RA2007-3-1

Railway Accident Investigation Report
(Excerpt)

Train Derailment Accident between Tsukaguchi and Amagasaki Stations of the Fukuchiyama Line of the West Japan Railway Company

June 28, 2007

Aircraft and Railway Accidents Investigation Commission

Railway Accident Investigation Report

Railway operator:	West Japan Railway Company
Accident type:	Train derailment
Date and time:	Around 9:18, April 25, 2005
Location:	Amagasaki City, Hyogo Prefecture Between Tsukaguchi and Amagasaki Stations of the Fukuchiyama Line (approx. 1,805 m from the Origin at Amagasaki Station)

June 22, 2007

Adopted by the Aircraft and Railway Accidents Investigation Commission

Chairman	Norihiro Goto
Member	Yukio Kusuki
Member	Yasuo Sato
Member	Toshiko Nakagawa
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Member	Akiko Matsuo

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1. Process and Progress of the Railway Accident Investigation

1.1. Summary of the Railway Accident

The rapid up train "5418M" (a seven-cars train set) operated by the West Japan Railway Company started from Takarazuka Station bound for Doshisha-mae Station left Itami Station about 10 s past 9:16 a.m., April 25 (Monday), 2005. After passing through Inadera Station, the train passed through Tsukaguchi Station about 22 s past 9:18 a.m. Then, while the train was running along a 304 m-radius rightward curved track located to the south of the Meishin Expressway, the first car of the train fell left and derailed about 54 s past 9:18 a.m. This was followed by derailment of the second to fifth cars. The rearmost car (seventh car) stopped about 4 s past 9:19 a.m.

The first car toppled left to the ground, with the front section of the car collided against the wall of the back of the mechanical parking lot on the first floor of a condominium located to the east of the railway track and the lower part of the rear section of the car colliding against the northwest column of the condominium. The left side of the middle section of the second car collided against the northwest column of the condominium with the body of the second car jackknifed with the rear section of the first car caught in between. The left side of the rear section of the second car collided against the northeast column. Both wheelsets of the third car's front bogie derailed to the left, both wheelsets of the third car's rear bogie derailed to the right, both wheelsets of the fourth car's front and rear bogies derailed to the right, both wheelsets of the fifth car's front bogies derailed to the left, and the left wheels of both wheelsets of the fifth car's rear bogie derailed with the wheels lifted off the rail. The sixth and seventh cars did not derail.

The number of people killed in the accident was 107 (106 passengers and the driver), and the number of people injured was 562 (562 passengers, according to the information provided by the Hyogo Prefectural Police Headquarters).

1.2. Outline of the Accident Investigation

1.2.1. Investigation Organization

On April 25, 2005, the Aircraft and Railway Accidents Investigation Commission (hereinafter referred to as "the Commission") appointed an investigator-in-charge and four other railway accident investigators to investigate the accident. In addition, one, two, two, one, and one additional railway accident investigators were appointed on May 9, June 2, June 13, June 20, and July 19 of the same year, respectively, and one additional railway accident investigator was appointed on February 17, 2006.

The Commission sent the chairman, members, expert adviser, the director-general, railway accident investigators, and other staffs to the accident site and related places.

On April 26, 2005, the Commission appointed Professor Yoshihiro Suda of the Center for Collaborative Research of the University of Tokyo as an expert adviser to investigate the accident in relation to vehicles.

The Kinki Transport Bureau sent its staffs to the accident site to provide support for the investigation of the accident.

For the investigation of the accident, the Commission entrust component analyses of the samples of adhering materials taken from railway facilities, vehicles, etc.; the test to reproduce and measure the shifts of the centers of gravity of the passengers in the individual vehicles; computer simulations of the derailing and swaying of the individual vehicles; the ballast scattering test; the test to measure the brake performance (test using actual trains); and other tests and simulations to the Railway Technical Research Institute (incorporated foundation).

The Commission also entrust the task of analyzing the audio recorded data in the long-time audio recording equipment to Japan Acoustic Lab. and TEAC Corporation and the task of testing the monitor equipment to Koito Industries Limited.

The Commission obtained information on the accident from the Hyogo Prefectural Police Headquarters, Amagasaki City Fire Department, Kobe City Fire Department, Osaka City Fire Department, and other organizations concerned.

The Commission also obtained the cooperation of passengers, witnesses, and other people concerned.

1.2.2. Implementation of Investigation

On-site survey: April 25 to May 6, 2005, May 17 to 28, 2005, and July 21, 2005

Performance test using actual trains (conducted on the Fukuchiyama Line): June 13 to 16, 2005, October 19 to 21, 2005, and February 3 to 5, 2006

Braking test using actual trains (conducted on the Sanyo Line): October 2 to 28, 2006, and November 12 to 19, 2006

Examinations and tests of railway facilities and vehicles: May 10, 2005, to March 17, 2006

Interviews and questionnaire surveys: April 25, 2005, to May 27, 2007

Ballast scattering test: December 13, 2005, and February 17, 2006

Test to reproduce and measure the shifts of the centers of gravity of the passengers subjected to the centrifugal force in the individual vehicles: November 1, 2005

Simulations of the derailing: December 12, 2005, to March 17, 2006, and June 30, 2006, to August 31, 2006

1.2.3. Interim Report of the Investigation and the Proposals

On September 6, 2005, the Commission submitted an interim report prepared based on the results of the factual investigation conducted up to that day to the Minister of Land, Infrastructure, Transport and Tourism and made the proposals for the improvements to be made in the short term to the Minister (see Attachment 1).

1.2.4. Hearing Public Comments

A "Draft of Reports on Factual Investigation", written in Japanese, was published on December 20, 2006, and a hearing was held on February 1, 2007, in which 13 witnesses were interviewed.

(1) Time and date of the hearing: from 10:00 a.m., February 1 (Thursday), 2007

(2) Location of the hearing: Common Meeting Room A (on the tenth floor of the Central Government Building No. 3, 2-1-3 Kasumigaseki, Chiyoda-ward, Tokyo) of the Ministry of Land, Infrastructure, Transport and Tourism

(3) Chairperson for the hearing: Masato Kakami (director-general of the Commission)

(4) Witnesses

People who were asked by the Commission to be interviewed as witnesses:

Masakazu Iguchi (Professor Emeritus, The University of Tokyo)

Nobukuni Ishii (Adviser, Japan Train Operation Association (an incorporated association))

Isao Kuroda (President, Japan Institute of Human Factors)

People who volunteered to be interviewed as witnesses:

Kazuaki Maruo	(Vice President of the West Japan Railway Company and the head and an operating officer of the Railway Headquarters of the West Japan Railway Company)
Hideo Yamanaka	(Assistant General Manager, Conduits Department, Nakai Engineering Co., Ltd.)
Kiyomichi Sugihara	(Secretary-General, Central Headquarters, West Japan Railway Company Labor Union)
Satoshi Ogura	(Subsection Head, REIJINSHA Co., Ltd.)
Yasakazu Asano	(President, CKKplan.net)
Kazumitsu Shinohara	(Associate Professor, Graduate School of Human Sciences, Osaka University)
Makoto Maekawa	(Vice Chairman, Central Headquarters, West Japan Railway Company Labor Union)
Seiji Abe	(Professor, Faculty of Commerce, Kansai University)
Shogo Yoshioka	(Secretary-General, Western Japan Headquarters, Japan Railways Labor Union)
Kazuhiko Nagase	(Professor, Department of Mechanical Engineering, Kanazawa Institute of Technology)

(5) Outline of the hearing and the Commission members who participated in the hearing

Refer to "Proceedings of Hearings for Railway Accidents (Hearing for the Train Derailment Accident on the Fukuchiyama Line of the West Japan Railway Company held in February 2007)," written in Japanese.

1.2.5. Comments from the Parties Relevant to the Cause of the Accident

The Commission held hearing of opinions with parties relevant to the cause of the accident.

2 Factual Information

2.2 Train Operation on the Day of the Accident

2.2.7 Operation of the 5418M from Itami Station to the Accident Site

After leaving Itami Station at around 9:16:10, approx. 1 minute 20 seconds later than the schedule time, the accident train continued power running and passed Inadera Station (center of the station) at around 9:17:38. The accident train further continued power running to reach 124 or 125 km/h in excess of its maximum speed of 120 km/h described in 2.10.1.2 approx. 75 m before the up home signal 8LC at Tsukaguchi Station, up line 3k212m at around 9:18:09 (at this time, it is imagined that the speed meter of the first car indicated "121 km/h" or "122 km/h" due to its instrument error described in 2.9.4.1). Around that time, the service brake B1 notch was applied for approx. 2.0 seconds almost simultaneously with stopping power running and the accident train passed Tsukaguchi Station by coasting at around 9:18:22, approx. 1 minute 12 seconds later than the schedule time.

Continuing to coast, the accident train passed the up starting signal 6L at Tsukaguchi Station at approx. 122 km/h, the point at which brake application should be started, followed by the No. 4 up block signal at approx. 118 km/h. After that, it entered into the right circular curved track (beginning of circular curved track (end of transition curve), up line 1k949m) at the accident site with the speed limit of 70 km/h at approx.116 km/h. After passing the Kubota River bridge, up line 1k927m, the service brake B1 notch was applied, followed by the service brake B3 or B4 notch for 0.0 to approx. 0.2 second altogether at around 9:18:50, and then, service brake B5 notch for approx. 0.8 second, service brake B6 notch for 0.0 to approx. 0.2 second, and service brake B7 notch for approx. 2.4 seconds, respectively. Around the time of passing the No. 41 sub column[23] near up line 1k814m at approx. 105 km/h (approx. 2.4 seconds after passing the end of circular curve (beginning of circular curve), up line 1k889m), the service brake B8 notch was applied, but the first car derailed at around 9:18:54, as if tumbling to the left.

At the time of derailment, the accident trains was applied with emergency braking by an equipment factor, not by operating a brake handle,

[23] When there are pairs of poles connected with a beam on both sides of the railway, the pole on the down track side (right side with reference to the travel direction of the accident train) is called a "main column" and the one on the up track side is called a "sub column," respectively.

followed by backup braking approx. 1.0 second later (application of backup braking is estimated based on the monitor records at the accident train).

After that, the seventh car stopped around 9:19:04. When the seventh car stopped, the rear end part was located near up line 1k825m.

The communication record file "204T091757a" saved in a long-time audio recording device, which recorded communications by train radio between the conductor of the accident train and a train dispatcher(hereinafter referred to as "the train dispatcher A") at the General Control Center just before the accident, described in 2.8.7.2, covers their communications between when the accident train was running near the No.1 up block signal between the Inadera Station and Tsukaguchi Station and when the seventh car of the accident train stopped.

The time the accident train passed the point at which brake application should be started was during 5 seconds or so from around the time when the train dispatcher A repeated "8 m beyond the rear limit."

(See Figs. 1, 2, 5, 6, 12, 14, 16 (Parts 1 and 2), 19, 24, 25, 26, 27 and 32 (Part 2))

2.2.9 Statetments of Train Dispatcher A

The train dispatcher A at the General Control Center, who communicated with the conductor of the accident train by train radio after the accident train had left Itami Station, stated his communications as follows.

As the conductor of the accident train reported to me that the accident train had overrun the predetermined stop position by 8 m at Itami Station and left there 1 minute and a half late, I repeated that the train had overrun by 8 m, and asked about the delay again. I think I asked again because the crew generally says "1 minute 30 seconds," but the conductor of the accident train said "1 minute and a half."

(See 2.8.7.2)

About my addressing the train driver of the accident train after finishing communications with the conductor, it was because I did not know there was no level crossing ahead of Itami Station, and tried to ask the positional relations with the level crossing, worrying about the level crossing being not closed or left closed due to a retreat of the train, if there is any.

(See 2.12.1)

If an overrun distance is 8 m, a delay is generally approx. 30 seconds.

When I heard the delay was 1 minute 30 seconds, I figured it might contain a delay consequent upon boarding and alighting of passengers at the station, but I never imagined the conductor of the accident train had reported a shorter distance than the actual one.

Because I only have experienced working as a conductor, not a train driver, and do not know whether the train driver is busy operating the train, I sometimes address the train driver by train radio in such cases as well. If the train driver is busy, he would not respond. If he does not respond, I do not address him more than necessary, figuring he is busy.

(See Figs. 24 and 25)

2.2.10. Statetments of a Passenger Who Was on Board the Train at the Time of the Accident

2.2.10.1 Statement of the Passenger 1A (Female in her teens)

I got on the first car at Takarazuka Station and seated on the left side of the travel direction between the second and third doors.

After leaving Itami Station, I was sleeping around Tsukaguchi Station, but was awakened by violent "rattling" of the car body. The first car was tilted instantly; it had been considerably tilted before ramming into a condominium (to be simply referred to as the "condominium") located on the east (left) side of the railway near the accident site. At the same time as the passengers sitting on the other side (right side of the travel direction) fell down, it got completely dark inside the car and I felt people and objects banging against me.

I received cuts on my hands and legs, but got out of the first car by myself. It is not clear where I got out of from, but I climbed a wire net hung in the pit of a mechanical parking space to get out. I went to a hospital, accompanying other heavily injured passengers of the first car.

2.2.10.2 Statement of the Passenger 1B (Male in his 40s)

I got on the first car at Kawanishi Ikeda Station and was standing at the right third door while watching outside. The seats were fully occupied and there were some standing passengers.

The train overran as far as just before the No. 5 up block signal at Itami Station. When the train started moving back, I saw a green light ahead and figured the train had stopped at the 11th hour. When moving back, the train ran at a modest speed because there was a distance.

There was nothing unusual after leaving Itami Station. A few moments after leaving Tsukaguchi Station, the train was violently braked. I looked ahead with a start and saw a curve approaching in front. I felt a considerable speed. Apparently impossible to successfully turn the curve, I immediately felt being pushed outward by a centrifugal force. I grabbed a door handrail, but the centrifugal force was so strong that I disparately held onto it. I hoped the train could turn the curve somehow, but the right side of the car body started "floating" and was never completely lowered down to the ground. In the meantime, I felt derailment of the left wheels and saw the condominium in front, ramming into it straight.

Then, I found myself buried from both knees down under several passengers lying at my feet.

I received heavy injuries such as a lung contusion in this accident.

(See Figs. 15 and 29)

2.2.10.3 Statement of the Passenger 1C (Female in her 20s)

I got on the first car at Takarazuka Station and was standing face to face with my friend before the right-side seat of the travel direction between the third and fourth doors, facing the rear of the travel direction.

After leaving Itami Station, there was an announcement to notify that the next stop is Amagasaki Station, followed by another one "We are deeply sorry for an overrun."

Approaching the curve at the accident site, I was talking about a high train speed with my friend. Then, the windows started "rattling," the train was abruptly braked, generating a piercing squeaky sound which I had never heard, and the car started tilting to the left. Because I was standing, facing the direction orthogonal to the tilting direction, I fell down to the left more belatedly than the passengers around me. Over the shoulder of my friend standing face to face with me, I saw shifting of the front-end window of the second car visible through the rear-end window of the first car. When the car was tilted by approx. 40 to 45°, lighting went off in the car. About that time, I saw the second car tilting in the same direction as the first one. After seeing a lady holding onto a strap in the second car falling backward, I closed my eyes.

Immediately after getting dim, the train caved in with a "thump." Vibrations were felt 5 to 6 times greater than the Great Hanshin Earthquake.

It was "chaotic" in the car like in a washing machine. Struck all over the body, I finally fell down onto someone. I climbed a net wire hung in the pit of a mechanical parking space to get out of the car. Other three passengers or so got out in the same manner.

I received injuries such as the crushed shin of the left leg in this accident.

(See Figs. 15 and 29)

2.2.10.4 Statement of the Passenger 1D (Male in his 20s)

When the accident train was pulling into Kawanish Ikeda Station on the day of the accident, I was waiting on the platform, but it did not overrun.

I got on the first car and stood before the right-side seat of the travel direction between the second and third doors. When I got on the train, there was no empty seats and several passengers were standing. The number of passengers did not increase so much at Itami Station.

After leaving Itami Station, there was an announcement of apology as to an overrun.

The train had always decelerated the speed around Tsukaguchi Station, but did not at that time, running at a high speed.

Generally, once the train enters into the curve at the accident site beyond the Meishin Expressway, the car body tilts to the right. At the time, however, it kept running without tilting. When I saw the train driver's seat, I noticed a train driver, but could not see fine movements. As the car body tilted more to the left, I regrabbed a strap with both hands, but could not endure the tilt, falling down to the left-side seat. I did not know, but the left-side window glasses were broken halfway.

I was not sure whether I had lost consciousness, but when I came back to myself, I found myself in the front part of the car, caught by other passengers from above and below. I could not see the front part of the car body because it was bent. In the car, I heard a female passenger saying, "It hurts" and someone saying, "Call the police," but it was calm, not noisy. Some passengers got out of the car through the broken windows. I also got out into the pit of the mechanical parking space through the same window.

I received a bruise requiring 1 month to heal and had the waist and both ankles sprained in this accident.

(See Fig. 15)

2.2.10.5 Statement of the Passenger 1E (Male in his 40s)

I got on the first car of the accident train at Kawanishi Ikeda Station and was standing facing the travel direction, with my left shoulder leaning against the rear handrail of the left fourth door.

Approaching next Itami Station, I was standing ready for the train to be braked, but it kept running without being braked. I was puzzled.

I supposed the accident train had moved back at a modest speed after stopping.

More than 1 minute, I felt, after leaving Itami Station, when I looked in the travel direction, wondering why there is no announcement of apology different from usual, I saw the train driver calling someone. I thought the train driver was talking to a conductor. I remember the train driver was talking, holding a receiver in his right hand. There was an announcement of apology immediately after the train driver had put down the receiver, but it seemed to be finished in a short time.

Since a factory came into my sight while running, I knew the train was almost arriving at Tsukaguchi Station. At that time, I felt the train speed was as usual, not faster.

I did not notice the car body was tilting near the accident site, but was startled because a female passenger standing near the door on the opposite side was thrown over to me. I felt myself being pressed to my left shoulder and there occurred continuous fine "rattling."

When I thought "What's going on?" the railway flagstones were closing in on me and I realized the car had fallen down.

I had no subsequent memory, and when I came back to myself, I found myself in the pit of the mechanical parking space.

I remember the thrown-over female passenger was lying near my right hand. When I looked up, I saw the fully opened door of the accident train.

Other passengers were climbing a fence hung from above to get out of the pit, but I could not because my injuries hurt too much. After a while, a stepladder extended like a ladder was lowered into the pit. I climbed it slowly, but there was a fence at the top of climbing. Because I could not climb it over, it was cut off for me to get out.

About 1 hour after that, I was brought to a hospital in a private car (like a van).

I received heavy injuries such as a rib fracture.

2.2.10.6 Statement of the Passenger 1F (Male in his teens)

I got on the accident train at Itami Station and was standing holding on to a handrail, facing the left side of the travel direction on the front side of the left first door of the first car.

I was looking outside through a door window. I glanced at the back view of the train driver after the train started derailing, but at that time, he was tilted in a normal driving posture, holding a handle without panicking.

I remember there was a factory near where the car body started tilting. With my sight gradually lowered toward the ground, I felt my body slightly floating and falling down, so I instantaneously held onto my handrail with both hands. At that time, I heard other passengers screaming in a frightening voice.

