3. Examples of the accident investigation

Case 1, Gauge widening — Occurred at about 21:26, Wednesday, February 22, 2017

Train derailed by the rail tilting, etc., due to the continuous defects of the rail fastening devices

Summary : At about 21:26, the driver of the outbound train composed of two vehicles, just after departed from A station, and operating in around B level crossing at the velocity of about 20 km/h, felt a shock, and applied the emergency brake to stop the train.
All axles in the front bogie of the first vehicle derailed to right when the train stopped. It was cleared that all axles in the rear bogie of the first vehicle once derailed to right and restored to the track, by the investigation after the accident occurred.
There were about 50 passengers and the driver were boarded on the train, but no one was injured.

Process to the occurrence of the accident

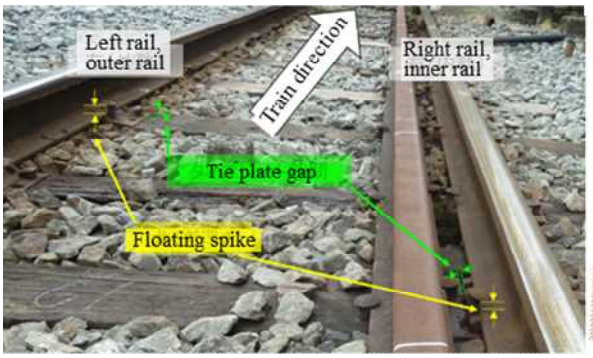
Insufficient comprehension on the danger of dynamic gauge widening by the continuous defects of rail fastening devices.

Dynamic gauge widened large due to rail tilting, etc., by the lateral force while train was running.

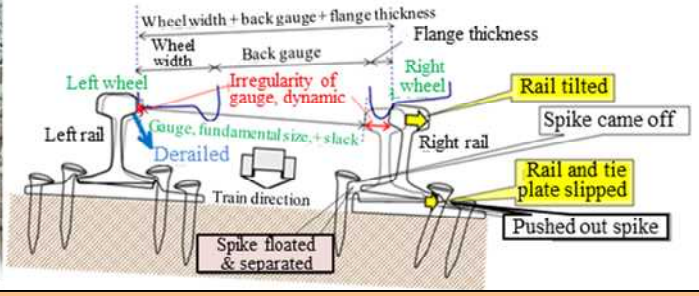
Slack in relatively large curve.

Decreased margin against derailment to inside gauge.

At about 21:26 **Outer rail side wheel fell to inside gauge and the train derailed.**



Supposed running status when derailed in this accident



Probable causes : It is probable that the train, while passing through the 200 m radius right curve, left wheels on the front and the rear bogies fell to inside gauge due to largely widened gauge, the front bogie derailed to right although the rear bogie restored by the guard rail, in the first vehicle.

As for that the gauge had widened largely, it is likely that the gauge had widened dynamically due to the rail tilting, etc., caused by the lateral force when train was running, because the defects of rail fastening devices had been continued in the curved track, and related by that the margin against derailment to inside gauge had been decreased due to relatively large slack in the curved track.

For the prevention of recurrence

Required Safety Action

(1) Certain implementation of the track maintenance
- Check the corrosion of sleepers and the loosened spikes, etc.
- Implement re-hammering or additional hammering of spikes, replacement of sleepers or the installation of the gauge tie, *i.e.*, metal to hold the gauge, etc.
- Establish the system that can implement the above two items certainly.
- Maintain in high priority when defects of sleepers, etc., continued or existed in steep curve with large slack.
- Pay attention to the inner rail side same as for the outer rail side in the management of sleepers and rail fastening devices in the curved section.

(2) Change of material of sleepers
- Replace to the concrete sleepers, etc., which is superior in the durability and easiness of maintenance compared to the wooden sleepers.

(3) Study to shorten slack
- In order to increase margin against derailment to inside gauge, study in line with the improvement of the track, and shorten in the possible range.

Measures taken by the operator after the accident

(1) Change of material of sleepers in around the accident site, etc.
- Changed to the concrete sleepers and replaced the ballast as the measure to improve the drainage.

(2) Additional hammering of spikes
- The number of spikes fastening the outer rail was increased from one to two, in the place of wooden sleepers in the curves of the radius less than 250 m.

