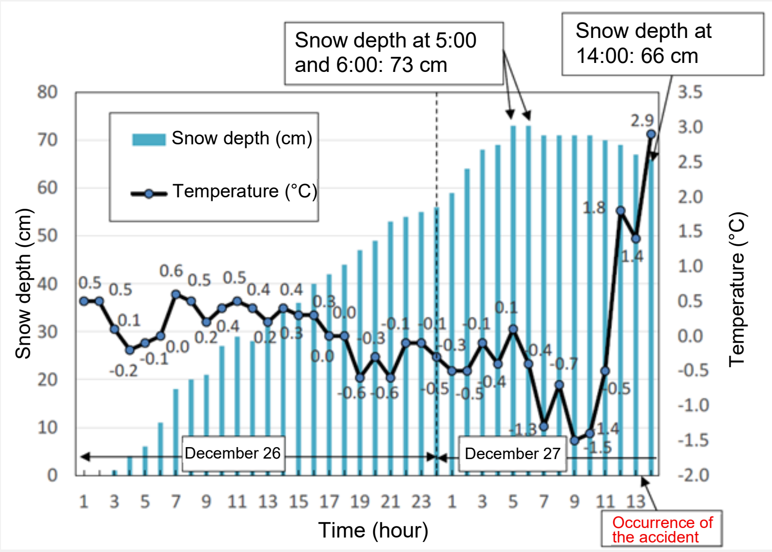


Figure 19: Trends in snow depth and temperature near the accident site

| | Day of the accident | Previous day when trains were operated in the presence of accumulated snow | Remarks |
|---|---|---|---|
| Snow depth | Snow depth at 14:00 was 66 cm. | Snow depth at 6:00 was 33 cm. | Compared using the time period when the test-run train was operated. |
| Snowfall amount | From 20:00 on the day before to 5:00 on the day of the accident there was snowfall of at least 1 cm per hour, and the cumulative snowfall was 26 cm. | There was only a snowfall of 1 cm or more at 6:00, and the cumulative snowfall was 1 cm. | Compared using the time period between the operation of the preceding train and the operation of the test-run train. |
| Temperature | Remained around 0°C (1°C–3°C from 12:00 to 14:00). | Remained around 0°C. | Compared using the time period between the operation of the preceding train and the operation of the test-run train. |

Figure 20: Comparison of weather conditions on the day of the accident and on the previous day when trains were operated in the presence of accumulated snow (snow depth, snowfall amount, and changes in temperature near the accident site)

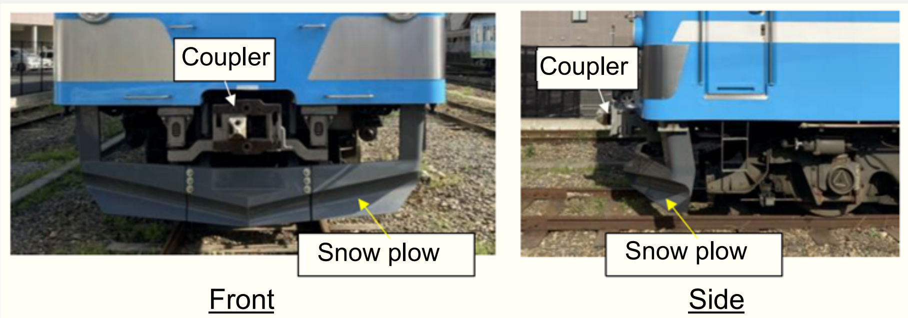


Figure 21: Example of a car equipped with a snow plow

**Probable causes**: The JTSB concludes that it is possible that the accident occurred because the wheel load of the front bogie of the leading car decreased, and while the train was running with that bogie turned to the left, the first axle of the bogie climbed up onto compacted snow that was on the rails and in the flangeways at the level crossing, causing a derailment.

As for the decrease in wheel load on the front bogie of the leading car, it is possible that when the train ran while pushing aside a large amount of snow on the track, the volume of snow that had entered from below and above the skirt increased, causing an upward load to be applied to the leading car's front bogie.

Regarding the front bogie's turning to the left, it is possible that snow accumulated on the front of the leading car's carbody and front bogie pushed the front of the carbody and the front bogie.

As for the presence of a large amount of snow on the track, it is possible that under conditions of low temperature and heavy snowfall, in addition to the snow that was on the track when the last train passed the level crossing on the previous day, much of the snow that fell before the train ran had not melted and therefore remained.