As the car body was tilting, squeaky noise was heard as if generated from the wheels, followed by an impact and a crashing sound, and the car body fell down.

When I came back to myself, it was completely dark. I think my body was thrown over onto the equipment in the train driver's seat, breaking through the rear glass window of the train driver's seat.

The forefront glass of the train was shattered, allowing me to communicate with a rescue squad. I was rescued 22 hours after the occurrence of this accident.

I received a heavy injury requiring to have both legs amputated.

(See Fig. 15)

2.2.10.7 Statement of the Passenger 1G (Male in his 30s)

I got on the first car at Kawanishi Ikeda Station and was standing with my back against the travel direction, near the front handrail of the left third door.

After the accident train stopped beyond its predetermined stopping position, it suddenly started moving back in a rough manner after a lapse of 10 seconds or longer. I felt the speed had been relatively high and the train had stopped abruptly.

I think there was an announcement after leaving Itami Station, but do not remember what was announced and when. I felt the accident train ran at a considerably high speed with shaking as if riding a new rapid train from

Osaka to Sannomiya.

As the train started turning near the accident site without deceleration, I wondered whether it can make it. When I looked back to the left in the direction of the train driver's seat, the right side floated lightly and the scenery gradually started tilting to the right as if the train was slowly tilting to the left. At that time, I crouched because I could not hold onto something right away.

When I looked in the direction of the train driver's seat, the train driver was not moving at all in a normal driving posture. I think I saw the train driver when the train was about to start tilting.

When the train tilted lightly, someone struck me as if falling down from behind. From that moment until the train came to stop, the internal situation of the train was like in a washing machine and I felt like being struck by a sandbag. When the train was tilting, I think I saw the left-side window glasses being broken into pieces.

When I came back to myself later, I found myself lying on the backrest of the seat with my head to the travel direction, legs stretched and right side of the body downward. A few passengers were piled on me. I saw a downward window through a gap between the passengers, but its glass looked broken. Because a few people were piled on me, I could not move until a rescue squad arrived.

I received heavy injuries such as a pelvic fracture in this accident.

2.2.10.10 Statement of the Passenger 2C (Male in his 20s)

While chatting with my friend, I was waiting for a train, sitting in a chair close to the center of nine of them located to the direction of Amagasaki Station in a designated smoking area. As the accident train was coming, I stood up from the chair and moved straight forward in order to get on. When the accident train stopped after moving back, I was standing in front of the first door of the second car.

I was standing at the first door, facing the left side of the travel direction. Around the time of passing Tsukaguchi Station, the car body shook around. As I lost my balance and was almost falling down, I grabbed a strap.

I remember hearing squeaky sound when the train neared the curve at the accident site. I took a train after a long time, but I felt a high running speed and said so to my friend.

I saw the first car tilting to the left. First I thought it was tilting because of the curve. Changing for the worse, it tilted rhombic to an extent that the right corner came to the middle. I was startled and found may car also tilted.

I have no memory after that. I think someone probably rescued and carried me to a hospital in an ambulance.

I received heavy injuries such as a brain contusion and a fracture.

(Note) According to this statement, the stopping position of the accident train at Itami Station after moving back is approx. 3 m backward (to Fukuchiyama Station) from the predetermined stopping position.)

(See Fig. 15)

2.3 Information on the Deaths and Injuries Caused by the Accident

2.3.2 Locations in the Train at the Time of the Accident of the Passengers Killed in the Accident

According to police information, the numbers of male and female casualties for each car are as illustrated in Fig. 55. Of the dead passengers, 102 of them were in the first to third cars except for 4 passengers whose boarded car numbers were not identified.

2.8 Information on Railway Facilities

2.8.2 Railway Tracks

2.8.2.1 Structure of the Track

With a 1,067-mm gauge, the track structure near the accident site consisted of 50-kgN rails and 39 PC sleepers per 25 m, using a ballast bed with a thickness of 250 mm, and the ballast fastener had been sprayed on the left-side ballast of the left rail in the up track.

The cant[50] of the circular curve section of a radius of 304 m near the accident site is 97 mm. When running at a limited speed of 70 km/h, the cant deficiency[51] for equilibrium cant of 135.4 mm is 38.4 mm, being within a

[50] In order to prevent a centrifugal force at the time of running along a curve from having a bad effect on running safety and riding comfort, the outside rail of the curve is installed higher than the inside rail. The "cant" refers to a setting value of level difference between the outside and inside rails of the curve in this case. The "balanced cant" refers to a cant at which the direction of the resultant force of the centrifugal force and the gravity applied to the car becomes rectangular to the track level, and apparently eliminating the centrifugal force. It is determined by a speed, curve radius and gauge.

[51] The "cant deficiency" refers to an actual cant deficiency for the equilibrium cant (cant deficiency = equilibrium cant – actual cant > 0), and the "permissive cant deficiency" refers to the upper limit of the permissive cant deficiency from a viewpoint of running safety and riding

permissive cant deficiency for the car of the Company, 50 to 110 mm (60 mm for the 207 series train). Gauge widening52 in the circular curve section is 10 mm.

A rail lubricator53 had been installed at the left rail in the up track near up track 1k922m.

(See Fig. 5)

2.8.2.2 Inspection of the Track

"Track irregularity inspection" was conducted by a high-speed track inspection car on Feb. 18, 2005, which has to be conducted once or more a year as provided by the Railway Structure Implementing Standards and its results indicated no abnormalities. Also, track maintenance work was conducted on Feb. 23, 2005 and Apr. 10, 2006, respectively. Inspection conducted thereafter found no abnormalities.

(See Fig. 9)

2.8.5 Operation Records of the Level Crossing Protection Device for the Daiichi Shin Yokomakura Level Crossing

An operation records (hereinafter referred to as "the level crossing memory") is installed in the level crossing protection device for No. 1 Shin Yokomakura level crossing.

As with An operation records of the interlocking device (hereinafter referred to as "the interlocking memory"), the level crossing memory samples the contact opening or closing status of a major relays every 1/64 second. Different from the interlocking memory, however, it records a contact opening or closing time as effective only when a sampling result is the same as the preceding two times.

The level crossing memory contained a relay contact opening or closing record seemingly corresponding to when the accident train ran from near Tsukaguchi Station to near the accident site.

The clock of the level crossing memory has a function to calibrate by a

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comfort.

52 In a curved section, the gauge has been expanded to the inside of the curve so that the bogie can run smoothly. The setting value of this gauge expansion iscalled "gauge widening."

53 The "rail lubricator" is an apparatus designed to mainly apply grease to the outside rail at a sharp curve in order to inhibit wear of the rail.

clock calibration signal to be output at 3:00 every day by a GPS based automatic time correction unit device. The level crossing memory contained a record of having calibrated the clock at 3:00 on the day of the accident.

According to the level crossing memory, it took about 7.8 seconds from when the rear-end wheel axle of the accident train passed a safety block section boundary located near the No.4 up block signal between Tsukaguchi Station and Amagasaki Station until when the front-end one of the wheel axles (limited only to those having track-shunted the safety block of the No. 3 up block signal to Amagasaki Station) of the accident train passed a safety block section boundary located near the No. 3 up block signal. On the other hand, according to a records of the onboard ATS-P equipment at the first car (hereinafter referred to as " the P1 records") as described in 2.13.6.2, it took approx. 7.1 seconds from when the rear-end wheel axle of the accident train passed the safety block section boundary located near the No. 4 up block signal until when the front-end wheel axle of the accident train passed the safety block section boundary located near the No. 3 up block signal. Accordingly, the safety block of the No. 3 up block signal to Amagaski Station was track-shunted approx. 0.7 second after the front-end wheel axle of the accident train entered the track-shunted.

According to the level crossing memory, there was a change of the relay contact opening or closing status presumed to have resulted from track-shunt of the safety block Down-1T between the No. 1 down block signal, down line 1k769m and the down home signal at Tsukaguchi Station by the derailed fourth car at around 9:19:02 on the day of the accident.

Furthermore, the records indicate that the push button of the obstruction warning device for level crossing for the No. 1 Shin Yokomakura level crossing was pushed in at around 9:20:25 on the day of the accident.

(See Figs. 6 and 27)

2.9 Information on Vehicles

2.9.2 Brake Equipment

2.9.2.6 Inspection of the Braking System

Concerning the first to fourth cars of the accident train, a regular inspection68 was conducted at the Aboshi Comprehensive Railway Yard, Akashi Quality Control Center of the Company on Apr. 13, 2005. This

[68] A "regular inspection" is conducted on the status and functions of the cars in a regular train set.

inspection included replacement of brake shoes exceeding a wear limit, a test to check operations of service, emergency and backup brakes, and a test to check operations of an electric air compressor, and every test report says "no abnormalities found."

Concerning the fifth to seventh cars of this accident train, the regular inspection was also conducted at the Akashi Quality Control Center on Apr. 14, 2005 and every inspection/test report says "no abnormalities found."

2.9.7 Static Wheel Load Ratio

The following table lists the ratios of wheel load unbalance[71] of the first to seventh cars at the latest inspection time. They have met a criterion of 1.15 or less provided by the Electric Train Maintenance Regulations, part of the reported implementating standards.

They were measured at the time of general inspection completed on Dec. 29, 2002 as to the first to fourth cars and at the time of important parts inspection completed on May 18, 2004 as to the fifth to seventh cars, respectively.

Table 18. Ratios of Wheel Load Unbalance of First to Seventh Cars

	Front bogie		Rear bogie	
	First axle	Second axle	First axle	Second axle
First car	1.004 (R)	1.006 (R)	1.024 (L)	1.030 (L)
Second car	1.013 (R)	1.060 (R)	1.104 (L)	1.064 (L)
Third car	1.001 (R)	1.021 (R)	1.031 (L)	1.022 (L)
Fourth car	1.079 (R)	1.082 (R)	1.019 (R)	1.017 (L)
Fifth car	1.023 (L)	1.005 (R)	1.026 (L)	1.042 (L)
Sixth car	1.032 (R)	1.012 (L)	1.018 (R)	1.038 (L)
Seventh car	1.026 (R)	1.023 (L)	1.026 (L)	1.012 (L)

* (R) indicates that the wheel load of the right wheel is higher than that of the left wheel, and (L) vice versa.

2.9.8 Inspection of the Accident Train set and Its Records

The following table lists the dates of latest inspections on the first to

[71] A "ratio of wheel load unbalance" here refers to a higher ratio to the average value of the right and left wheel loads.

seventh cars. These inspection records do not indicate other abnormalities than those of the speed meter described in 2.9.4.4.

Table 19. Dates of Latest Inspections

Type of inspection	Inspection frequency (within the following period)	First to fourth cars	Fifth to seventh cars
General inspection	8 years	Dec. 29, 2002	Oct. 26, 2001
Important parts inspection	4 years or car mileage of 600,000 km	Jan. 29, 2000*	May 18, 2004
Regular inspection	90 days	Apr. 13, 2005	Apr. 14, 2005
Daily inspection	5 days	Apr. 24, 2005	Apr. 24, 2005

* The important parts inspection items are included in the general inspection items.

2.10 Duties of the Onboard Train Drivers

2.10.12 Reciting and Making Notes of Instructions etc. from Train Dispatcher, Stationmaster, etc.

Recording and repetition of the notifications, etc. from the train dispatcher and the stationmaster are prescribed as follows in the Basic Section for "Operation."

"When the train crew receives a notification or an instruction (excluding information from the train dispatcher) from the train dispatcher or the stationmaster, he has to record and repeat the required matters such as an instructor's name, time and content (at the possible time of recording if impossible when receiving the instruction), even if not specified in the Work Standards.

Record in the specified sheet (operating notice card, etc.) if any, and record in the Crew Roster, etc. if not."

When a notification is received by a radio, etc. its entry into the operating notice card is prescribed as follows in the Basic Section for "Operation."

When an operation notification is received by a radio, etc. during train operation, be sure to record its content in the operating notice card. In this case, observe the following, prioritizing the safety of the train.

(1) Local train

Basically, record in the operating notice card after stopping at the next stop.

(2) Other trains

Although it differs depending on the conditions of the railway section, content of the notification, and so on, stenograph the required matters on an expedient sheet of paper, portable timetable, etc. and record them in the predetermined operating notice card after stopping at the next stop as a basic rule. If the crew admits it necessary for safety, however, he may stop the train at the nearest station, etc. to record after contacting the train dispatcher.

2.16 Overview of the Accident Site

2.16.1 Traces Left on the Track

Concerning the up track near the accident site, there were many vestiges on the left side of the left rail from the No. 107 to No. 146 sleepers, seemingly left by running of wheel flanges, etc. Of them, intermittent linear vestiges (to be referred to as "vestige lines") were found on the No. 107 (up track 1k818m) to No. 113, No. 116 (up track 1k812m) to No. 124, No. 128 (up track 1k805m) to No. 134, and No. 137 (up track 1k799m) to No. 146 sleepers, respectively. These four vestige lines seem to have been left by running of the left wheel of the first or second axle of the different single bogies, respectively.

Intermittent curved scratches were found within the gauge from the No. 161 to No. 180 sleeper, and there was lateral displacement of the track to the left in that section.

Furthermore, there was damage on the right side of the right rail from the No. 198 to No. 201 sleeper and lateral displacement of the track to the left in that section, respectively.

On the left rail near the above-mentioned vestige lines, there were vestiges seemingly left by running of the wheel flanges, etc.

Concerning the down track, there was damage on the left side (up track side) of the left rail (up track side) from the No. 321 to No. 335 sleeper and lateral displacement of the track to the right in that section.

Furthermore, the ballast between the up and down tracks seemed to have been shoved to Amagasaki Station by the rear bogie of the third car.

A distance between the up track panel[94] and down track panel was expanded near the No. 195 sleeper.

(See Figs. 5 and 7 (Parts 2 to 4))

2.16.2 Status of Scattering of Ballast, etc.

After the No. 85 sleeper, fine powder looking like crushed ballast was found around the fastening device at left rail and white powder was found on the top surface of the rails, respectively. Scattered after the No. 82 sleeper was the ballast exposing the surface bonded by grouting agent for the ballast

Furthermore, many white vestiges were found on the side surface of the left outside rail. There were scattered pieces of ballast of the standard grain size on the top surface of the rail bottom near the rail fastening device on the side of the left outside rail as if corresponding to these vestiges.

(See Fig. 7 (Part 1) and Fig. 8 (Parts 1 and 2))

2.16.3 Three-dimensional Measurement of Tracks, etc.

The contour line map of the section from the up-track No. 47 to No. 108 sleeper (up track 1k857m to 1k817m) created based on three-dimensional measurement data and the longitudinal profiles at the positions of 0.1, 0.2, 0.3, 0.4 and 0.5 m from the end of the sleepers in that section are provided, respectively.

On the left side of the left rail, the ballast height abruptly decreases after the No. 90 sleeper.

Also, there are periodic ups and downs having bumps (artificially made to place replacement rails) peaking at the Nos. 53, 64, 73 and 84 sleepers, respectively, and the ballast fastener was found near those bumps.

(See Fig. 8 (Parts 1 and 2))

2.21 Tests etc. to Certify Factual Information

2.21.2 Component Analyses of Samples of Adhering Materials Taken from Railway Facilities, Vehicles, etc.

In order to help identify the railway facilities and objects with which the train cars, etc. came into contact, component analyses were conducted on the adhering materials collected from the railway facilities, train cars, etc.

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[94] A track panel refers to a ladder type configuration of rails and sleepers, using a rail fastening device.

Fig. 70 lists the results of component analyses. The following outlines major results.

(1) A brown adhering material collected from approx. 2.2 m above the top surface of the left rail of the pole (near the No. 108 sleeper) approx. 3 m to Fukuchiyama Station from the No. 41 sub column (pole near the No. 113 sleeper) was homogeneous with the roof sheet of the first car, and a green adhering material collected from approx. 2.0 m above the top surface of the left rail of the No. 41 sub column was homogeneous with the vinyl tube covering earth wire of the said sub column, respectively.

(2) A green adhering material collected from rear upper roof (above rain water gutter) and the side (below rain water gutter) of the third door on the left side of the first car was homogenous with the vinyl covering earth wire of the No. 41 sub column, and a gray adhering material collected from the rear upper roof (above rain water gutter) of the third door on the left side of the first car was homogeneous with the vinyl chloride tube covering earth wire, respectively.

(3) For the brown vestige found on the No. 41 sub column and seemingly caused by the left edge of the rear pantograph head of the second car, described in 2.16.4, its adhering material seemed to contain homogeneous components with the pantograph head.

(4) The white powder on the top surface of the left rail after the No. 85 sleeper (number of sleeper : see Figs. 5), described in 2.16.2, contained homogeneous components with the ballast.

2.21.3.3 Test Results

(1) When the lower edge of the skirt was 30 mm lower than the upper edge of the ballast part,

The ballast flicked off to the front side of the skirt was relatively little according to the pictures taken by a high-speed camera; much of the ballast was scattered to the rear side.

(2) When the lower edge of the skirt was 50 mm lower than the upper edge of the ballast part,

More ballast was scattered than the case of 30 mm lower and a considerable amount of the ballast was scattered to the rear side of the skirt as with the case of 30 mm lower. On the other hand, however, there were many pieces of the ballast flicked off to the front side of the skirt.

(See Fig. 71 (Parts 2 and 3))

2.21.4 Shifts of the Gravity Centers of the Passengers by the Excessive Speed at Curved Track

2.21.4.1 Test Method

An excessive centrifugal force applied to the passengers was simulated by placing the subjects on a car model with an image analysis marker attached thereto and tilting the car model, and the situation was photographed by 3 video cameras to measure the shifts of the center of gravity of the passengers.

Assuming based on the description in 2.2.7 that the accident train entered into the right curve with a radius of 304 m and a transition curve length of 60 m at the accident site at 115 km/h, the car model was tilted to an extent that the excessive centrifugal acceleration of 3.15 m/s2 (equivalent to the excessive centrifugal acceleration at the time of running along a circular curve) will be applied in 1.88 seconds (equivalent to the time from entering into a transition curve to entering into a circular curve) from the start of tilting in order to simulate the excessive centrifugal force applied to the passengers at that time, and tilting was maintained for 4 seconds from the start of tilting.

Also, attitude conditions were set assuming the standing and sedentary passengers; those for the standing passengers were set assuming that the passengers were holding or not holding the straps in 3 attitudes such as facing the train travel direction, facing to the left of the train travel direction and facing to the right, respectively. The subjects were 51 male adults and 12 female adults, and they were tested one by one.

2.21.4.2 Test Results

No significant correlations were found among the body height, body weight, age, muscular strength and the shifts of the center of gravity of the subjects.

In the standing attitude, no significant correlations were found between(among) the body directions (facing the front, to the left and to the right) and the shifts of the center of gravity of the subjects.

In the standing attitude holding the straps, the shifts of the center of gravity were approx. 20 cm on the average for the males and approx. 25 cm on the average for the females after 1.88 seconds from the start of tilting the car model, and the maximum shifts of the center of gravity were approx. 40 cm on the average for both males and females during 4 seconds from the start of tilting the car. In the standing attitude not holding the straps, the shifts of the center of gravity were approx. 18 cm on the average for the males and approx. 26 cm on the average for the females after 1.88 seconds from the start of tilting the car model, and the maximum shifts of the center of gravity were approx. 57 cm on the average for the males and approx. 69 cm on the average for the females during 4 seconds from the start of tilting the car model.