(3) Thoroughgoing of the inspection of sleepers
- Educated the staffs to pay thoroughly attention to the status of drainage in the inspection of sleepers, etc.

The investigation report of this case is published in the home page of the JTSB, published on January 25, 2018,
http://www.mlit.go.jp/jtsb/railway/rep-acci/RA2018-1-6.pdf

Case 2, Gauge widening — Occurred at about 11:00, Sunday, January 22, 2017

Train derailed by the rail tilting, etc., due to the continuous defects of the sleepers, etc.

Summary : The outbound train composed of one vehicle departed from A station at about 10:58.

The driver of the train noticed abnormal sounds from under floor several times when proceeded about 500 m from A station, therefore, applied the emergency brake to stop the train. The driver detrained and checked the situation and found that all axles in the rear bogie of the train had been derailed to right.

There were five passengers and the driver were boarded on the train but no one was injured.

Process to the occurrence of the accident

Comprehension on the danger of dynamic gauge widening by the continuous defects of sleepers and rail fastening devices were insufficient.

Insufficient track maintenance.

Continuous corrosion and cracks generated in the sleepers in the curve.

Rail fastening force by spikes decreased continuously.

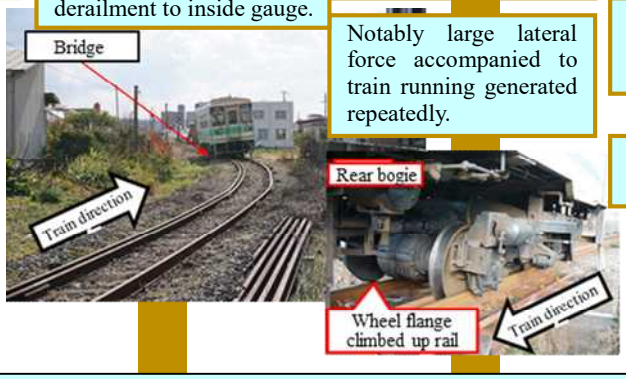
Gauge dynamically widened largely due to rail tilting, etc., by lateral force by train running.

Slack in relatively large curve.

Decrease margin against derailment to inside gauge.

Large irregularity of alignment in rail joint due to long-term angular rotation.

Notably large lateral force accompanied to train running generated repeatedly.



Fastened number of guard rail to sleepers lacked.

Fastening force of guard rail decreased.

Derailment could not be prevented.

At about 11:00 **Inner rail side wheel fell to inside gauge and the train derailed**

Probable causes : It is probable that left wheels in the first and the second axles in the rear bogie derailed to inside gauge, right side of the left rail, *i.e.*, inner rail, because the gauge had widened largely while the train was passing the 160 m radius left curve, in this accident.

There was the possibility that the gauge widened dynamically by the rail tilting, etc., due to lateral force accompanied to the train running, because the rail fastening force by the spikes had been decreased by the effects of the continuous collision and cracks generated in the sleepers in the curve.

It is likely that the rail fastening force had decreased by corrosions and cracks generated in the sleepers continuously, related by that the company had not been comprehended the danger to cause derailment accident by the dynamically widened gauge due to the continuous defects of sleepers and rail fastening devices, in the inspection for track materials, etc., and the track maintenance responded these situations had not been implemented promptly.

For the prevention of recurrence

Required Safety Action : The following measures were added to the measures described in Case 1.

(1) Review the maintenance standard values
- Establish the handling when exceeded the maintenance standard value, and to take measures certainly according to it.
- The maintenance standard value of the gauge shall be increased or decreased corresponding to the slack.

(2) Proper installation of guard rail, etc.
- The guard angle shall be installed properly by using tie plate for the section where installed the guard rail, etc.
- Or study the replacement to the guard angle considering the easiness of the maintenance.

(3) Inspection of guard rail, etc., and measures when noticed the traces
- Add the existence of contacted trace with wheel in guard rail, etc., as requiring care item in the periodic inspection, etc.
- When the trace was found, confirm the existence of abnormality and take measures if there is abnormality.