As for the operation of the train that did not use cars equipped with a snow plow without performing snow removal, it is probable that, although the conditions of snow accumulated on the track and compacted snow at the level crossing were presumed to differ between the previous day when trains were operated and the day of the accident, the chief safety management officer thought that the conditions of snow accumulated on the track and compacted snow at the crossing on the previous day were the same as those on the day of the accident, and finally determined the necessity of snow removal and the possibility of operations based on the past instance in which trains ran without problems. Furthermore, it is possible that the following factors were involved: the operator's internal regulations, etc., contained no objective standards and conditions that enable the determination of the necessity of snow removal, the use of cars with a snow plow, and the possibility of operations based on the conditions of snow accumulation and compacted snow, for example; and information gathering for determining the necessity of snow removal and the possibility of operations was insufficient because the operator had not checked the condition of compacted snow at the level crossing.

## For the prevention of recurrence

### Required measures to prevent recurrence:

It is possible that the accident occurred because the train was operated without performing snow removal, although a large amount of snow was accumulated on the track and there was compacted snow on the rails and in the flangeways at the level crossing. Regarding the operation of the train that did not use cars equipped with a snow plow without performing snow removal, it is possible that the following factors were involved: the chief safety management officer thought that the conditions of snow accumulated on the track and compacted snow at the level crossing on the day of the accident were the same as those on the previous day when trains were operated, and finally determined the necessity of snow removal and the possibility of operations based on the past instance; objective standards and conditions that enable the determination of the necessity of snow removal, the use of cars with a snow plow, and the possibility of operations based on the conditions of snow accumulation and compacted snow, for example, had not been provided; and information gathering for determining the necessity of snow removal and the possibility of operations was insufficient.

It is necessary to clarify objective standards and conditions for determining the necessity of removal of snow on tracks and at level crossings, the use of cars with a snow plow, and the possibility of operations after collecting accurate information on the conditions of snowfall, snow accumulation, and compacted snow, for example.

### Measures taken by the railway operator after the accident:

A manual for handling operations during snowfall and snow accumulation was established. The manual includes the following major items:

(1) Setting of operation controls corresponding to the amount of snow

It was stipulated that train operations are to be canceled when snow accumulation at a height of 25 cm or more above the top of the rail or 40 cm or more above the top of the sleepers is observed.

(2) Designation of snow-removal target level crossings

It was stipulated that level crossings other than wooden-decked level crossings are to be the target of snow removal because wooden-decked level crossings have relatively deep flangeways and low daily traffic volumes (for example, 15 or fewer cars with three or more wheels per day) and are considered less prone to the formation of compacted snow.

(3) Setting of conditions for carrying out snow removal

It was stipulated that snow removal on tracks is to be carried out by running an inspection vehicle equipped with a snow plow after removing snow from the rails and flangeways at level crossings that are the target of snow removal. The inspection vehicle is to be operated when snowfall of 20 cm or more above the rail head is observed during the period from the last train to the first train, or where train operations are canceled, and will not be operated if snowfall exceeds 35 cm above the rail head and 50 cm above the top of the sleepers. In addition, when operating an inspection vehicle, the track will be closed.

(4) Setting of conditions for lifting the cancellation of operations

It was stipulated that the operation control center will make a comprehensive assessment of the situation and issue instructions to resume operations when an inspection vehicle has been operated and the electrical, track maintenance, and train depot staff have confirmed that there are no abnormalities.

Furthermore, snow plows were installed on two train sets of the same type as the train in this case.

The investigation report and materials of this case are published on the website of the JTSB. (Published on October 26, 2023.)

https://jtsb.mlit.go.jp/railway/rep-acci/RA2023-8-1.pdf (Report)
https://jtsb.mlit.go.jp/railway/p-pdf/RA2023-8-1-p.pdf (Materials)

## Column  Planned train service cancellations

In recent years, planned cancellations, in which train operations are canceled in advance when significant weather conditions, such as due to approaching or landing of a typhoon, are expected, have been implemented.

The "11th Traffic Safety Basic Plan" announced in March 2021 defined the general outline of traffic safety measures to be implemented over the five years from FY2021 through FY2025. In this plan, planned cancellations are described as follows:

> (7) Initiatives for planned cancellations
>
> When weather conditions are forecast to interfere with train operations, such as when a large typhoon is approaching or making landfall, railway operators will be instructed to pay more attention to weather conditions and to make efforts to ensure safety by systematically canceling train operations after providing information in advance in accordance with the characteristics of the route from a safety perspective.