In the sedentary attitude, the shifts of the center of gravity were approx. 5 cm on the average for both males and females after 1.88 seconds from the start of tilting the car body model, and the maximum shifts of the center of gravity were approx. 6 cm on the average during 4 seconds from the start of tilting the car model.

(See Fig. 72)

2.21.5 Computer Simulation of the Derailing Mechanism

2.21.5.1 Simulation Model and Calculation Conditions

(1) Vehicle models

The cars were modeled based on the specifications of the first and second cars of the accident train, taking the following matters into consideration.

-1. The stoppers for yawing and rolling of the car body of the bogie, air spring abnormal rise stopper mechanism, polygonal line characteristic non-linear springs and dampers, and non-linear air springs including level controlling valves and differential pressure valves were modeled in details, respectively, to build the bogie models of the first and second cars of the accident train.

-2. The wheel tread shape used was modified arc wheel profile and the wheel diameters used were the measured values (786 mm for the first car and 783 mm for the second car).

-3. The vehicle model used allowed for the longitudinal and crosswise biases of the center of gravity of the car body for the empty car, and the standing passenger shift model used allowed for the shifts of the center of gravity of the standing passengers by the unbalanced centrifugal force.

(2) Track model

The track shape of the track model near the accident site used for simulation was a right curve with the same radius of 304m as the accident site, and a 300-m straight section was added before the end of transition curve (beginning of circular curve). Concerning track irregularity, the measurement results at the accident site immediately after the accident conducted by the Company were reflected.

(3) Contact model between the wheels and the rail, and the criterion for derailment

In the process of reaching overturn of the car, the model was used, which allows outside rail wheels to come into contact with the rail at two points of the tread and the flange. Also, the criterion for derailment used was "when crosswise displacement of the tread center of the left wheels exceeds 100 mm against the (center of the) top surface of the left rail."

(4) Calculation conditions for the simulation

Simulation was conducted as to when the first car (Kuha (Control trailer) 207) and second car (Moha (motor car) 207) ran alone, respectively.

Estimating the number of passengers based on the number of casualties for each car described in 2.3.2, it was assumed to be 93 for the first car and 133 for the second car.

When this was done, only crosswise shifts of the center of gravity of the standing passengers were taken into consideration, assuming that there are no crosswise shifts of the center of gravity of the sedentary passengers. Weighting the test results of the shifts of the center of gravity of the passengers described in 2.21.4.2 by the numbers of male and female passengers estimated based on the male and female casualties for each car described in 2.3.2, the crosswise shifts of the center of gravity of the standing passengers were, for instance at 115 km/h, assumed to be 21.3 cm after 1.88 seconds and 48.9 cm after 4.00 seconds for the first car, and 21.1 cm after 1.88 seconds and 33.4 cm after 4.00 seconds for the second car.

The running speed of the first car was simulated at a constant speed of 105, 110 and 115 km/h and based on the pattern simulating a speed change near the accident site obtained from the P1 records, and that of the second car was simulated at a constant speed of 110 and 115 km/h.

Concerning the first car, simulation was also conducted as to when a friction coefficient factor was increased and decreased between the wheels and rail, in order to verify the effects of the oil of the rail lubricator described in 2.8.2.1 and those of powder produced by shattering of the ballast.

Furthermore, simulation was conducted as to when the setting pressure of the differential pressure valve is increased and decreased, in order to verify the effects of divergence of the setting pressure of the differential pressure valve from a design value.

The following table lists the combinations of various quantities such as the running speed (calculation conditions) used for simulations.

Table 42 Calculation Conditions and Results of Simulating the First and Second Cars

Car	Condition number	Running speed (km/h)	Friction coefficient	Setting pressure of differential pressure valve	Result (Derailed/Not derailed)
First car	1	105	0.3	Design value (98 kPa)	Not derailed
	2	Pattern simulating a speed change			Derailed
	3	110	0.1		Derailed
	4		0.3		Derailed
	5		0.5		Derailed
	6		0.3	Design value – 10%	Derailed
	7			Design value + 10%	Derailed
	8	115	0.1	Design value (98 kPa)	Derailed
	9		0.3		Derailed
	10		0.5		Derailed
	11		0.3	Design value –10%	Derailed
	12			Design value +10%	Derailed
Second car	13	110	0.3	Design value (147 kPa)	Not derailed
	14	115			Derailed

2.21.5.2 Simulation Results

The following provides the simulation results of the first car based on the simulation model and the calculation conditions described in 2.21.5.1. (See Table 42)

(1) The first car did not derail under the speed condition of 105 km/h (Table 42, condition number 1).

(2) The first car derailed under the speed condition of 110 km/h and 115 km/h (Table 42, condition number3to12), regardless of a coefficient of friction and a differential pressure valve of air spring setting pressure.

(3) Based on the results in (2) above, an analysis was conducted on the contact status of the skirt (life guard equipment) of the first car with the ballast. Under the speed condition of 115 km/h, when the front-end part of the car came to a point approx. 12 to 9 m to this side from the No. 41 sub column (pole near the No. 113 sleeper), the lower left edge of the skirt started coming into contact with the ballast.

(4) The first car derailed under the condition (Table 42 condition number2) of a running profile simulating a speed change near the accident site, obtained from the P1 records of the accident train. A derailing point at this time was almost the same as the simulation result of a constant speed of 115 km/h.

In the meantime, the second car did not derail under the constant speed condition (Table 42 condition number13) of 110 km/h, but did derail under that (Table 42, condition number14) of 115 km/h.

(See Fig. 74)

2.21.6 Estimation of the Critical Speed of Overturning Using Simplified Calculation Formulae

The following table lists the results of the critical overturning speeds of the first car (Kuha 207) and second car (Moha 207) of the accident train and those of the commuter trains of the West Japan Railway Company (hereinafter referred to as "the Company"), 205 series train (Kuha 205) and 103 series train (Kuha 103), estimated by the following calculation formula[108], using the car data presented by the Company. This calculation formula is known to show dynamic relations concerning overturn of the railway car.

Without taking a wind pressure into account, the estimation used the estimated numbers of passengers described in 2.21.5.1 as the loaded condition; 93 passengers in the first car of this accident train, 205 series and 103 series trains, and 133 passengers in the second car of the accident train,

[108] Masaharu Kunieda; "Theoretical analysis on dynamics of overturning of railway vehicles", Railway technical research institute report No.793, 1972.2 (in Japanese)

respectively.

$$v=\sqrt{\left\{\frac{GD}{2h_{G}*}-\left(1-\frac{\mu}{1+\mu}\cdot\frac{h_{GT}}{h_{G}*}\right)\frac{\alpha_{y}}{g}+\frac{C}{G}\right\}Rg}$$ (g: gravitational acceleration)

Table 43. Estimation of Critical Overturning Speed of First Car of the Accident Train, etc. by Simple Calculation Formula

	First car of the accident train (Kuha 207)			
	93 passengers (Carbody vibrations considered[*1])	93 passengers (Carbody vibrations not considered)	Empty car (Carbody vibrations not considered)	Published by said company[*2] Empty car (Carbody vibrations not considered)
D: Risk rate	1	1	1	1
C: Cant (m)	0.097	0.097	0.097	0.097
G: Distance bet. wheel contacts (m)	1.120	1.120	1.120	1.067
h_{G*}: Center of gravity effective height of car (m)	1.894[*3]	1.894[*3]	1.821[*3]	1.457[*4]
h_{GT}: Center of gravity height of bogie (m)	0.490	0.490	0.490	0.490
R: Radius of curve (m)	304	304	304	304
μ: Mass ratio of bogie to carbody	0.378	0.378	0.493	0.493
α_y: Lateral vibration acceleration (m/s^2)	0.981	0	0	0
v: Critical overturning speed (m/s)	29.4	33.8	34.3	36.9
v: Critical overturning speed (km/h)	106	122	123	133

	First car of accident train (Kuha 207)		Second car of accident train (Moha 207)	205 series train (Kuha 205)	103 series train (Kuha 103)
D	150 passengers (riding capacity) (carbody vibrations considered[*1])	Estimation[*6] for standard gauge (93 passengers. Carbody vibrations considered[*1])	133 passengers (Carbody vibrations considered[*1])	93 passengers (Carbody vibrations considered[*1])	93 passengers (Carbody vibrations considered[*1])
D	1	1	1	1	1

C		0.097	0.097	0.097	0.097	0.097
G		1.120	1.486	1.120	1.120	1.120
h_G*		1.955*3	1.894*3	1.688*3	1.880*3	1.919*3
h_{GT}		0.490	0.490	0.490	0.500	0.500
R		304	304	304	304	304
μ		0.330	0.378	0.391	0.390	0.409
α_y		0.981	0.981	0.981	0.981	0.981
V	(m/s)	28.9	33.0	31.2	29.5	29.2
	(km/h)	104	119	112	106	105

*1. "Carbody vibrations considered" means that lateral vibration acceleration of 0.1 g (= 0.981 m/s^2) was taken into consideration.

*2. The Company (West Japan Railway Company) published the estimation of critical overturning speed on the day of the accident.

3. Considering the effects of springs, it was assumed that h_G = 1.25 x Center of gravity height of the car." It is described in the paper mentioned in Footnote 108 that it is appropriate to set the center of gravity effective height of the car to 1.25 times the center of gravity height of the car, taking the effects of springs into consideration.

4. It had been assumed that h_G = Center of gravity height of the car.

*5. It is defined that μ = Mass of (one car worth of) bogies/Mass of (one car worth of) carbody.

*6. In case of the standard gauge (1,435 mm), estimation was made, assuming that the conditions other than the distance between wheel contacts are the same as "First car of the accident train (Kuha 207)/93 passengers (Carbody vibrations considered)."

2.21.10 Questionnaire Survey to the Train Drivers Belonging to the Kyobashi Operation District of the Company

After this accident, the Committee conducted a questionnaire survey in the Kyobashi operation district. The survey was conducted in the form of interview as a rule, targeting all the train drivers (except those who could not cooperate because of their own convenience) who had finished their duties during the time of implementing the questionnaire.

2.21.10.1 Questionnaire on the Relations between Delay Cause and Psychological Burden

Targeting 51 train drivers belonging to the Kyobashi operation district, a questionnaire was conducted as to when their trains are delayed, what delay cause will give them the most psychological burden, leading to an operation error. They were asked to choose an answer from among three choices of possible daily delay causes. The following table lists the results.

Table 44. Results of Questionnaire on Relations between Delay Cause and Psychological Burden

Choice (Delay cause)	No. of train drivers
(1) When your train is delayed even if you drive as predetermined while viewing a progress aspect, because of a short operation time in the train timetable.	28 persons (55%)
(2) When your train is delayed even if you drive while viewing signal indications of deceleration, caution and warning, because the preceding train is being delayed.	11 persons (22%)
(3) When your train is delayed because of a short stopping time in the train timetable.	12 persons (24%)

* The total percentage has amounted to 101% because all the fractions were rounded up.

2.21.10.2 Questionnaire on the Relations between the Delay Time and Psychological Burden

Targeting 51 train drivers belonging to the Kyobashi operation district, a questionnaire was conducted as to when their trains are delayed, what degree of delay time gives them the most psychological burden, leading to an operation error. They were asked to choose an answer from among four choices. The following table lists the results.

Concerning that a delay of 3 minutes or longer does not relatively become a psychological burden, many train drivers answered that they would give up recovering a delay when it exceeds 3 minutes.

Table 45. Results of Questionnaire on Relations between Delay Time and Psychological Burden

Choice (Delay time)	No. of train drivers
(1) Less than 1 minute	12 persons (24%)
(2) 1 minute to less than 3 minutes	31 persons (61%)
(3) 3 minutes to less than 10 minutes	4 persons (8%)
(4) 10 minutes or longer	5 persons (10%)

* The total number of train drivers has amounted to 52 persons because one of them chose 2 choices.

2.21.10.3 Questionnaire on the Object at the Beginning of the Left Circular Curve with the Radius of 250 m Located in the Down Track between Mitejima Station and Kashima Station

Targeting 47 train drivers belonging to the Kyobashi operation district, a questionnaire was conducted as to an object for recognizing the position of the beginning of the left circular curve with a radius of 250 m (start of transition curve) located in the down track between Mitejima Station and Kashima Station of the JR Tozai Line. They were asked to choose an answer from among five choices. The following table lists the results.

Table 46. Results of Questionnaire on the Object at the Beginning of the Left Circular Curve with the Radius of 250 m Located in the Down Track between Mitejima Station and Kashima Station

Choice (Object)	No. of train drivers
(1) Bend of the track	30 persons (64%)
(2) Curve post	3 persons (6%)
(3) Bodily sensation	8 persons (17%)
(4) No idea	2 persons (4%)
(5) Others	9 persons (19%)

* The total number of train drivers has amounted to 52 persons because three of them chose 2 choices and one of them chose 3 choices.

2.21.10.4 Questionnaire as to Whether to Know the Warning Start Point of the Nakasuji Level Crossing

Targeting 47 train drivers belonging to the Kyobashi operation district, a questionnaire was conducted as to whether they know the warning start point of the Nakasuji level crossing. Only two of them answered "yes." A photo was shown to the two train drivers to see whether they can point its exact location, but they failed.

2.21.10.5 Questionnaire on the Powering Notch Used for Pulling the Down Train into Takarazuka Station

Targeting 47 train drivers belonging to the Kyobashi operation district, a questionnaire was conducted on a powering notch used for pulling a 207 series 7-car down train into Takarazuka Station without delay. The following table lists the results.

The questionnaire was conducted on all the cases of when the train pulls into the No. 1 Track with the down home signal 1RA1 indicating G aspect, when it pulls into No. 1 Track with the down home signal 1RA1 indicating Y aspect, and when it pulls into No. 2 Track with the down home signal 1RA2 indicating Y aspect, as to when the down home signal changes from R aspect.

Table 47. Results of Questionnaire on Powering Notch Used for Pulling Down Train into Takarazuka Station

	Arrival at No. 1 Track (1RA1 indicating G aspect)	Arrival at No. 1 Track (1RA1 indicating Y aspect)	Arrival at No. 2 Track (1RA2 indicating Y aspect)
3 notches or less only	17 persons (36%)	32 persons (68%)	39 persons (83%)
5 notches or more only	26 persons (55%)	11 persons (23%)	7 persons (15%)
4 notches and others	4 persons (9%)	4 persons (9%)	1 person (2%)

2.21.10.6 Questionnaire on Handling When Emergency Braking Is Activated by the ATS-SW Long Function

Targeting 53 train drivers belonging to the Kyobashi operation district, a questionnaire was conducted on whether they recognize the need to contact a train dispatcher as to handling when emergency braking is activated by the ATS-SW long function described in 2.13.7.2. They were asked to choose an answer from four choices. The following table lists the results.

Table 48. Results of Questionnaire on Handling When Emergency Braking Is Activated by ATS-SW Long Function

Choice (Understanding related to recovery of the ATS device)	No. of train drivers
(1) Recognize the need to contact the train dispatcher before recovery of the ATS device.	47 persons (89%)
(2) Recognize the need to contact the train dispatcher after recovery of the ATS device.	3 persons (6%)

(3) Recognize no need to contact the train dispatcher as to recovery of the ATS device.	3 persons (6%)
(4) No idea	None

* The total percentage has amounted to 101% because all the fractions were rounded up.

2.21.10.7 Questionnaire on the Braking Force of the Train Consisting of the 207 Series Train Cars

Targeting 50 train drivers belonging to the Kyobashi operation district, a questionnaire was conducted on the braking force of the train consisting of the 207 series train, questioning which brake has the strongest force. They were asked to choose an answer from among five choices. The following table lists the results.

Table 49. Results of Questionnaire on Braking Force of Train Consisting of 207 Series Train Cars

Strongest brake \ Initial braking speed	115 km/h or higher	100 km/h or lower
(1) Brake B8 (Regenerative brake works properly)	4 persons (8%)	5 persons (10%)
(2) Emergency brake	16 persons (32%)	14 persons (28%)
(3) Backup brake	4 persons (8%)	3 persons (6%)
(4) Combined application of brake B8 and backup brake	20 persons (40%)	22 persons (44%)
(5) Combined application of emergency brake and backup brake	20 persons (40%)	19 persons (38%)

* The total number of train drivers exceeds 50 because some of them chose multiple choices.

2.21.10.8 Questionnaire on Experiences of Having Exceeded the Speed Limit Because of Distraction by the Train Radio

Targeting 50 train drivers belonging to the Kyobashi operation district, a questionnaire was conducted as to whether they have experiences of having exceeded the speed limit or having almost exceeded it because of delayed start of braking due to distraction by the train radio. They were asked to choose an answer from three choices. The following table lists the results.

Table 50. Results of Questionnaire on Experiences of Having Exceeded the Speed Limit Because of Distraction by the Train Radio

Choice	No. of train operators
(1) Have experiences of having exceeded the speed limit or having almost exceeded it because of delayed start of braking due to distraction by the train radio.	17 persons (34%)
(2) No experience of (1).	29 persons (58%)
(3) No idea.	4 persons (8%)

2.21.10.9 Questionnaire on the Use of the Gloves

Targeting 47 train drivers belonging to the Kyobashi operation district, a questionnaire was conducted as to whether they had not worn a glove on the right hand, and for what purpose, if any.

They were asked to choose an answer from choices (multiple choices may be chosen). The following table lists the results.

Table 51. Results of Questionnaire on Use of Gloves

Choice	No. of train drivers
To rub the eye.	17 persons (36%)
To scratch the head.	13 persons (28%)
To check the "motion," etc.	13 persons (28%)
To take something out of a bag.	12 persons (26%)
To make temporary notes of a notification, instruction and information from the train dispatcher on a timetable (on the cover).	11 persons (23%)

* The table lists only the choices chosen by more train drivers.

2.21.10.10 Questionnaire on Recognition of the Critical Overturing Speed

Targeting 53 train drivers belonging to the Kyobashi operation district, a questionnaire was conducted as to whether they had recognized the critical overturning speed at the accident site of the accident train at the time of occurrence of this accident. They were asked to choose an answer from choices. The following table lists the results obtained from 50 train drivers who answered.

At the time of conducting the questionnaire, the choices in steps of 5 km/h were organized into steps of 10 km/h to tally.

As described in 2.21.6, the estimation value of the critical overturning speed of the first car publicized by the Company on the day of the accident is

133 km/h.

At the time of the questionnaire, many train drivers added that they recognized the critical overturning speed to be tens of kilometers higher than the speed limit of 70 km/h, and that they would never intentionally run the train at tens of kilometers higher than the speed limit no matter how hasty they are.