Measures taken by the operator after the accident

(1) Replacement of sleepers and realignment of track
- Replaced 100 wooden sleepers and spikes to new ones in the section included the accident site, enforced track by supplied ballasts and tamping, realignment of track.

(2) Review of the slack
- Changed the slack in the accident curve from 25 to 20 mm, and managed the irregularities based on the new slack.

(3) Enforced the management system of the track
- Hired the retired staffs from the major railway company experienced in the track maintenance, and implemented education from these company staffs to the other company staffs, on the track maintenance.

(4) Replacement to the guard angle
- Replaced the guard rail already installed in the accident curve to the guard angle.

(5) Used the concreate sleepers
- Replaced to concrete sleeper every one of two wooden sleepers, in the curves scheduled to be maintained next to the accident curve.

The investigation report of this case is published in the home page of the JTSB, published on January 25, 2018,
http://www.mlit.go.jp/jtsb/railway/rep-acci/RA2018-1-2.pdf

Case 3, Rail folded and damaged — Occurred at about 19:25, Friday, April 15, 2016

Train derailed by the folded and damaged rail

Summary : The inbound train composed of one vehicle departed from A station on schedule at 19:23.
After that, the driver of the train, while operating in the coasting operation between A station and B station at the velocity of about 50 km/h, noticed abnormal sounds and severe vibration in the tunnel, therefore, immediately applied the emergency brake to stop the train. After the train had stopped, the driver detrained and checked the surroundings of the train and found that all two axles in the rear bogie had been derailed to left. There were two passengers and the driver were boarded on the train, the driver was injured in this accident.

Process to the occurrence of the accident

The status that cross-section of rail had been decreased remarkably by corrosion could not noticed.

Missed to find crack in the rail.

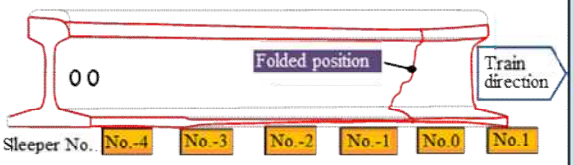
Missed to find continuous looseness of rail fastening bolt and removed track pads, in the track where relatively large irregularity of cross level had been existed.

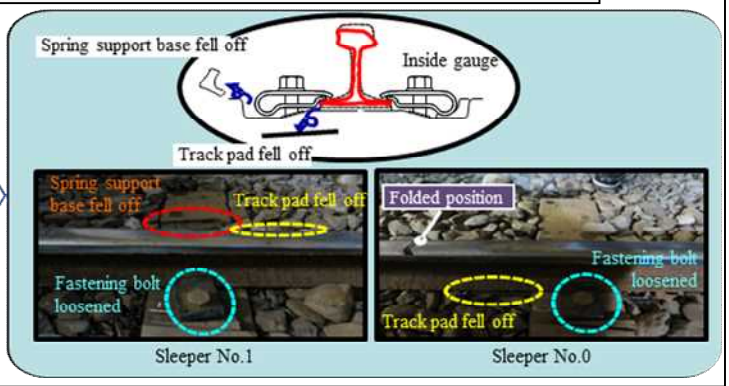
Lateral force in outer rail generated in the curve increased by the existence of relatively large irregularity of alignment.

Rail, outer rail, was folded and damaged.

Derailment coefficient increased due to decrease of outer rail side wheel load and increase of lateral force.

At about 19:25 **Outer rail side wheel ran over the rail and the train derailed.**





Probable causes : It is likely that left wheel in the third axle in the rear bogie of the train ran over the rail and derailed, because the wheel load decreased significantly and the derailment coefficient had increased while the train was running in the circular curved section in the tunnel, based on the followings.

(1) The outer rail side lateral force which is generated steadily in the curved track, increased further due to the existence of relatively large irregularity of alignment.

(2) The loosed fastening bolts of the rail fastening devices and the falling off track pads had been existed continuously, in the track where relatively large irregularity of cross level to promote to decrease wheel load had been existed.

(3) The left rail, the outer rail, had been folded and damaged when the rear bogie of the train passed.