Prior to this, in September 2018, railway operators implemented planned cancellations in preparation for an approaching typhoon. The response at that time was verified and summarized by the Study Meeting on Planned Cancellations of Railways convened by the Ministry of Land, Infrastructure, Transport and Tourism, which also discussed planned cancellations and information provision that are in accordance with the characteristics of each route. From the perspective of preventing railway accidents, the following should also be noted:

> **2. Safety checks when resuming operations**
>
> ○ In the event that strong winds occur because of a large typhoon, etc., when resuming operations, basically, it is necessary to inspect the entire line to check the condition of structures and the presence or extent of obstructions caused by flying debris.
>
> Ministry of Land, Infrastructure, Transport and Tourism website    Press release, July 2, 2019
> Excerpt from "Planned service cancellations: Railway companies to create timelines—Final summary on the approach to planned cancellations"

Based on the Ministry of Land, Infrastructure, Transport and Tourism's Disaster Management Operation Plan (as of June 2024), the following guidance is also provided to railway operators when heavy snowfall is expected:

> ○ Provide guidance to railway operators to ensure appropriate implementation of measures such as installing snow-melting equipment, strengthening pre-event preparedness based on disaster weather information, conducting the resumption of operations and passenger rescue in parallel and enhancing provision of concrete information to passengers when prolonged stops between stations are expected, strengthening cooperation with municipalities and other relevant agencies, and carrying out practical, scenario-based drills, in order to avoid situations such as prolonged entrapment of passengers due to trains stopping between stations during snowfall and snow accumulation.
>
> ○ Provide guidance to railway operators that when weather conditions are expected to interfere with train operations, such as when heavy snow is expected, they should pay increased attention to the weather conditions and, from a safety standpoint, make efforts to ensure safety by, for example, providing advance information and, according to the characteristics of the route, canceling train operations in a planned manner (planned cancellations). In addition, regarding how to provide information to users, based on the results of discussions with railway operators concerning (1) the content, timing, and methods of information provision to users, (2) arrangements for alternative transportation in the event of planned cancellations, and (3) ways of providing information to municipalities, provide guidance to railway operators to prepare an information-provision timeline in advance using as a reference the model cases prepared by the Ministry of Land, Infrastructure, Transport and Tourism.
>
> Ministry of Land, Infrastructure, Transport and Tourism website    June 2024
> Excerpt from the Disaster Management Operation Plan, Part 7—Snow Disaster Countermeasures

When heavy snowfall is expected, we think it is effective for the prevention of accident, etc., to check snow-removal arrangements and implement planned cancellations in accordance with the characteristics of the route, and when resuming operations, to check conditions caused by falling or accumulated snow, etc., and carry out appropriate snow removal, etc.

## 4. Summary

We verified that accidents caused by snow, etc., have the following characteristics, which are shown below together with points to prevent accidents:

**○ Trends in accidents**

- Among accidents caused by natural phenomena such as weather, those attributed to snow and snowmelt are the most common, which occur not only in heavy snowfall areas, etc., but also in low-snowfall areas.
- About 90% of accidents caused by snow, etc., are train derailment accidents, and of those, about 90% occurred because of flange climbing. The objects most frequently climbed up were caught snow and compacted snow at level crossings.
- As for the cases where trains climbed up onto compacted snow at level crossings, they involved compaction of snow by vehicles passing over the crossing, and in many cases there were snowfall of 20 cm or more from the previous day and intervals of 10 hours or more after the previous train.

**○ Human factors and organizational factors**

- There were accident cases in which human and/or organizational factors were involved, and as for accidents caused by climbing up onto snow, etc., human and/or organizational factors related to snow removal were involved in about 40% of them.
- These accidents involved either or both of errors in situational judgment by individuals or organizations or deficiencies in rules. Specifically, they include cases, for example, where snow removal was not carried out appropriately because of insufficient checks of snow conditions, erroneous judgments based on empirical practice, etc., and where no objective standards and conditions were given for determining the necessity of snow removal and the possibility of operations in internal regulations.

**Points to prevent accidents**

Implement the following in advance:

- Understand the nature of accidents in heavy snowfall areas, etc., and past accidents caused by snow, etc.
- Establish arrangements, for example, for snow removal and operation controls for routes, level crossings, etc., during snowfall and snow accumulation, and define objective decision criteria, etc., for implementing them.

Implement the following during snowfall and snow accumulation:

- Properly ascertain snow conditions on routes, level crossings, etc.
- Pay attention to the reduction in braking force caused by snow, ice, etc., entered between brake shoes and wheels and take appropriate measures.

As we are approaching the winter season, we hope you will refer to the characteristics and cases of accidents introduced in this digest, review measures to prevent accidents caused by snow once more, and advance their implementation.

### Comment from the Director of the Analysis, Recommendation and Opinion Office

Heavy snowfall, snow accumulation, and even snowfall are rare in some areas, and railway operators and routes in low-snowfall areas may have little or no experience in snow disaster countermeasures. With limited management resources, it may be difficult and burdensome to establish concrete systems to respond to events such as snow disaster. However, once an accident, etc., occurs, it can have a significant social impact. Therefore, we expect you will refer to the analyses and specific cases of railway accidents introduced in this digest, further advance the development of systems including planned cancellations, and ensure the safe and stable railway transportation.

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We welcome your comments on “JTSB Digests” and requests for outreach lecturers.

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