Table 52. Results of Questionnaire on Recognition of Critical Overturning Speed

Critical overturning speed	No. of train drivers (Percentage)	Cumulative percentage
150 km/h or higher	0 person (0%)	0%
140 km/h to less than 150 km/h	9 persons (18%)	18%
130 km/h to less than 140 km/h	9 persons (18%)	36%
120 km/h to less than 130 km/h	7 persons (14%)	50%
110 km/h to less than 120 km/h	5 persons (10%)	60%
100 km/h to less than 110 km/h	14 persons (28%)	88%
90 km/h to less than 100 km/h	6 persons (12%)	100%
Less than 90 km/h	0 person (0%)	100%

3 Grounds for Certificate Factual Information

3.8 Analyses of the Driving Operation by Train Driver

3.8.6 From Itami Station to the Accident Site

3.8.6.1 Continuation of Power Running Until the Speed Meter Indicated 121 or 122 km/h

As described in 2.2.8 (6), the conductor of the accident train stated that he made next-stop and apology announcements after leaving Itami Station, and it is estimated that these announcements were audible in the driver's cab of the first car. Based on the statement of the conductor of the accident train that there was on-train telephone like "Will you overlook .....?" instantly after the next-stop announcement without a break, it is likely that the train driver of the accident train was listening to these on-train announcements. As described in 2.5.8, the train driver of the accident train had operated trains 5,701 km on the Fukuchiyama Line and had sufficient experiences of operating up rapid trains. Although it is presumed that he knew a train transfer announcement would be made after a next-stop announcement in accordance with the announcement manual described in 2.11.3, he gave an on-train communication signal "Take the phone" when the conductor of the accident train was about to make a destination announcement or a train transfer announcement, as stated by the conductor. In view of this, the train driver of the accident train may have been pressed for contacting the conductor of the accident train before the conductor reports to the train dispatcher the incident of overrunning the predetermined stop position at Itami Station.

Also, according to the statement of the conductor of the accident train described in 2.2.8 (6) and that of the passenger 7A described in 2.2.10.15, the train driver of the accident train made on-train telephone asking for a false report such as "Will you overlook .....? and the conductor of the accident train responded, "It was some overrun." Around then, it is estimated that there was a complaint from a passenger, "Why no apology announcement?" and responding to the complaint, the conductor of the accident train made an apology announcement to the passengers without answering to "Will you overlook ....?" followed by the report of overrunning the predetermined stop position to the General Control Center. As mentioned in the statement of the conductor of the accident train described in 2.2.8 (6) that the train driver of the accident train had no idea of what is happening in the seventh car and he may have figured, "The phone was hung up. The conductor is mad," it is considered that the train driver of the accident train had no idea of the complaint from the passenger. Accordingly, taking that his on-train telephone asking for a false report was turned down by the negative response "It was some overrun," he was likely paying special attention to the apology announcement and subsequent communications between the conductor of the accident and the train dispatcher (see Figs. 24 and 25). Also, the train driver of the accident train, who had gone through retraining 3 times for 18 days as described in 2.5.7.4 and been given reprimands, etc. 4 times as described in 2.5.10, may have been looking for an excuse, etc. worrying about the possibility of retraining, as mentioned in the statement of the train driver described in 2.20.1.9, who had exceeded the speed limit at the right curve of the accident site, and the statement of the train driver J belonging to the Kyobashi home depot described in 2.7.4.10, who was transferred to the car management section of other operation district 5 days before (Apr. 20, 2005) the occurrence of this accident. Furthermore, according to the statement of his female acquaintance described in 2.5.12.2 and the statement, etc. of his friend A described in 2.5.12.3, it is also likely that the train driver of the accident train was looking for an excuse or being disordered, worrying about dismissal from the position as a train driver like the train driver G belonging to the Kyobashi home depot, who was transferred to the car management section of other operation district in Jul. 2004 because he operated the train backward between Housono Station and Shimokoma Station in May 2004 as described in 2.20.1.12 just before overrun operation beyond the predetermined stop position by the train driver J belonging to the Kyobashi home depot and that by the train driver of the accident train at Shimokoma Station of the Katamachine Line in Jun. 2004 as described in 2.5.11.2.

Accordingly, considering that he was paying special attention to the apology announcement and subsequent communications between the conductor of the accident train and the train dispatcher, thinking the on-train telephone asking for a false report had been turned off, and that he was looking for an excuse, worrying about being sent to retraining, it is presumed that distracted attention of the train driver of the accident train made him continue power running of the accident train until the speed meter indicated "121" or "122" km/h as described in 2.2.7.

When the train driver of the accident train applied the service brake B1 notch before Tsukaguchi Station, it is considered that he operated the brake handle, trying to observe the maximum speed limit of 120 km/h.

3.8.6.2 Delayed Application of the Brake by the Train Driver of the Accident Train at the Accident Site

As described in 2.2.7, after applying the service brake B1 notch for approx. 2.0 second, the train driver of the accident train continued to coast the train for approx. 39 seconds. Meanwhile, the accident train passed Tsukaguchi Station at around 9:18:22 and passed a point at which brake application should be started during approx. 5 seconds from when the train dispatcher A repeated "8 m beyond the rear limit."

Then, after passing the Kubota River bridge, the train driver of the accident train applied the service brake B1 notch, followed by service brake B3 or B4 notch for 0.0 to approx. 0.2 second altogether at around 9:18:50, and then, service brake B5 notch for approx. 0.8 second, service brake B6 notch for 0.0 to approx. 0.2 second, and service brake B7 notch for approx. 2.4 seconds, respectively. It is estimated that around the time of passing the No. 41 sub column near the up track 1k814m at approx. 105 km/h, the service brake B8 notch was applied, resulting in derailment. Suppose the running speed was decelerated to the speed limit of 70 km/h before reaching the beginning of circular curve at a rate of 2.8 km/h/s, almost the same as the measured deceleration value of the service brake B5 notch (regenerative) described in 2.9.2.7, it was around 9:18:35 (around 9:18:29 if decelerated at a rate of 2.0 km/h/s which is the deceleration of the deceleration brake in the train data left in the creating system computer described in 2.14.5.2) when the accident train passed the point at which brake application should be started, and a delay time in starting brake application is estimated to be approx. 16 seconds (it is 15 seconds from 9:18:35 to 9:18:50, but 16 seconds in relation to rounding; it is approx. 22 seconds if decelerated at a rate of 2.0 km/h/s).

In this case, the delayed application of brake by the train driver of the accident train was presumably caused by distracted train operation by the train driver of this accident train, judging from that he was paying special attention to communications between the train conductor of the accident train and the train dispatcher, thinking that an on-train telephone asking for a false report was turned off by a negative response, based on the circumstances described in 3.8.6.1, and that he was looking for an excuse, etc. consistent with "8-m overrun" stated by the conductor of the accident train, worring about being sent to retraining (see Figs. 24 and 25).

Based on (1) and (2) below, it is also presumed that distracted train operation may have resulted because the train driver of the accident train tried to make notes of communications between the conductor of the accident train and the train dispatcher in addition to paying special attention to these communications.

(1) As described in 2.5.2.1, there was a red pencil in the driver's cab, which is believed to be a possession of the train driver of the accident train (and as described in 2.10.12, it is prescribed that when the train driver of the rapid train "receives an operation notification by a radio, etc. during train operation," "he is basically required to stenograph required matters on an expedient sheet of paper, portable timetable, etc. and write them in the predetermined Operation Notification Receipt after stopping at the next stop").

(2) As described in 2.5.2.1, the train driver of the accident train seemed to wear no glove on his right hand, and according to the questionnaire on the use of gloves described in 2.21.10.9, approx. 23% of the train drivers had not worn the glove on the right hand in order to "temporarily make notes of a notification, instruction and information from the train dispatcher on the timetable (on the cover)."

According to the questionnaire results described in 2.21.10.10, half of the train drivers belonging to the Kyobashi home depot recognize the critical overturning speed to be 120 km/h (maximum speed of the accident train between Amagasaki Station and Shinsanda Station of the Fukuchiyama Line) or higher, but in view of the following paragraphs (1) to (5), it is not very likely that the train driver of the accident train intentionally ran the train into the right curve of the accident site at approx. 110 km/h in order to recover a delay.

(1) If the train driver was intentionally passing the curve with a radius of 304 m at approx. 110 km/h, where the speed limit was 70 km/h, it is considered that he was paying considerable attention to train operation. If he had felt the need to brake the train, accordingly, he would have immediately

applied a strong brake such as the emergency brake or maximum service brake. It is unlikely to apply the service brake B5 notch for approx. 0.8 second.

(2) As described in 2.2.7, application of the service brake B1 notch started at around 9:18:09 when the speed meter of the first car was seemingly indicating "121" or "122" km/h. At that time, it is considered that the train driver of the accident train was trying to strictly observe the maximum speed limit of 120 km/h to some extent. On the other hand, according to the above estimation, it was approx. 9:18:35 when the accident train passed the point at which brake application should be started. It is considered that up to approx. 25 seconds before that, the train driver of the accident train was trying to strictly observe the maximum speed of 120 km/h to some extent.

(3) The auxiliary teaching material in 2.5.7.1, used by the train driver of the accident train describes "To observe an operating speed is an absolute requirement for safety operation of the train" and "A force to jump outside (centrifugal force) is applied to the train running along a curve and if it exceeds a limit, there may be derailed." It is considered that the train driver of the accident train knew the possibility of derailment by significant overspeed.

(4) On the questionnaire described in 2.21.10.10, many train drivers answered it highly unlikely to intentionally run the train at the speed tens of kilometers higher than the speed limit.

(5) The train driver of the accident train, who operated the accident train running on two rails with a gauge of 1,067 mm, (his eye level during train operation is approx. 2.5 m above the rail surface as described in 2.9.1) feels more danger of overturn by overspeed in a curve section than general automobile drivers. Accordingly, it is considered unlikely to greatly exceed the speed limit in an intentional manner.

Concerning that the train driver of the accident train applied the service brake B5 notch for approx. 0.8 second instead of immediately applying a stronger brake such as the emergency brake or maximum service brake, it is likely that he habitually operated the brake handle.

Furthermore, concerning that the train driver of the accident train applied the service brake B5 notch for approx. 0.8 second and service brake B6 notch for 0.0 to approx. 0.2 second, respectively, followed by the service brake B7 notch instead of the emergency brake or maximum service brake, it is likely based on (1) to (4) below that he habitually operated the brake handle.

(1) As described in 2.2.4, when the forwarding train 4469M arrived at Takarazuka Station on the day of the accident, a red light was turned on by the ATS-SW long function, the train stopped power running approx. 0.4 to 0.5 second after sounding of a bell, etc., and the service brake B7 notch was applied approx. 0.4 to 0.6 second after power running was stopped. As described in 2.2.6, when the accident train arrived at Itami Station, the brake handle of the first car was supposed to have been positioned at B8 from at least approx. 5 seconds before application of the emergency brake by the emergency brake switch of the seventh car, but it is not known whether the service brake B7 or B8 notch was applied immediately after applying the service brake. Accordingly, the circumstances in this case give us no help.

(2) As described in 2.10.3.1, the Company does not assume to apply the emergency brake as a deceleration brake, and as described in 2.10.13, the case of having applied the emergency brake was mentioned as a report example (reference) at the time of roll call at the end of duty. Furthermore, as described in 2.20.1.9, the train driver, who had experienced exceeding the speed limit at the right curve of the accident site, stated, "The service brake B8 notch was applied instead of the emergency brake because if the emergency brake is applied, there is a sensation that electric braking goes off, momentarily disabling braking, and there was hesitation about applying the emergency brake in order to decelerate the train."

(3) As described in 2.10.3.2, it is instructed to make efforts not to apply the maximum service brake (maximum service brake notch, B8), and as described in 2.9.2.2, in some (not including the first car of the accident train) of the 207 series train cars (only limited to those having a driver's cab), the brake handle tends to get stuck between the B8 position and the emergency position, disabling both the service and emergency brakes in a relatively frequent manner. As described in 2.5.11.3, according to the Near-Accident Report written by the train driver of the accident train, he had experienced overrunning the predetermined stop position at Nada Station of the Tokaido Line in July 2004, which had resulted from the above phenomenon. Accordingly, it is also likely that he avoided shifting from the B5 position to the B8 position at a stretch upon starting application of the service brake.

(4) As described in 2.2.7, the service brake B7 notch was applied for approx. 2.4 seconds after entering into the circular curve. It is presumed that even while the carbody of the first car was tilting under an excessive centrifugal force, the service brake B7 notch was continuously applied instead of the emergency brake or maximum service brake, but it is highly unlikely that the train driver of the accident train intentionally operated the brake handle in such a manner so as to pass the right curve of the accident site at high speed.

3.9 Analyses of the Causal Factors of the Derailing and the Behavior of the Vehicles in the Train before and after the Derailment

3.9.1 Shifts of the Center of Gravity of the Passengers by the Centrifugal Forces in the Vehicles Running in the Curved Track

As described in 2.21.4.1, the first car having entered into the curve at the accident site at approx. 116 km/h in excess of the speed limit by approx. 46 km/h reached an excessive centrifugal acceleration of 3.15 m/s2 during approx. 1.88 seconds between the end of transition curve and the end of circular curve. As described in 2.21.5.1, the shift of the center of gravity of the passengers is 21.3 cm if the test results of the shift of the center of gravity of the passengers described in 2.21.4.2 are weighted by the numbers of male and female passengers estimated based on the numbers of male and female casualties for each car described in 2.3.2, allowing presumption of the possibility of such a magnitude.

3.9.2 Analyses of the Causal Factors of the Derailment

3.9.2.1 Causal Factors of the Derailment of the First Car

Based on the following, it is estimated that derailment of the first car at the accident site was caused by the unbalanced centrifugal force attributable to over speed.

(1) As described in 2.8.2.1 and 2.8.2.2, no defects connected to causal factors of derailment were found on the track.

(2) As described in 2.9.2.6, 2.9.7 and 2.9.8, no defects connected to causal factors of derailment were found on the car.

(3) According to the statements of the passengers 1A, 1B, 1C, 1D, 1E, 1F, 1G and 2C in 2.2.10.1 to 2.2.10.7 and 2.2.10.10, they said the first car had derailed as if tumbling down to the left.

(4) As described in 2.16.1, there is what is believed to be the vestiges of the left wheels on the track to Amagasaki Station from near the No. 107 sleeper, but not what is believed to be the vestiges of the right wheels.

(5) According to the 3-dimensional measurement results of the track described in 2.16.3, the ballast height abruptly decreases after the No. 90 sleeper on the left side of the left rail.

(6) As described in 2.21.2, a brown stuck material collected from a pole near the No. 108 sleeper was homogeneous with the roof sheet of the first car, and a green stuck material collected from the No, 41 sub column (pole near the No. 113 sleeper) was homogeneous with the vinyl tube covering earth wire of the same pole, respectively.

(7) As described in 2.21.2, a green stuck material collected from rear upper roof (above rain water gutter) and the side (below rain water gutter) of the third door on the left side of the first car was homogenous with the vinyl coated earth wire of the No. 41 sub column, and a gray stuck material collected from the rear upper roof (above rain water gutter) of the third door on the left side of the first car was homogeneous with the vinyl chloride tube covering earth wire, respectively.

(8) As described in 2.21.2, the white powder on the top surface of the left rail after the No. 85 sleeper contained the components homogeneous with the ballast.

(9) As described in 2.8.5, the safety block of the No.3 up block signal to Amagasaki Station was track-shunted 0.7 second after the forefront wheel set of the rapid up train "5418M" (hereinafter referred to as "the accident train") entered into the safety block. Because the accident train runs approx. 20 m equivalent to the length of the first car in 0.7 second, the first car was tilted to the left by a centrifugal force when it entered into the safety block, causing the right wheels to be not in contact with the right rail, but the second car seems to have its right wheels being in contact with the right rail when it entered into the safety block.

(10) As described in 2.2.7, the first car entered into the circular curved track at the accident site at approx. 116 km/h and was passing near the No. 41 sub column at approx. 105 km/h. As described in 2.21.5.2, however, derailment was predicted in the simulation based on a running profile simulating a speed change near the accident site.

(11) As described in 2.21.6, it was concluded that the train would derail if

it runs at 106 km/h, according to the calculation result by a simple calculation formula, with a traverse vibration acceleration taken into account. Accordingly, it is estimated that derailment was caused by the excessive centrifugal force attributable to over speed.

Based on the facts that the components of the white powder on the top surface of the left rail after the No. 85 sleeper described in 2.16.2 were homogeneous with the ballast as described in 2.21.2, that there were scattered pieces of ballast exposing the surface bonded by a ballast fastener after the No. 82 sleeper as described in 2.16.2, that the ballast height abruptly decreases after the No. 90 sleeper on the left side of the left rail as described in 2.16.3, and that the skirt blew up the ballast toward the rear in a ballast scattering test and part of it fell near the rails as described in 2.21.3.3, it is considered highly probable that the left skirt of the first car blew up the left-side ballast of the left rail and the wheels of the accident train shattered it.

3.13 Analyses of the Safety Management in the West Japan Railway Company

3.13.1 Methods Employed to Grasp Incidents, etc.

Prior to the occurrence of this accident, there had been incidents similar to this accident or a preceding incident just before such as the case of a down train exceeding the speed limit when pulling into Takarazuka Station as described in 2.20.1.3 and the case of exceeding the speed limit at the right curve of the accident site as described in 2.20.1.9. These incidents, however, had not been reported to the Company by that train driver and no measures had been taken.

Concerning this, as indicated by the remark of the committee member F, "It is good that those incidents were brought to light, but it is necessary to give some guidance depending on the detail of the incident" and that of the committee member G, "It is still premature to overlook near-accident incidents," found in discussion about near-accident incidents at the Comprehensive Safety Control Committee as described in 2.19.2.3, it is considered there was involvement of the Company's system that the reports of these incidents, etc. may have led to retraining regarded as a penalty by part of the train drivers as described in 3.6.3.1, or disciplinary action.

Like the statement of the head of the Railway Headquarters, "Concerning concealment of the accident, ……, we instructed very strictly, having no tolerance," as described in 2.19.3.1, it is presumed that the Company had been implementing stricter retraining or disciplinary actions against the crew, etc. who neglected to report incidents, etc.

Such a strict response, however, may lead to the cases described in 2.20.1.9 like having exceeded the speed limit at the right curve of the accident site when operating the train while thinking, "I did not mean to tell a lie to the train dispatcher, but will be regarded as having told a lie. How should I make an excuse?"

For this reason, it is considered that accidents may be adversely induced by the above-mentioned Company's method of grasping the incidents, etc. that the Company requests the crew, etc. to report an incident, etc. and imposes retraining or disciplinary action on the crew, etc. who reported it, and imposes stricter disciplinary action or retraining on those who neglected to report.

Accordingly, in order to grasp the incidents, etc., the Company should not only consider appropriate retraining and disciplinary actions, but improve a system to recommend positive reports from the crew, etc. such as developing a non-punitive report system from a viewpoint of preventing serious accidents.

As described in 2.13.8.9, the Company said they had come to know about wrong speed limit information related to the ATS-P curve speed check function in the JR Tozai Line, etc. for the first time after the occurrence of this accident. As described in 2.20.1.1, however, it is considered that the Company was able to easily know the wrong speed limit information related to the ATS-P curve speed check function described in 2.13.8.9 because the number of train services in the down track of the JR Tozai Line had been 162 on weekdays and 146 on Saturdays and holidays, the number of passing times on the said line had been approx. 50 per application of the maximum service brake by the ATS-P curve speed check function and the maximum service brake had been applied approx. 3 times daily on the average by the ATS-P curve speed check function.