For the prevention of recurrence

Required Safety Action :

(1) On the measures for the folded and damaged rail
- On the places of leaking water from tunnel, manage properly as to concentrate to confirm the corroded status of rail, including the replacement of rails according to the necessity. It is effective to suppress leak of water from tunnel, and to introduce rust proof treatment which apply antiseptic to rails.
- Conduct systematic replacement of rails when the corrosion of rails had been deteriorated.
- Replace rail as soon as possible when deterioration of corrosion of rail was in danger. When replacement was difficult, watch carefully the change of the rail by on-foot patrol and reinforce the rail according to the necessity.

(2) Implementation of the careful track inspection.
- Implement careful inspection so as not to overlook continuous looseness of the rail fastening devices and the falling off track pads.

Measures taken by the operator after the accident

(1) Replacement of the decrepit rails in the tunnel section.
- Total 25 rails in five tunnels were judged to be replaced in the status inspection including the rail bottom, and completed to replace all designated rails.

(2) Certain implementation of track inspection in the tunnel section.
- Adopted bolt cap with white one line and paint of fitting mark with a marker, in order to find looseness of bolts visually and easily.

(3) Measures against folded and damaged rails in the tunnel sections.
- Newly installed the point to measure the corroded status of rails in the place of water leakage in tunnel section, and implemented the status check of rails by the on-foot patrol, etc.

(4) Measures against the folded and damaged rails in the open section.
- Reinforced the rails which the flaw was found on the rail head, according to the necessity.

(5) Implemented education and training.
- Planned the standardization of inspection method and improvement of the inspection accuracy, by increased chances of practical education and training, referring the cases of the past accidents and the measures taken in the other companies, etc.

The investigation report of this case is published in the home page of the JTSB, published on February 23, 2017,
http://www.mlit.go.jp/jtsb/railway/rep-acci/RA2017-1-1.pdf

Case 4, Turnout — Occurred at about 17:32, Thursday, October 29, 2015

Train running in the turnout entered the route different to the designated direction and derailed

Summary : The outbound train composed of two vehicles departed from A station on schedule at 17:29. The driver of the train confirmed the speed restriction signal of the outbound home signal of B station, while the train was running at around No.11 turnout in the premises of B station at the velocity of about 20 km/h, and felt abnormal sound and applied the brake. But the driver further felt large sound and vibration, and the train had stopped. The driver confirmed the situation after the train had stopped, and found that all axles in the front bogie of the first vehicle had been derailed to right, and all two axles in the rear bogie of the first vehicle and all axles of the second vehicle had been entered the up main line in the branch line side different from the designated direction of travel, *i.e.*, the down main line.

There were 11 passengers, the driver and the conductor were boarded on the train, but no one was injured.

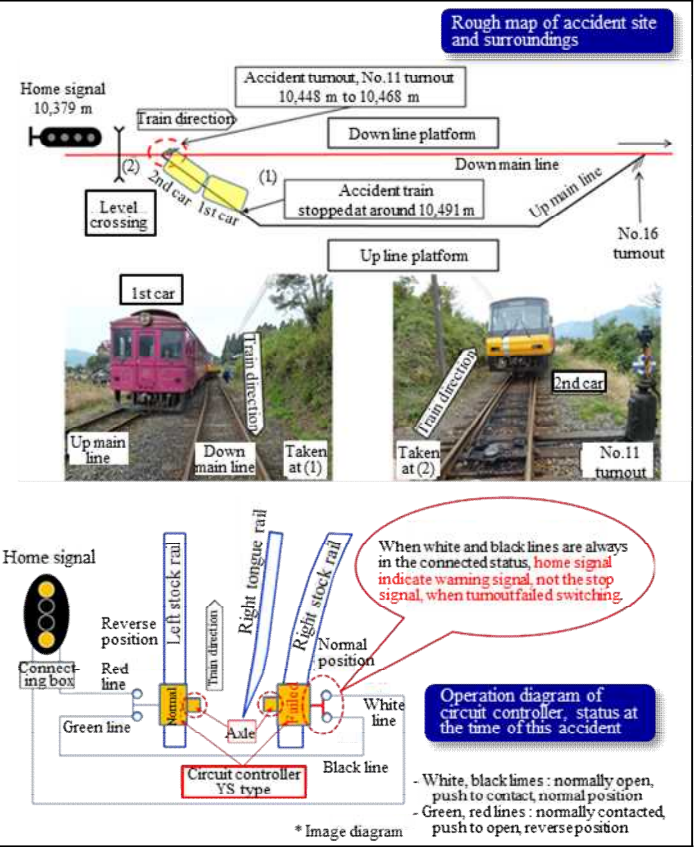
It is likely that the turnout had been in the status of defect of switching, furthermore, it is highly probable that the outbound home signal of B station had not indicated the stop signal, but had been indicated the speed restriction signal, when the train entered the down main line of B station. Therefore, the factors to cause these situations were analyzed.