Accordingly, the Company should not only wait for the reports from the crew, etc., but accurately grasp the incidents, etc. by utilizing already installed an ATS-P recording part, etc.

Because the above-mentioned circumstances may be true with other railway operators, the Ministry of Land, Infrastructure, Transport and

Tourism should promote an approach to recommend positive reports from the crew, etc. by developing a non-punitive report system for the incidents, etc. in addition to "Installation and Utilization of Equipment that Records the Operating Status and Related Data of Trains" and so on proposed by Japan Transport Safety Board on Sep. 6, 2005.

3.13.2 Methods Employed to Utilize Information on Incidents etc.

As described in 2.5.11.3, there were at least four disabled brake incidents because of the brake handle stuck between the B8 and emergency positions which occurred with the trains operated by the train drivers belonging to the Kyobashi home depot in 2004 and were recorded in the Near-Accident Reports, but the Company had taken no measures.

Also, as described in 2.9.4.4, the speed meter of the seventh car, Kuha 206-1068, of the accident train had an abnormality indicating non-conformity to the ministerial ordinance for technical standards. The train driver repeatedly pointed it out, but the Company kept using the train car in service without correcting the abnormality.

Furthermore, as described in 3.13.1, the maximum service brake had been applied approx. 3 times daily by the ATS-P curve speed check function in the down track of the JR Tozai Line. The Company was able to easily know this fact, but did not correct wrong setting of the speed limit information related to the ATS-P curve speed check function, or the relevant cause, until after this accident.

Railway operators, despite the circumstances which allow them to easily know the abnormalities of the railway facilities or the train cars, should not neglect necessary management and continue to use them without knowing the abnormalities. It goes without saying that they should not continue to use the train cars equipped with the speed meters not conforming to the laws and regulations or having an incident of disabled brakes with the knowledge of those abnormalities.

Also, if the Company continues to use a defective device like a speed meter, an important device for safety, without correcting it despite repeated pointing out by the crew, the crew could take it meaningless to report and neglect to accurately report an incident, etc. or consider it unnecessary to comply with the laws and regulations because the Company does not, thereby leading to operation not conforming to the laws and regulations.

Accordingly, the Company should take required steps so as to analyze the information on the grasped incidents, etc. and implement necessary measures without delay.

3.14 Analyses of Factors that May Have Contributed to the Accident

3.14.1 Interception of the Train Radio Communication

As described in 3.8.6.2, the delayed application of brake by the train driver of the accident train was presumably caused by distracted train operation, judging from that he was paying special attention to communications between the train conductor of the accident train and the train dispatcher, thinking that an on-train telephone asking for a false report was turned off by a negative response, and that he was looking for an excuse, worring about being sent to retraining.

As described in 2.10.12, the Company had prescribed in the Basic Section for the Company's internal standards that when an operation notification was received by a radio, etc. during train operation, the notification was to be basically written in the operating notice card after stopping at the next stop in case of a local train, and in case of a rapid train, etc., required matters were to be basically stenographed on an expedient sheet of paper, portable timetable, etc. and written in the predetermined operating notice card after stopping at the next stop, prioritizing safety of the train. It had also prescribed that if the train driver approved it necessary for safety, he was allowed to stop at the nearest station to write after contacting the train dispatcher.

It is considered probable that reception of train radio by the train driver of the running train should not be uniformly banned because it is useful for the train driver to know the surrounding situation, etc. and properly respond to it.

However, it should be banned for the train driver of the running train to make notes because as described in 3.8.6.2, when the train driver of the accident train was delayed in using the brake, he may have been making notes of communications with the train dispatcher, and generally, making notes could delay the train driver in recognizing a stop signal from an obstruction warning signal, hindrance at a level crossing, etc.

Furthermore, the train dispatcher A is addressing the train driver of the accident train as shown in Figs. 24 and 25, but communications by the train driver of the running train should be limited only to when safety necessity is high such as when urgently stopping the train.

According to the statement of the train dispatcher A described in 2.2.9, he addressed the train driver of the accident train after finishing communications with the conductor (at the time of the occurrence of this accident) because he did not know there was no level crossing ahead of Itami Station, and tried to ask the positional relations with the level crossing, worrying about the level crossing being not closed or left closed. Accordingly, it is necessary to consider a method for reducing necessity of communications with the train driver of the running train by installing a device which allows the train dispatcher to understand accurate traffic information at real time.

It is also necessary to consider the methods for sending an operation notification, etc. in the written form so that the train driver can see it while the train is stopping, and for utilizing the conductor as much as possible.

3.14.2 Possible Effects of the Train Driver Management System in the Company

As described in 3.13.1, the Company had requested the crew, etc. to report incidents, etc. and ordered the train driver, who reported an incident, to take retraining which may be regarded as a penalty, or issued disciplinary action against him, and implemented stricter disciplinary action or retraining against the crew, etc. who neglected to report.

On the other hand, as described in 3.13.2, the Company had neglected necessary management and continued to use defective railway facilities and train cars while being in the position to easily know the defects, and continued to use the train cars equipped with the speed meters having errors beyond the criterion and those having failed to be braked while knowing those defects.

About the fact as described in 3.8.6.1 that the train driver of the accident train made on-train telephone asking for a false report, and the possibility as described in 3.8.6.2 that he was paying special attention to communications between the train conductor of the accident train and the train dispatcher or that he was looking for an excuse, worring about being sent to retraining, it is likely that there was involvement of the train driver management system of the Company that as found in the aforementioned example, the Company itself neglects required management and continues to use the defective railway facilities and train cars while being in the position to easily know the defects, and on the other hand, orders the train driver, who reported an incident, etc. to take retraining which may be regarded as a penalty, or issues disciplinary action against him, and implements stricter retraining or disciplinary action against the train driver who neglected to report.

4. Probable Causes

It is considered highly probable that the train driver's delay in applying the brake resulted in the entry of the train into a 304 m-radius rightward curved track at a speed of approximately 116 km/h, which was far higher than the specified speed limit of 70 km/h, and the running of the train along the curved track at the high speed caused the first car of the train to fall left and derail, which caused the second to fifth cars to derail.

It is considered probable that the train driver's delay in applying the brake is attributable to the diversion of his attention from driving the train to (1) listening to the dialogue between the conductor and the train dispatcher by radio communication which was caused by his belief that he had been hung up on by the conductor while he had been talking to the conductor on the intercom to ask him to make a false report and (2) making up an excuse to avoid being put on an "off-the-train" re-training course.

It is considered probable that the West Japan Railway Company's train driver management system in which drivers who caused an incident or a mistake are put on an "off-the-train" re-training course that can be considered as a penalty or are subjected to a disciplinary action and drivers who did not report an incident or a mistake they had caused or made a false report about such an incident or mistake are put on an even harder "off-the-train" re-training course or subjected to an even harder disciplinary action may have (1) caused the driver to make the call to the conductor on the intercom to ask him to make a false report and (2) caused the diversion of the driver's attention from driving the train.

5. Proposals

In view of the result of this accident investigation, the Aircraft and Railway Accidents Investigation Commission make proposals to the Minister of Land, Infrastructure, Transport and Tourism as follows:

Proposals Based on the Results of the Investigation of the Train Derailment Accident on the Fukuchiyama Line of the West Japan Railway Company

(1) Improvement of procedures to grasp and utilize information about incidents etc.

To allow railway operators to correctly grasp incidents etc., efforts to motivate crewmember to actively report incidents etc., such as efforts to develop a non-punitive reporting system, should be promoted, in addition to promoting the activities and efforts specified in the Commission's Proposals dated September 6, 2005 ("Installation and Utilization of Equipment that Records the Operating Status and Related Data of Trains", written in Japanese).

The Commission has been investigating train accidents etc. and publishing reports on them, but a system should be considered for other events as well in which railway operators etc. perform the necessary analyses and these results are utilized by other railway operators as well.

In addition, research and studies should be conducted on methods and procedures to make a comprehensive analysis of information on a variety of incidents etc. and utilize the analyzed results in an effective manner in consideration of the uniqueness of railway business in the sense that not only crewmember and vehicle but also train traffic control system and infrastructures are centrally managed by transportation operators.

(2) Limitation of using train radio by train driver while train is running.

Use of the train radio by train drivers while they are driving trains should be limited to cases where it is necessary to use the train radio for safety reasons such as the case where braking operation is necessary to stop the train in an emergency situation.

In addition, train drivers should be prohibited from making notes the dialogue exchanged over the train radio while they are driving trains.

For line sections in which trains run frequently and the burden on train drivers of confirming signals is high, a method to reduce the needs of communication using train radio while they are driving trains through the use of equipment that allows train dispatchers to grasp the status of the operation of the trains accurately and in real time, and a method to transmit driving-related instructions, etc., to the onboard device in the form of text information that can be read by the drivers when their trains are not moving, should be considered. In addition, a method to reduce the needs of communication using train radio for train through utilization of conductors to the maximum extent possible should be considered.

(3) Certain notification of the relevant laws and regulations to the related staffs in manufacturers.

Because equipment that is important for safety including vehicle equipment and signal equipment tends to be "black boxes" to railway operators, measures should be taken to ensure that all design, production, and quality control staff members, who are involved in actual design, production, and quality control work, of manufacturers of equipment that is important for safety know and understand the applicable laws and regulations so that sufficient quality control is exercised by such manufacturers.

In addition, because maintenance of vehicle and railway facilities is increasingly being outsourced, measures should be taken to ensure that all staff members, who are involved in actual maintenance work, of contractors of such maintenance know and understand the applicable laws and regulations.

6. Remarks

6.1. Measures that Should Be Taken by the West Japan Railway Company

The West Japan Railway Company should take the following measures:

(1) Improving training on train driving techniques

Training on train driving techniques should be improved and strengthened so that more practical training is provided, for example, by (a) introducing training based on findings on allotment of attention from analyses of information on incidents etc., (b) introducing training that appropriately uses driving simulators and training materials that are easy to understand and imagine, and (c) making train drivers fully aware of dangers associated with exceeding the speed limits.

In addition, "off-the-train" re-training courses, which are considered by some train drivers as a penalty, should also be turned into ones that do not place too much emphasis on spiritual training and are effective in preventing accidents and appropriate to be called "re-training," for example by introducing training on practical train driving techniques mentioned above.

(2) Improving brake equipment

Brake equipment should be improved so that the difference of decelerations for each brake handle position is small regardless of whether the regenerative brake is active or not. This would make it unnecessary for train drivers to pay attention to the status of the regenerative brake as to whether it has been activated or not.

In addition, brake equipment should be improved so that the actual brake deceleration does not exceed the specified standard value by an amount that is larger than necessary to ensure safety, to prevent unnecessary brake activation by ATS.

Furthermore, measures should be taken to solve the problem of non-activation of the brake when the brake handle is located between the service brake's 8-notch position and the emergency position.

Because train drivers may drive many different types of railway cars, brake equipment should be improved so that differences in brake performance between different types of railway cars should be minimized. This would reduce the burden on train drivers and allow them to pay more attention to confirming the safety in front of the train.

(3) Train operation control that gives highest priority to the safety of human lives

Train operation control systems should be improved so that train operation is controlled with highest priority given to the safety of human lives in all situations, for example, by preparing a manual describing the response actions to be taken in the event of a train derailment accident etc., which are considered safest, such as immediate shut off the electric power supply to the accident site and surrounding area as a general rule.

(4) Improving signs

Signs such as curve posts should be improved and enhanced so that they are recognized more easily and reliably.

6.2. Studies on Measures to Improve the Safety Performance of Railway Cars during Accidents

With regard to minimization of damages and injuries caused by accidents, the Commission made "Proposals on Strengthening of Efforts to Improve the Safety Performance of Railway Cars against Collisions" on April 26, 2002, written in Japanese, in response to the train collision accident on the Kagoshima Line of the Kyushu Railway Company on February 22, 2002. The railway operators should conduct studies on measures to improve the safety performance of railway cars, including modifications of railway car structures to ensure that sufficient space for the safety of passengers is retained in passenger cars even in the event of an accident, using the 2002 Proposals as a source of reference.

With regard to equipment in passenger cars, too, the railway operators should conduct studies to improve layouts, shapes, etc., of handrails so that injuries in the event of an accident are minimized.

7. Actions Taken

7.1. Measures that Have Been Taken by the West Japan Railway Company

(1) Development of a Safety Improvement Plan

In response to a direction from the Ministry of Land, Infrastructure, Transport and Tourism, the West Japan Railway Company developed a safety improvement plan on May 31, 2005, that included the provision of the SW curve speed check function and a revision of the train operation plan (see 7.2 (1)).

(2) Improving ATS

The West Japan Railway Company provided curve speed check functions in 1,234 curve sections in accordance with the safety improvement plan, to increase the number of curve sections equipped with curve speed check functions from 105 at the time of the Fukuchiyama Line accident to 1,370 (1,195 curve sections equipped with the ATS-SW curve speed check function, 96 curve sections equipped with the ATS-P curve speed check function, and 79 curve sections equipped with both the ATS-SW curve speed check function and the ATS-P curve speed check function) by the end of FY 2006 (see 1.2.3, Attachment 1, 2.13.8.4, and 7.2 (3)).

The West Japan Railway Company provided turnout speed check functions at 1,017 turnouts in accordance with the safety improvement plan, to increase the number of turnouts equipped with turnout speed check functions from 663 at the time of the Fukuchiyama Line accident to 1,696 (1,385 turnouts equipped with the ATS-SW turnout speed check function, 93 turnouts equipped with the ATS-P turnout speed check function, and 218 turnouts equipped with both the ATS-SW turnout speed check function and the ATS-P turnout speed check function) by the end of FY 2006.

(3) Provision of a backup power supply for the train protection radio equipment, etc.

The West Japan Railway Company provided a backup power supply for the train protection radio equipment in all railway cars (that have a driving cab) by the end of September 2006 and improved the power supply circuits so that the backup power supply will be activated in the event of a failure or disconnection of the normal power supply without the need to operate a power supply switching switch (see 1.2.3 and Attachment 1).

(4) Limiting the use of the train radio by train drivers

The West Japan Railway Company revised the basic section for "Operation" so that train drivers are normally required to refrain from making exchanges over the train radio until their trains arrive at the next station and implemented the revision beginning in May 2007 (see Figure 77).

(5) Improving the accuracy of speed meters of the same model as the speed meter of the first car of the derailed Fukuchiyama Line train

For speed meters of the same model as the speed meter of the first car of the derailed Fukuchiyama Line train, strict error reduction measures etc. had not been taken. For example, if the wheel diameter had been 794 mm, the wheel diameter setting had been set to "80" by rounding up the first place. However, the West Japan Railway Company modified the program by the end of December 2005 to comply with the ministerial ordinance for technical standards (see 1.2.3, Attachment 1, and 2.9.4.1).

(6) Installing EB equipment and TE equipment

The West Japan Railway Company has been installing EB (Emergency Brake) equipment and TE (One Touch Operative Emergency) equipment in railway cars towards the company's goal of installing EB equipment and TE equipment in all railway cars (which have a driving cab and are not a steam locomotive). The EB equipment and TE equipment installation rates as of the end of FY 2006 were 63.5% and 43.4%, respectively.

(7) Improving the train operation plan

Before resuming operation on June 19, 2005, in the line section in which the accident had occurred, the West Japan Railway Company revised their train operation plan. As part of this revision, they extended the minimum stop periods at Nakayamadera and Itami Stations for up-going rapid trains made up of seven 207 Series railway cars to 20 s (a 5-s extension for each station; see 2.14.4).

The revision also included an extension of the regular running time between the Fukuchiyama Line's Takarazuka Station (No. 2 Line) and Amagasaki Station (No. 6 Line) to 16 min and 20 s (a 45-s extension). Because the maximum operation speed for the section was lowered from 120 km/h to 95 km/h and the speed limit for the rightward curve section in which the accident had occurred was lowered from 70 km/h to 60 km/h, the basic "calculated time" increased to 15 min and 52 s (a 45-s increase) (see 2.10.1.2, 2.10.1.9, 2.14.3.1, Figure 51, and 7.2 (2)).

In addition, as a result of the train timetable revision of March 18, 2006, which involved regular running time and stop period changes for railway lines in the Osaka area, the regular running time between the Fukuchiyama Line's Takarazuka Station (No. 2 Line) and Amagasaki Station (No. 6 Line) for rapid trains made up of seven 207 Series railway cars was further extended to 16 min and 25 s (a 5-s extension).

(8) Establishing The Safety Laboratory

The West Japan Railway Company established a "Safety Laboratory" on June 23, 2006. At the laboratory, the West Japan Railway Company's research staff members conduct studies relating to safety-related management systems and human factors.

(9) Establishing safety management regulations in which the responsibilities of top management are clearly defined

The West Japan Railway Company established safety management regulations in which the responsibilities of the president in ensuring transportation safety were clearly defined, and started implementing the regulations on October 1, 2006 (see 7.2 (7)).

7.2. Measures that Have Been Taken by the Ministry of Land, Infrastructure, Transport and Tourism

(1) Directing the West Japan Railway Company to develop a safety improvement plan

On April 28, 2005, the Ministry of Land, Infrastructure, Transport and Tourism directed the West Japan Railway Company to develop a safety improvement plan describing the matters to be improved, the equipment- and management-related improvement measures, the investment plan, etc.

(2) Inspection of the train operation plan

On May 6, 2005, the Ministry of Land, Infrastructure, Transport and Tourism directed railway operators to inspect their train operation plans to check whether they were appropriate ones in which the necessary time margins had been added.

(3) Requiring railway operators to improve functions of ATS etc.

On May 27, 2005, the Ministry of Land, Infrastructure, Transport and Tourism directed the relevant railway operators to install ATS etc. equipped with a curve speed check function. In addition, the Ministry amended the ministerial ordinance for technical standards on March 24, 2006 (implementation date: July 1, 2006) to require the relevant railway operators to install speed-limiting equipment (ATS etc. equipped with a curve speed check function or turnout speed check function). This requirement takes into account the acceleration of trains in the descending sections (see 1.2.3 and Attachment 1).

By the end of FY 2006, ATS devices etc. equipped with curve speed check functions were installed in 2,254 curve sections of the relevant railway operators (47 railway operators).

(4) Reliable execution of train protection actions during and after accidents

On September 6, 2005, the Ministry of Land, Infrastructure, Transport and Tourism directed railway operators to inspect their train protection manuals and repeatedly provide train protection training courses for their train drivers and conductors (see 1.2.3 and Attachment 1).

(5) Securing accuracy of speed meters etc.

On September 6, 2005, the Ministry of Land, Infrastructure, Transport and Tourism directed railway operators to secure accuracy of their speed meters etc. (see 1.2.3 and Attachment 1.)

(6) Installation of equipment that records the traveling of trains and related data

The Ministry of Land, Infrastructure, Transport and Tourism amended the ministerial ordinance for technical standards on March 24, 2006 (implementation date: July 1, 2006) to require railway operators to install equipment that records the traveling of trains (see 1.2.3 and Attachment 1).

(7) Amendment of the Railway Business Act

The Railway Business Act was amended by "the Act for Partial Revision of the Railway Business Act etc. for the Purpose of Improving Transportation Safety" (promulgated on March 31, 2006), to require railway operators to establish safety management regulations and report the content of the regulations and to appoint a Chief Safety Management Officer and report his/her name (implementation date: October 1, 2006). In addition, the Railway Business Act as amended required that a transportation safety management assessment be conducted.

Attachment 1

Proposals Regarding the Train Derailment Accident on the Fukuchiyama Line of the West Japan Railway Company

Nat. Air Com. No. 15
September 6, 2005

To: Kazuo Kitagawa, Minister of Land, Infrastructure, Transport and Tourism

Junzo Sato, Chairman, Aircraft and Railway Accidents Investigation Commission

About Our Proposals Regarding the Train Derailment Accident on the Fukuchiyama Line of the West Japan Railway Company

The Commission is currently conducting, with all its might, the investigation to identify the cause of the train derailment accident that occurred at around 9:18 a.m., April 25, 2005, on the Fukuchiyama Line of the West Japan Railway Company (hereinafter referred to as JR-West). However, it is expected that we will have to continue the investigation for a significant number of days in order for us to draw final conclusions based on the results of multilateral examination of facts and scientific analyses

On the other hand, the accident, in which 107 people were killed and more than 500 people were injured, is the most serious railway accident in the recent railway accident history of Japan, and it is considered that the planning of measures to prevent similar accidents should be started as early as possible. Therefore, we hereby provide and publish an overview of the progress of our investigation to date and make our proposals on measures to be taken pursuant to the provisions of Article 22 of the Act for Establishment of the Aircraft and Railway Accidents Investigation Commission before completion of the investigation of the accident.

Proposals

(Improving function of ATS etc.)

1. As described in the interim report, a record shows that the accident train entered at a speed higher than 110 km/h a curve section that includes the accident site and for which the speed limit is 70 km/h. In addition, a record shows that, prior to the accident, a down-going deadhead train that had been made up of the same railway cars as those of the accident train and driven by the train driver of the accident train (hereinafter referred to as "the deadhead train") had traveled at a speed higher than 60 km/h on a turnout section for which the speed limit is 40 km/h before arriving at Takarazuka Station.

   Therefore, functions of ATS (automatic train stop) and similar devices should be improved, for example, by adding, taking into consideration the current situations regarding train operation and the current situations surrounding the individual line sections, functions to prevent trains from exceeding the speed limits in curve sections and at turnouts.

(Reliable execution of train protection actions during and after accidents)

2. As described in the interim report, power from the backup power supply would not have been supplied to the train protection radio equipment etc. of the seventh car unless the power supply switching switch had been set to the "Emergency" position. However, according to the confirmation after the accident, the power supply switching switch was set at the "Normal" position, which means that the train protection radio equipment had not functioned. In addition, the fuse of the seventh car had not been used and neither the portable fuse nor the track circuit shunt device had been used.

   On the other hand, there was no provision requiring that the power supply switching switch be set to the "Emergency" position when it is necessary to use the train protection radio equipment when it is not possible to use the normal power supply in the internal regulations of JR-West regarding the response of train conductors during abnormal situations including the "Standard Work Procedures (for the Conventional Lines) for Train Conductors - Standard Work Procedures for Abnormal Situations."

   Against this background, the train driver of Kita Kinki 3, which is the train that had arrived in the accident area from the opposite direction immediately after the accident, had stopped his train in response to the stop signal indication information received by the onboard ATS equipment and taking into consideration other information. However, Kita Kinki 3 did not receive any train protection radio transmission.

   Therefore, efforts should be made to improve the reliability of the train protection radio equipment, enhance ease of operation and further improve the training for train drivers and conductors, so that train protection actions will be executed in a reliable manner during and after accidents and in situations where such actions are required.

(Installation and utilization of equipment that records the traveling of trains and related data)

3. As described in the interim report, the deadhead train had traveled through the turnout at a speed higher than the speed limit before arriving at Takarazuka Station, and had temporarily stopped as a result of the activation of the emergency brake by ATS. In addition, the accident train had run past the stop sign by about 70 m at Itami Station and the train driver had corrected the stop position prior to the accident.

   In addition, there had been a similar incident on June 8, 2004, in which a train driven by the train driver of the accident train had run past the stop sign by about 100 m at Shimokoma Station of the Katamachi Line of JR-West and the driver had corrected the stop position.

   In addition, 46 incidents had occurred in FY 2004 in JR-West's service area in which a train had stopped as a result of the activation of the emergency brake by an ATS-SW-type ground coil (long), according to a report from JR-West.

   Grasping the situations of such incidents etc. accurately, analyzing the situations, and utilizing the analysis results would help prevent accidents.

   Therefore, equipment that records the train position and speed, powering handle position, brake handle position, ATS operation status, etc., should be installed on trains (and on tracks where necessary) so that incidents etc. can be grasped accurately.

In addition, the efforts described in 4 below to secure the accuracy of speed meters etc. should be made so that incidents etc. can be grasped more accurately using equipment that records the traveling of trains and related data.

(Securing accuracy of speed meters etc.)

4. As described in the interim report, speed values indicated on speed meters of the same type as that of the speed meter of the first car of the accident train may be as low as about 4 km/h below the actual speeds when the train is traveling at a speed of about 120 km/h, according to estimation calculations based on test results.

   Speed meters are instruments that are important for the driving of trains, and inaccurate indication may adversely affect the driving of trains. In particular, indication of speed values on speed meters that are lower than the actual speeds may (1) cause trains to exceed speed limits or run past stop signs, (2) cause emergency brake activation by ATS etc. equipped with an over-speed prevention function, (3) cause incidents that reduce safety, and/or (4) prevent trains from traveling safely. Therefore, measures should be taken to secure the accuracy of speed meters etc.

RA2007-3-2 (separate volume)

Railway Accident Investigation Report (Attachments)

Train Derailment Accident between Tsukaguchi and Amagasaki Stations of the Fukuchiyama Line of the West Japan Railway Company

June 28, 2007

Aircraft and Railway Accidents Investigation Commission

Attachments

Figure 1 – Route Diagram of the Fukuchiyama Line

Fukuchiyama Line (between Amagasaki and Fukuchiyama Stations): 106.5 km(Length of Line)

(Double line (except between Sasayamaguchi and Fukuchiyama Stations, which is a single line))

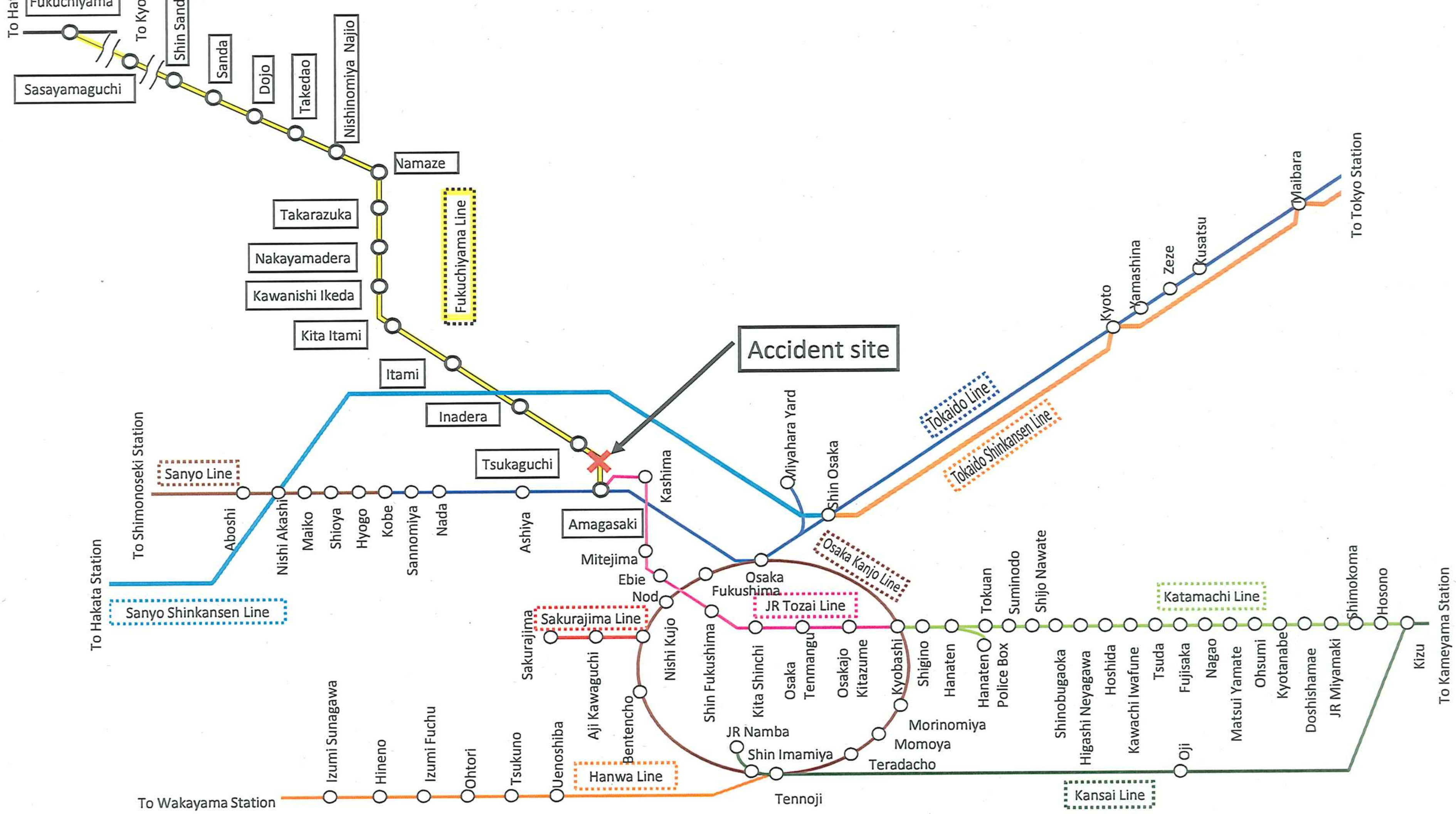
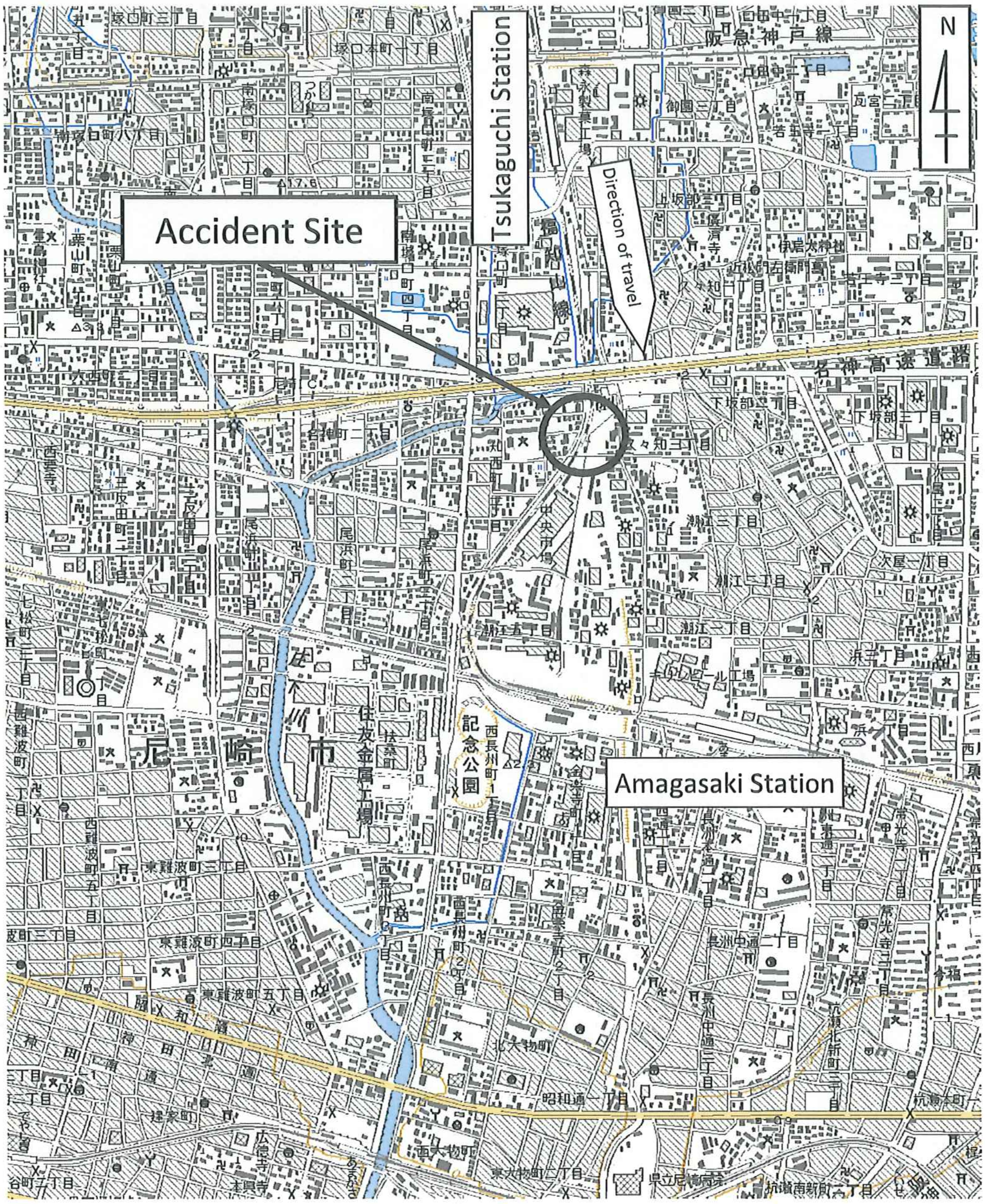


Figure 2 Topographical Map of the Area Surrounding the Accident Site



1:25,000 Northwestern Part of Osaka

500 m 0 500 1000 1500

A map created by editing a 1/25,000 topographic map published by the Geospatial Information Authority of Japan

Figure 5 - Simplified Diagram of the Accident Site

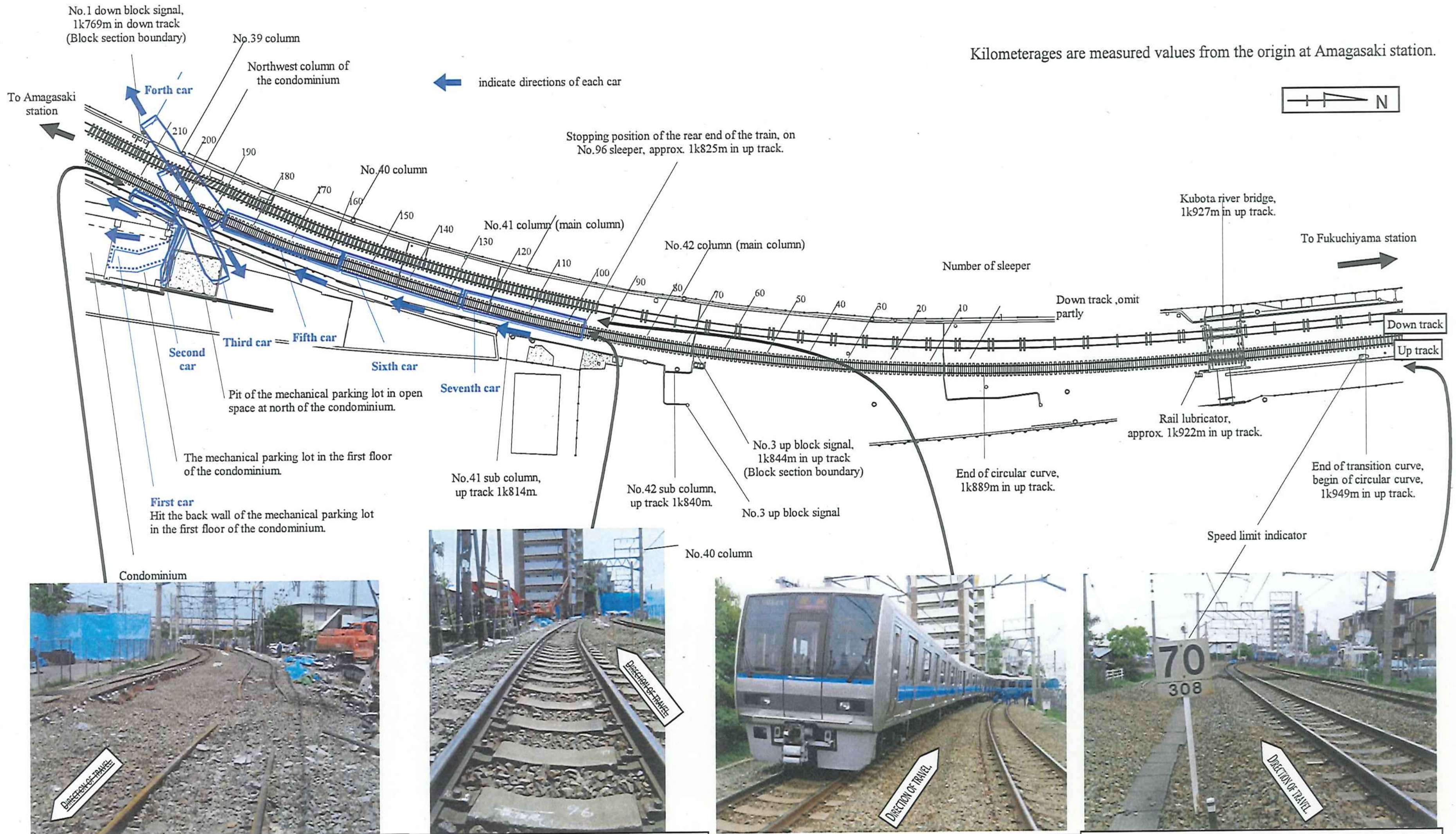


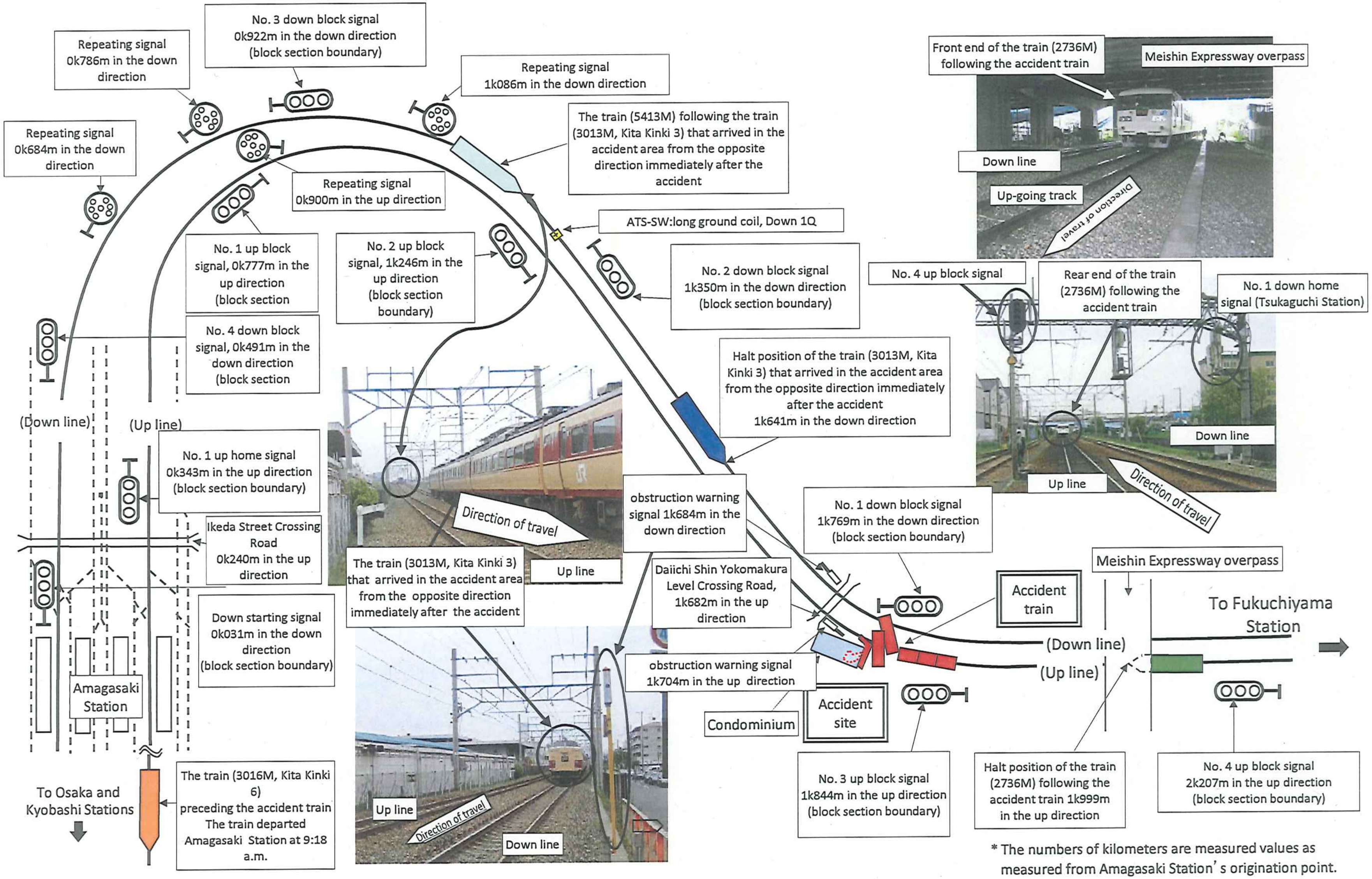
Photo taken from near the condominium to the direction of Fukuchiyama station, after removal of the accident train.

o taken from around the rear end of the accident train to the ction of Amagasaki station, after removal of the accident train.