(1) Defect of switching of the turnout

It is likely that the switching load exceeded the switching force of the spring switch, due to the increase of the coefficient of friction between the tongue rail and the floor board, caused by the lack of lubrication to the floor board in the point part of the turnout.

(2) Signal indication of the home signal

It is highly probable that the home signal did not indicate the stop signal but indicated the speed restriction signal even though the turnout had been in the status of the defect of switching, because the insufficient contact of the tongue rail could not be detected caused by that the contact point of the micro switch in the circuit control device to detect the defect of switching of the turnout did not switched and in the status as being conducted.



Probable causes : It is probable that right wheel flange of the first axle of the front bogie of the first vehicle went into the space between right stock rail and right tongue rail, and derailed to right, and the rear bogie of the first vehicle and all bogies of the second vehicle had entered to the up main line side different from the designated direction of travel, because right tongue rail of the turnout did not contact to the normal position side and in the status of the defect of switching, when the train entered the straight line side of the turnout obeying to the indication of the speed restriction signal of the home signal, in this accident.

For the prevention of recurrence

Required Safety Action : To comprehend the status that the home signal did not indicate the stop signal but indicated the speed restriction signal even though the circuit control device was in the status as could not detect the defect of contact in the home position side, was the dangerous status with the possibility of derailment, and implement the followings.

(1) Implement the maintenance and the management of changes by years of the circuit control device, certainly.

(2) Make reliability higher as not to spoil safety even in case of troubles.

Furthermore, it is desirable to implement lubrication to the floor board in the point part of the turnout, considering the status of rains, etc., in high frequency.

Measures taken by the operator after the accident

(1) Replaced the spring switch of the accident turnout by the new product.

(2) Decided the limited speed when passed the accident turnout and No.16 turnout in the premises of B station as 15 km/h or slower, and let the train crews known well, and newly installed the speed limit sign.

(3) Improved the security level of the circuit control device by making dual system in the home position side of the accident turnout and the No.16 turnout, because the exact signal control could not be implemented. Furthermore, replaced the circuit control device by new one.

(4) Implemented the switching test of the accident turnout once a month, in order to reinforce the confirmation of safety.

(5) Increased the number of the lubrication for the floor board in the point part of the accident turnout, certainly in the inspection described in the above (4) and when the effects by rainfalls are considered.

The investigation report of this case is published in the home page of the JTSB, published on September 29, 2016,
http://www.mlit.go.jp/jtsb/railway/rep-acci/RA2016-7-1.pdf

Case 5, Others　　Occurred at about 11:58, Thursday, August 27, 2009

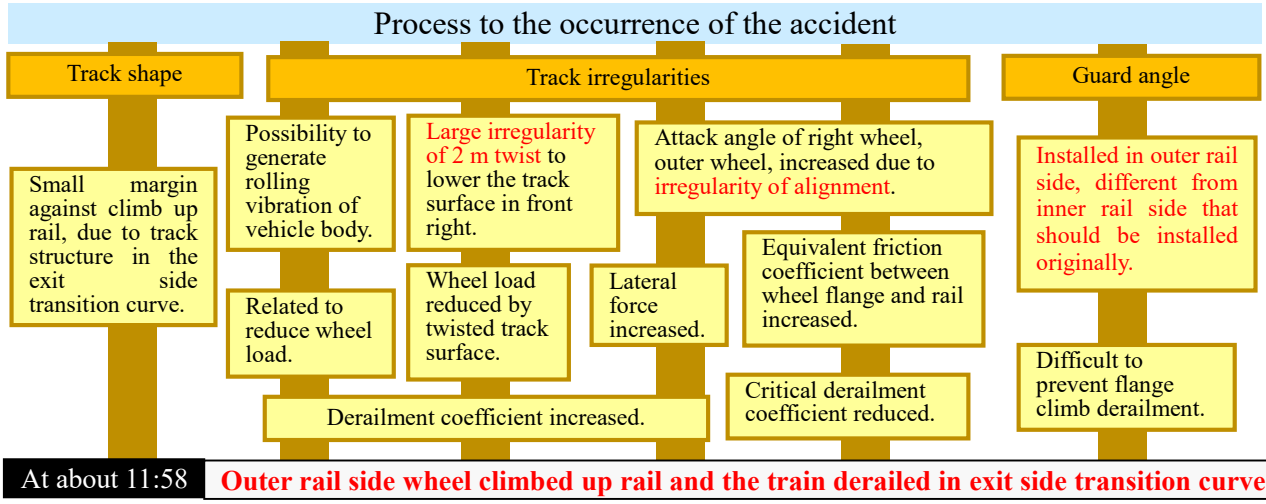
Train ran over the rail and derailed by the track irregularities in exit side transition curve