Photo taken from around the rear end of the accident train to the direction of Amagasaki station.

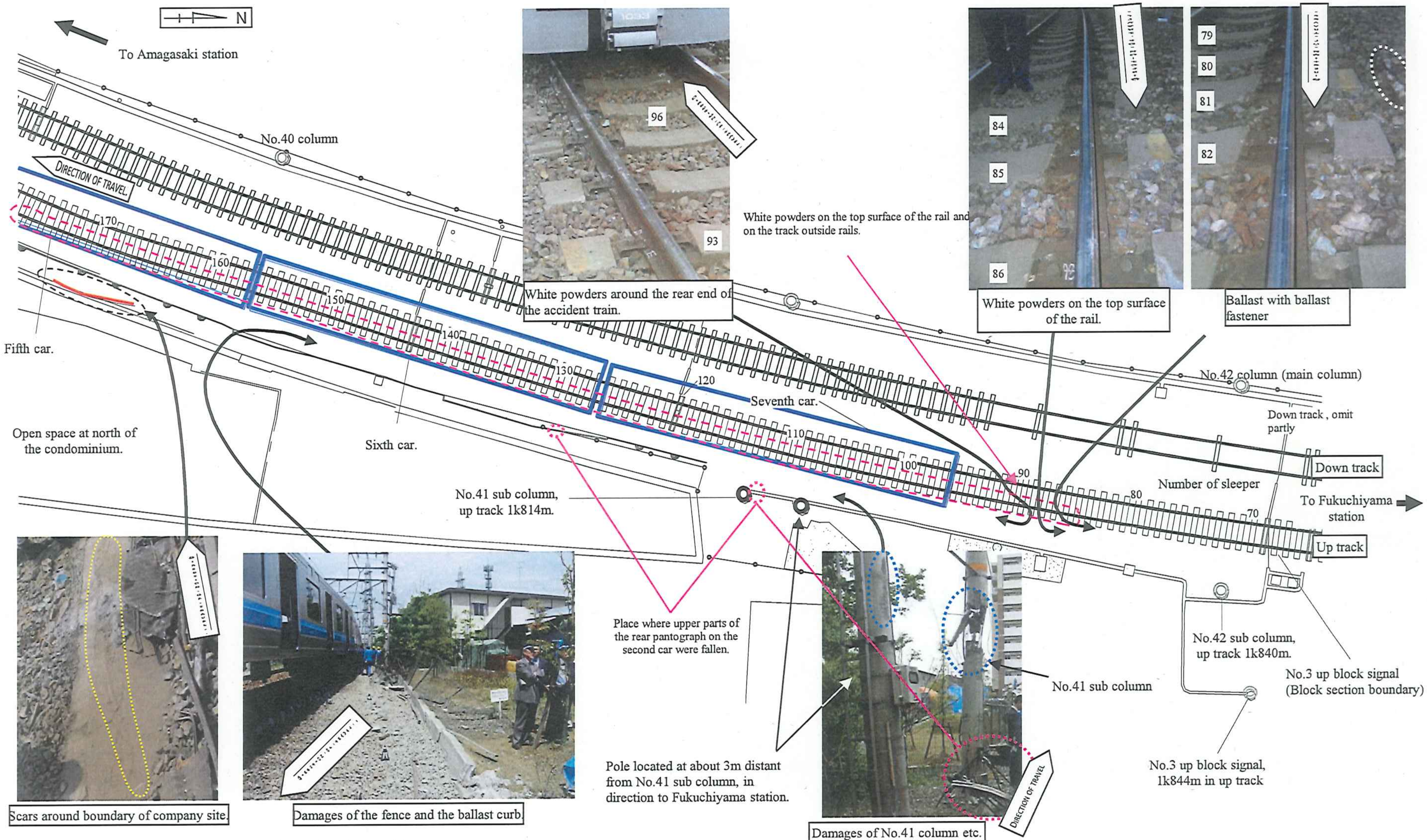
Photo taken from around end of transition curve and speed limit indicator to the direction of Amagasaki station.

Figure 6 – Simplified Diagram of the Spatial Relationships between the Trains Involved



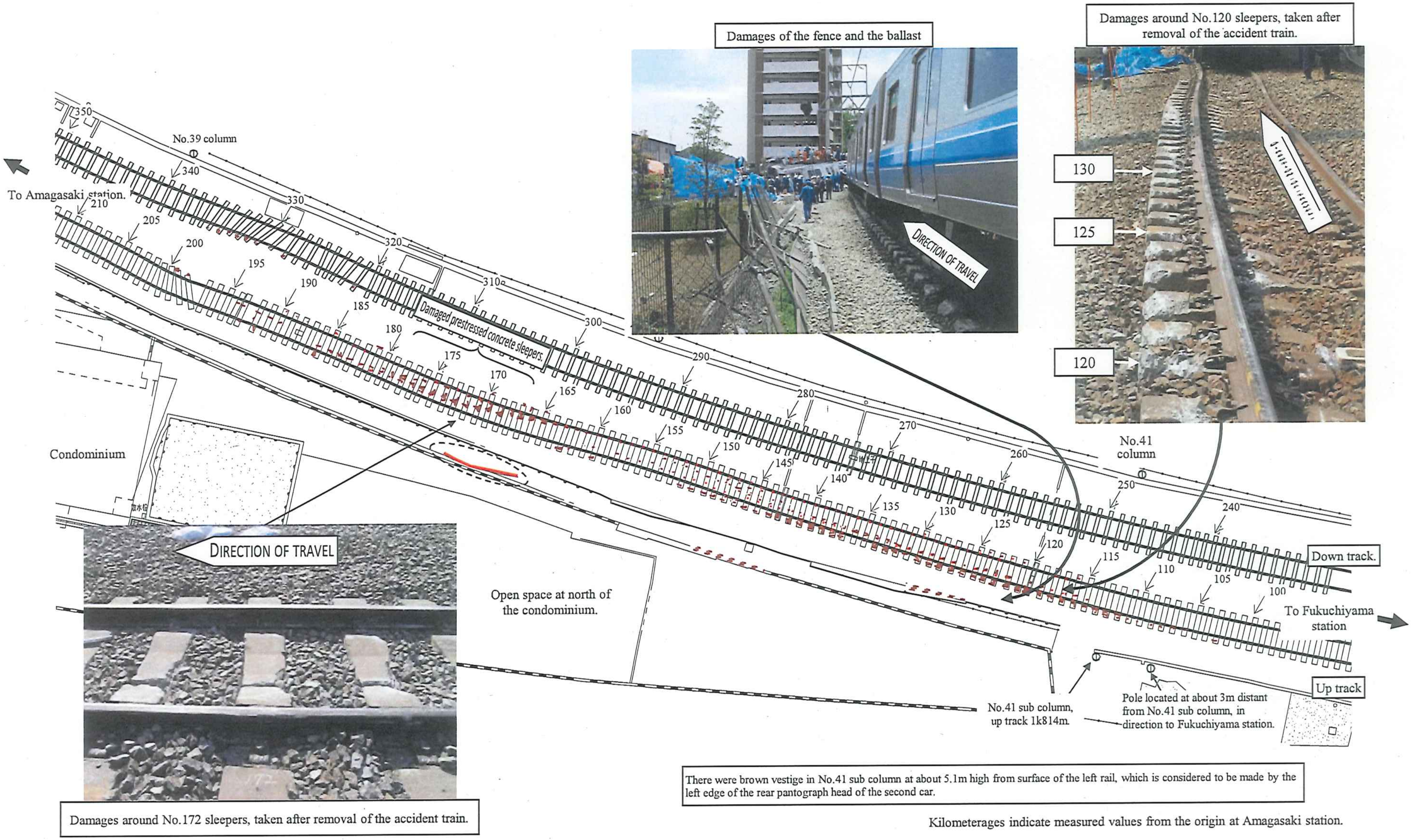
* The numbers of kilometers are measured values as measured from Amagasaki Station's origination point.

Figure 7 - States of Damage to Railway Facilities etc. (1)



Kilometerages indicate measured values from the origin at Amagasaki station.

Figure 7 - States of Damage to Railway Facilities etc. (2)



Kilometerages indicate measured values from the origin at Amagasaki station.

Figure 7 - States of Damage to Railway Facilities etc. (3)

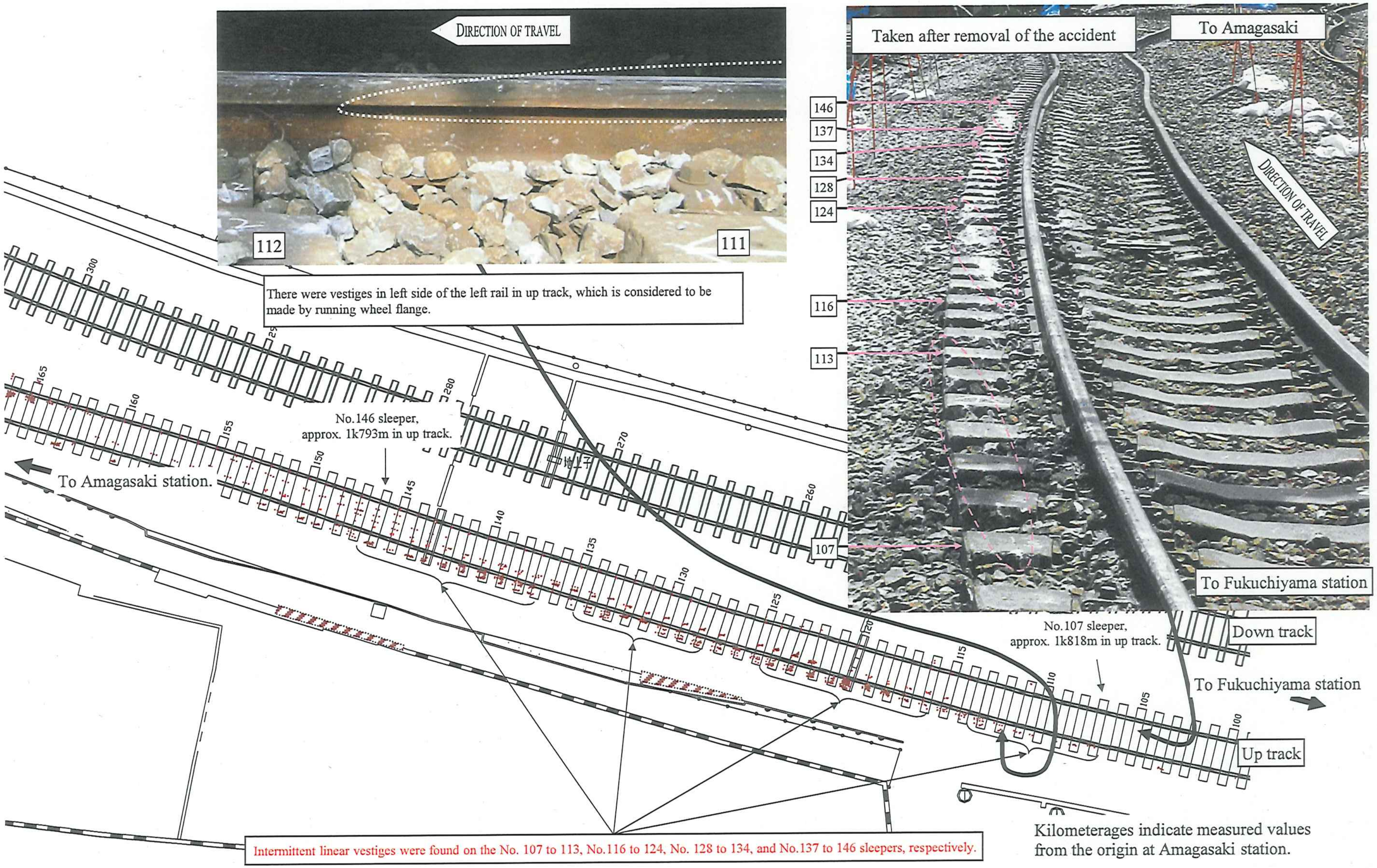


Figure 7 - States of Damage to Railway Facilities etc. (4) (Sleepers on the left rail side of the up track, 1/3)

Figure 7 - States of Damage to Railway Facilities etc. (4) (Sleepers on the left rail side of the up track, 2/3)

Figure 7 - States of Damage to Railway Facilities etc. (4) (Sleepers on the left rail side of the up track, 3/3)

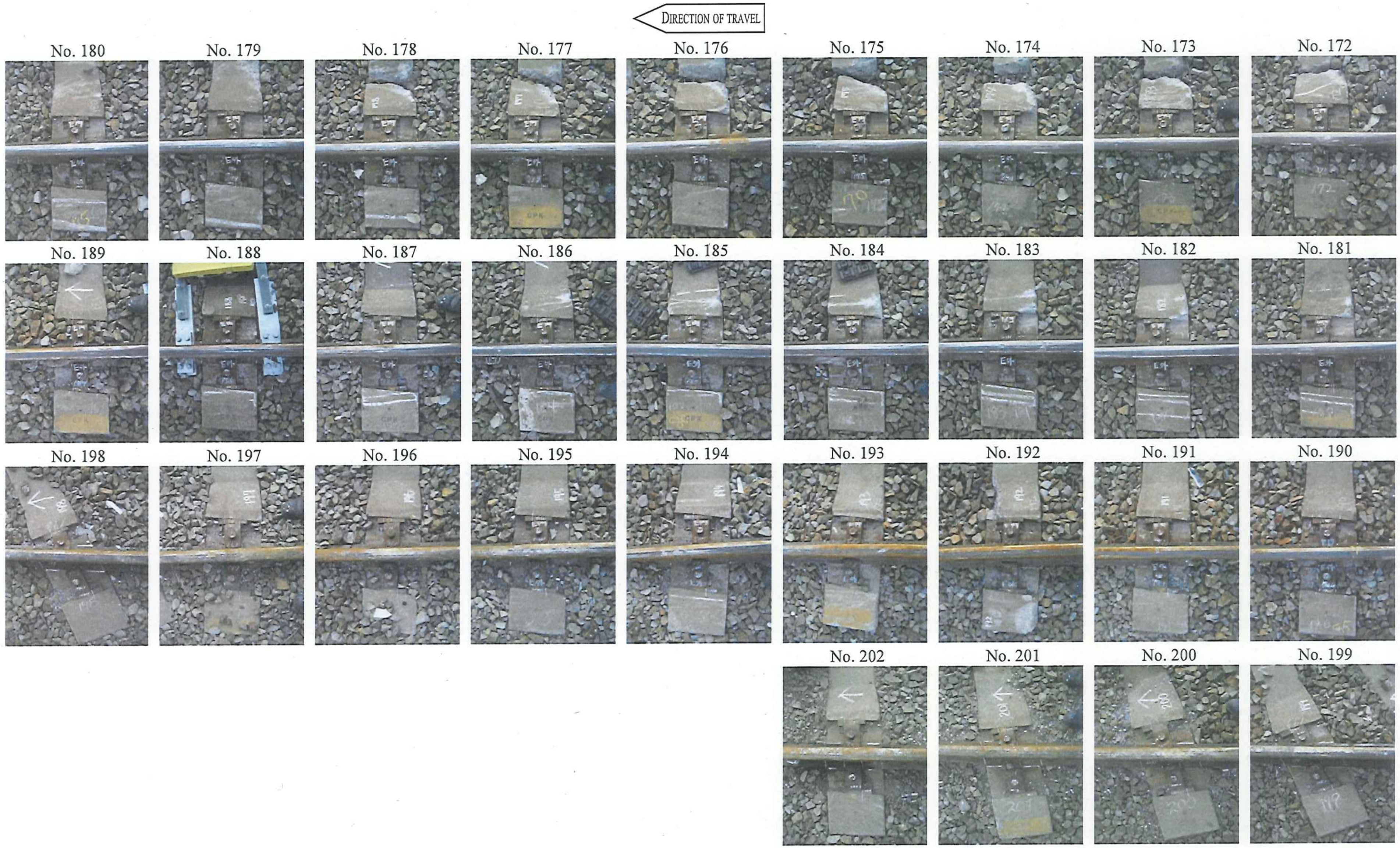
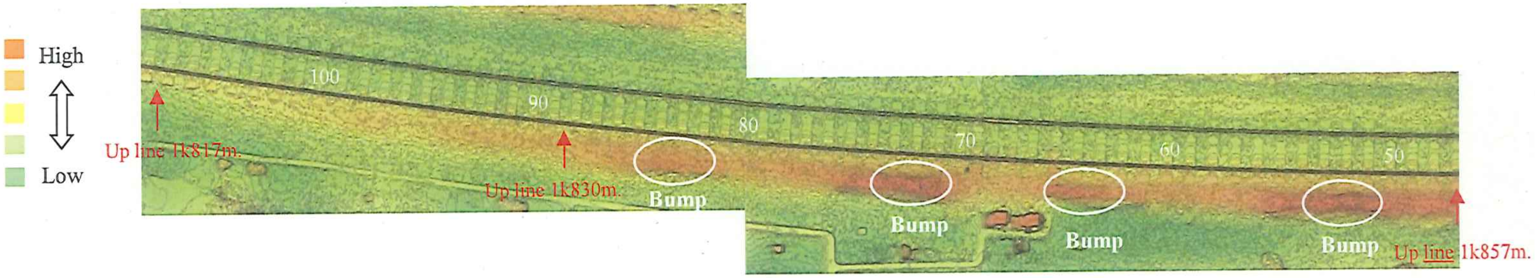