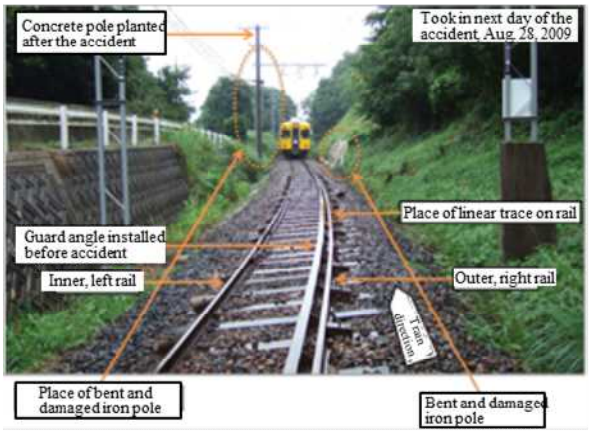
Summary : The outbound train composed of two vehicles departed from A station on schedule at 11:57, by the one-man operation. The driver of the train, while operating in the powering operation in the 200 m radius left curve at the velocity of about 55 km/h, felt abnormal sounds and vibration in the vehicle, therefore applied the emergency brake to stop the train.

All two axles in the front bogie of the front vehicle had been derailed to right.

There were 18 passengers and the driver were boarded on the train, among them, three passengers were injured.

Process to the occurrence of the accident





Probable causes : It is probable that right wheel in the first axle in the front bogie of the front vehicle climbed up right rail, outer rail, and derailed to right, because the lateral force had increased and the wheel load had decreased for the right wheel, outer rail side wheel, due to the existence of the irregularity of alignment in the direction to shorten radius of curvature and the irregularity of 2 m twist in the direction to lower front right of the track surface, in the exit side transition curve connected to the 200 m radius curve. In addition, it is highly probable that the derailment could not be prevented because the guard angles had been installed in outer rail side, different from the inner rail side where it should originally been installed.

For the prevention of recurrence

Required Safety Action :

(1) Guard angle in this accident site

- It is highly probable that this derailment accident could not be prevented because the guard angles had been installed in the place different from the place where it shall be installed originally.
- It is necessary to implement the safety measures of the company by using sufficiently the railway accident investigation reports and the security information, etc., and comprehending the purpose of the measures to prevent the recurrence which should be taken after the accident from the examples of the other accidents.

(2) Method of track management

- Comprehend the track irregularities from the results of the track inspection, review to enable the proper management of the track irregularities, and should maintain the track in good condition.

Measures taken by the operator after the accident

(1) Installed the guard rail in inner rail side of the accident curve, in addition, installed the guard angles in inner rail side of the curve in eight curved section, with the radius of 200 m or shorter, where the guard angles or the guard rails had been installed only in the outer rail side.

(2) The company reviewed the track management so as to estimate the track irregularities based on the measured values of the track measurement in the periodic inspection and manage the track irregularities based on the maintenance standard values.

The investigation report of this case is published in the home page of the JTSB, published on August 27, 2010,
http://www.mlit.go.jp/jtsb/railway/rep-acci/RA2010-4-1.pdf