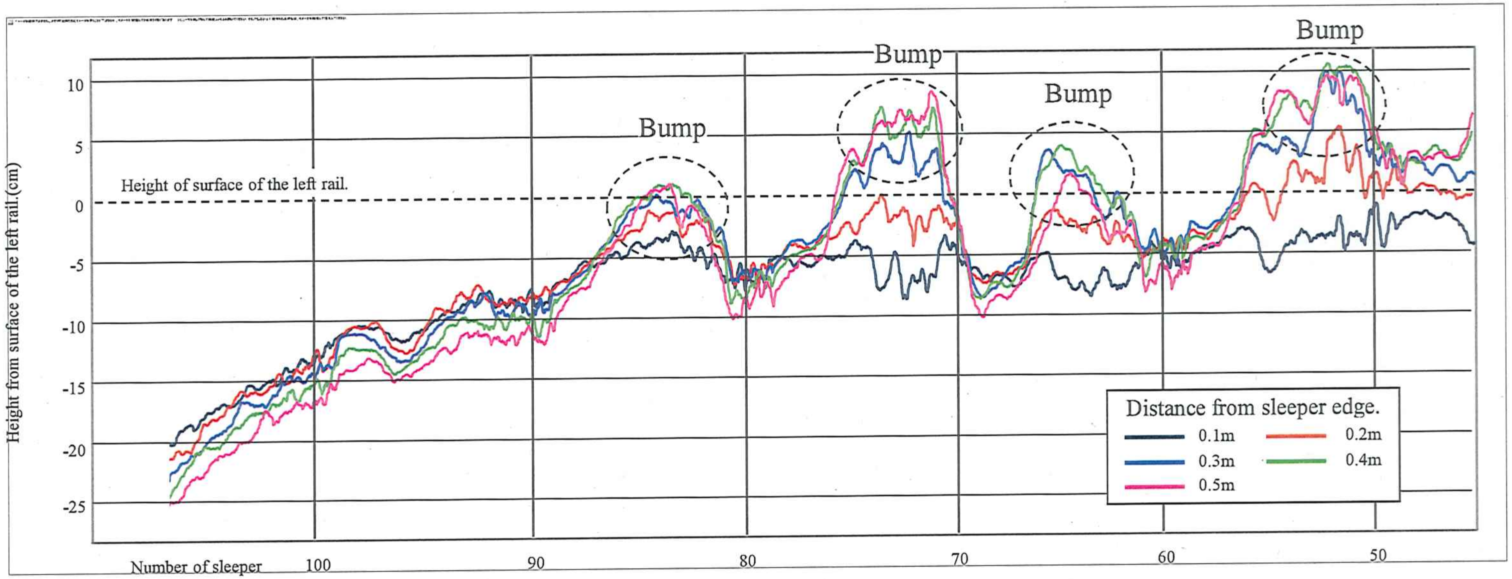
Figure 8 - Three-Dimensional Track Measurement (1) (Contour Line Map of the Accident Site)

← To Amagasaki station.

To Fukuchiyama station →

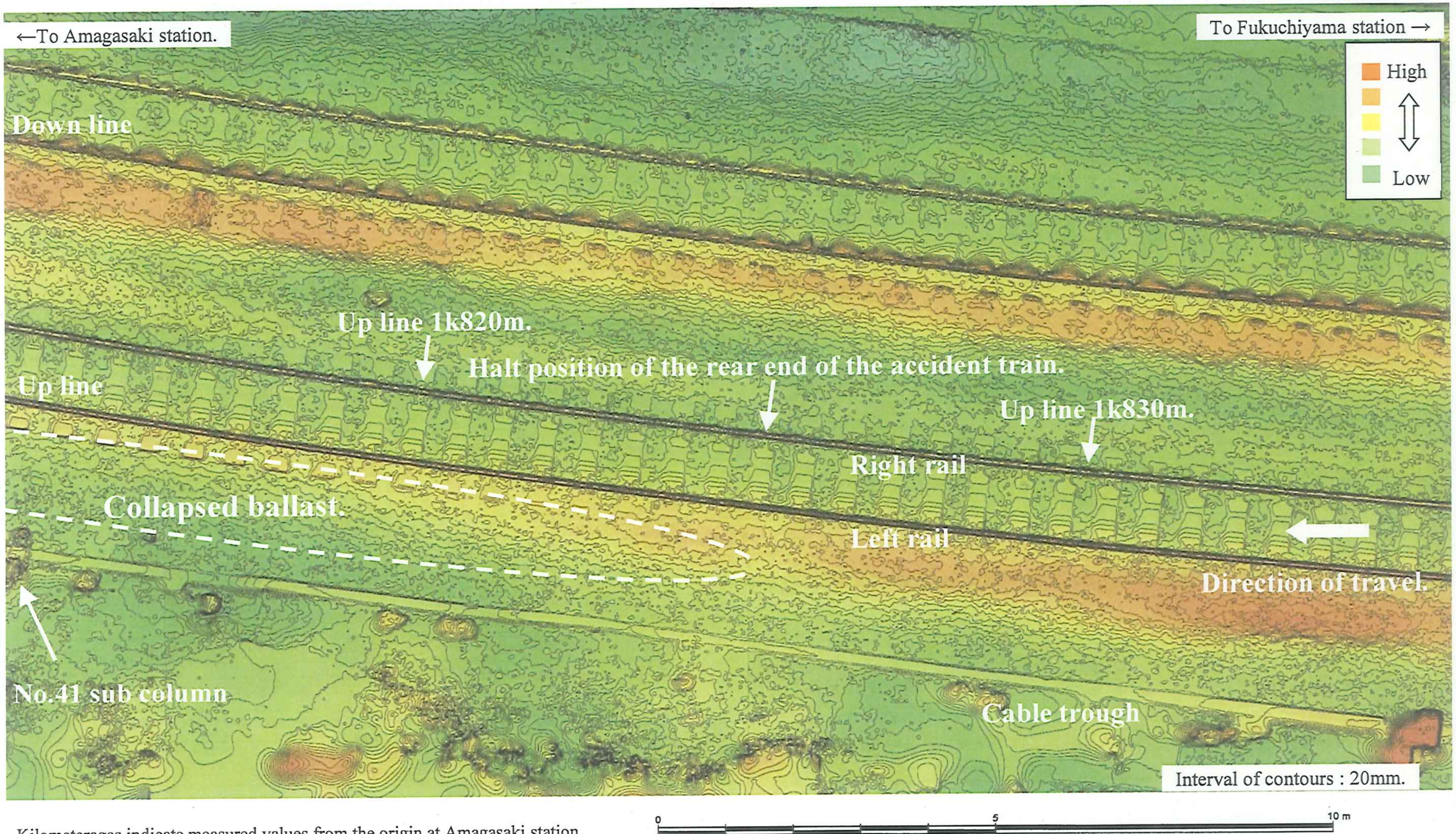
Position of No.108 - No.47 sleepers, up line 1k817m - 1k857m





Kilometerages indicate measured values from the origin at Amagasaki station.

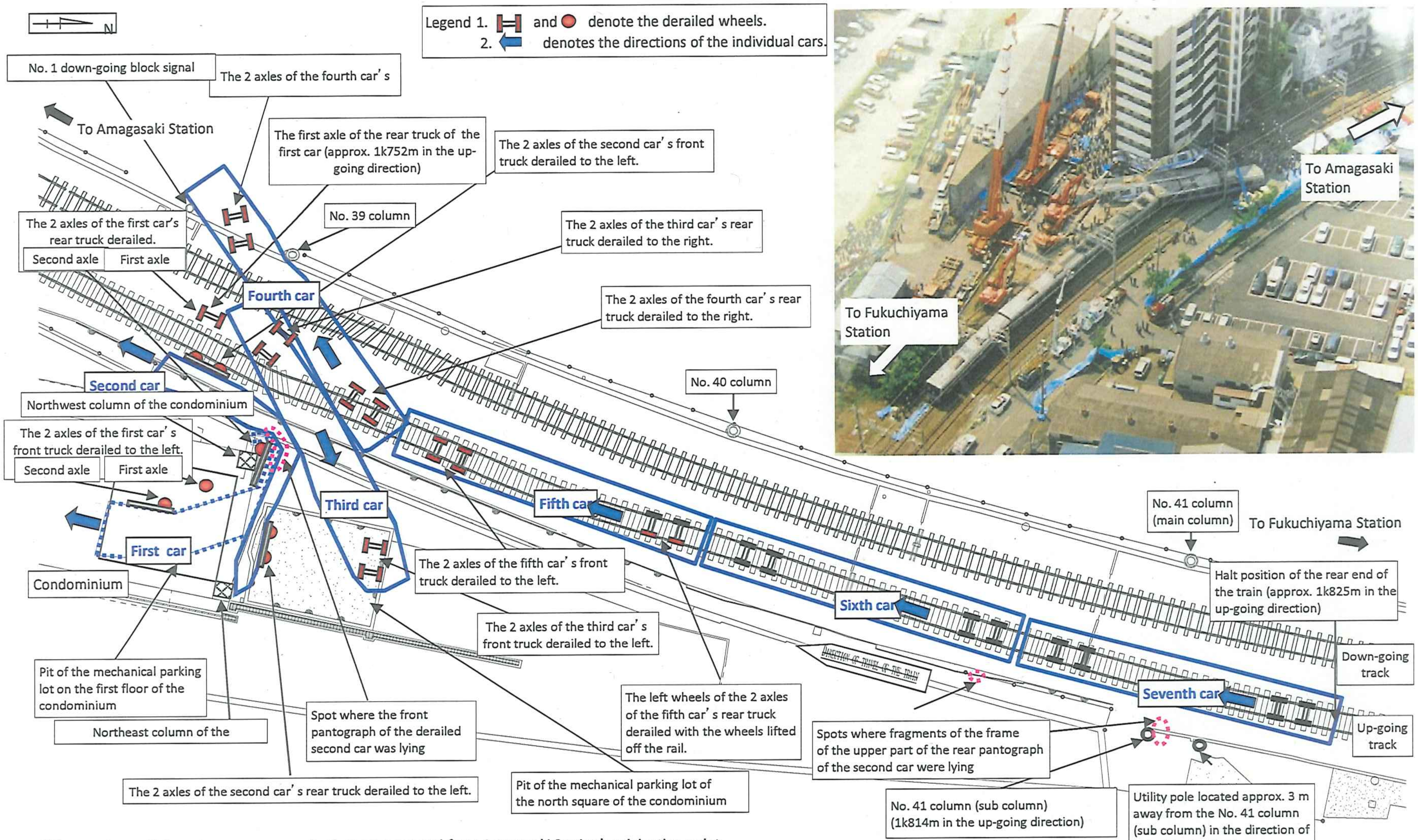
Figure 8 - Three-Dimensional Track Measurement (2) (Top of the Ballast)



Kilometerages indicate measured values from the origin at Amagasaki station.

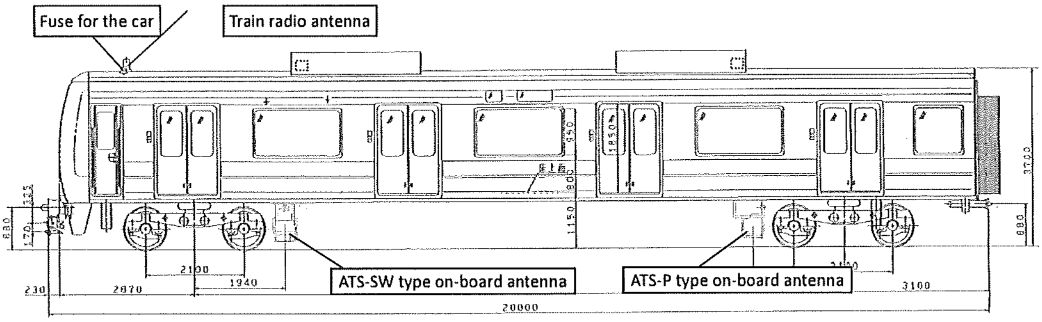
Figure 9 - Track Caused by the Accident

Figure 12 – Schematic Diagram of the Derailment of the Train

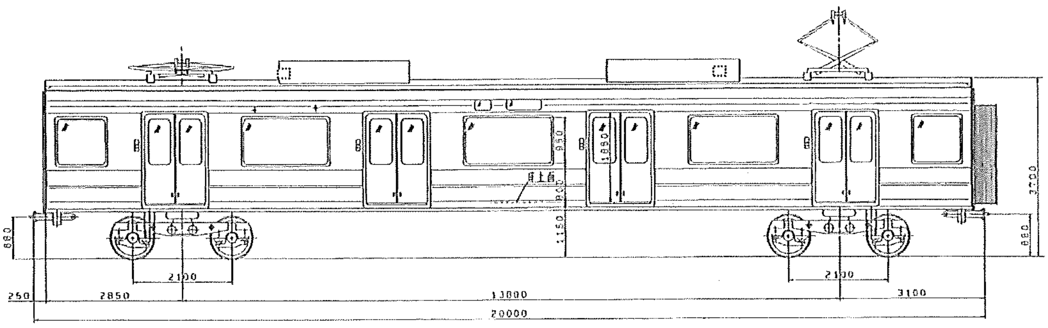


* The numbers of kilometers are measured values as measured from Amagasaki Station's origination point.

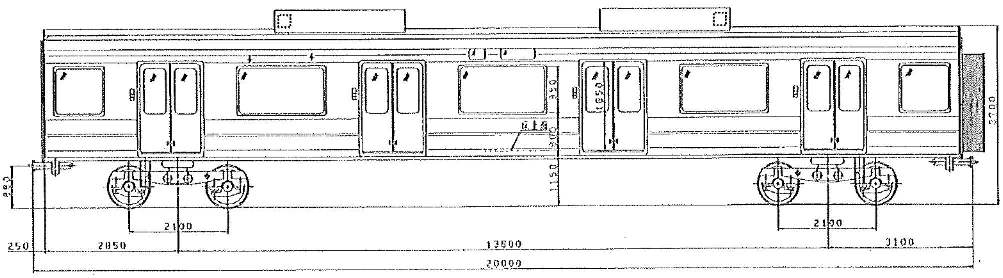
Figure 14 – Railway Car Types (1/3)



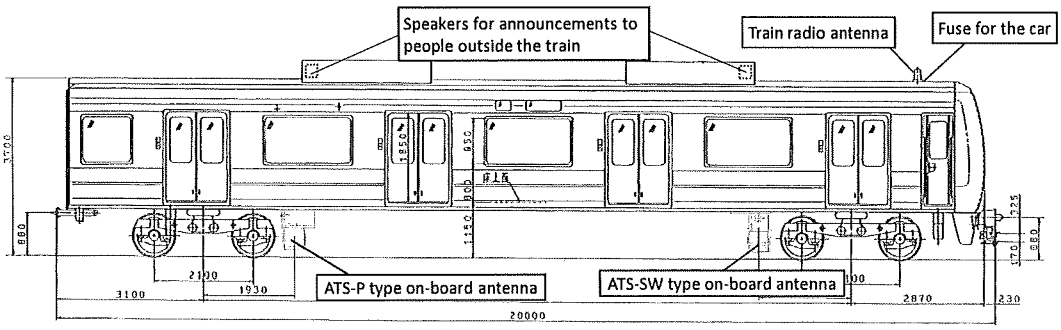
First car (KUHA207-17)



Second car (MOHA207-31)



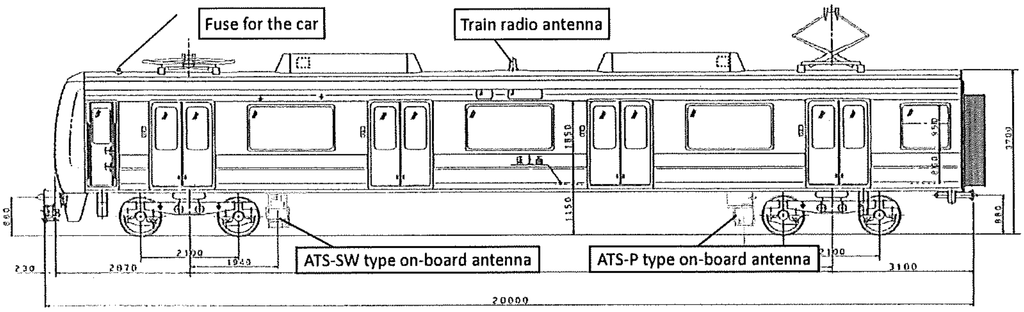
Third car (MOHA206-17)



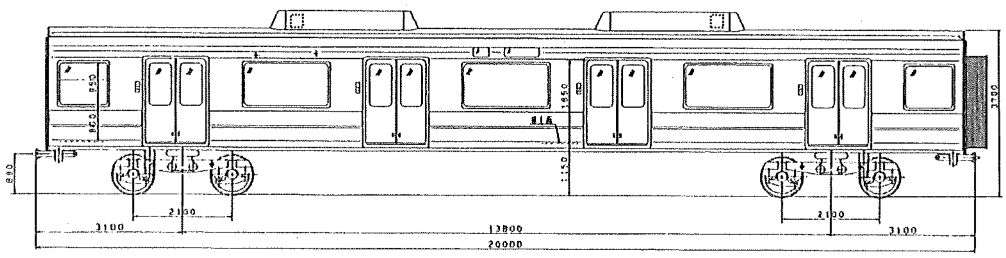
Fourth car (KUHA206-129)

* The locations of the speakers for announcements to people outside the train are the same on all cars.

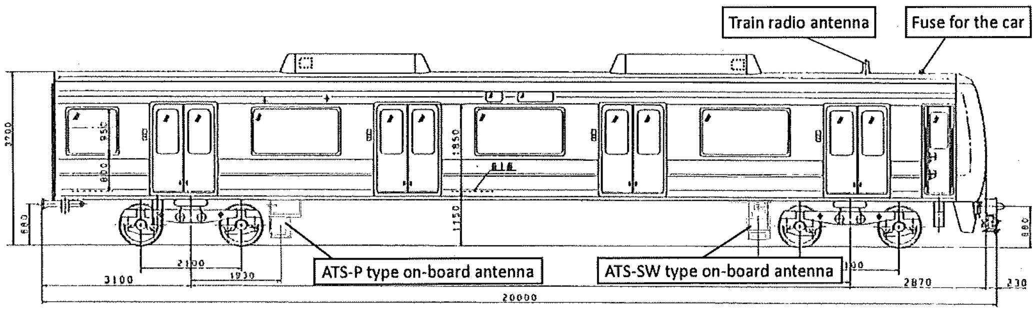
Figure 14 – Railway Car Types (2/3)



Fifth car (KUMOHA207-1033)



Sixth car (SAHA207-1019)



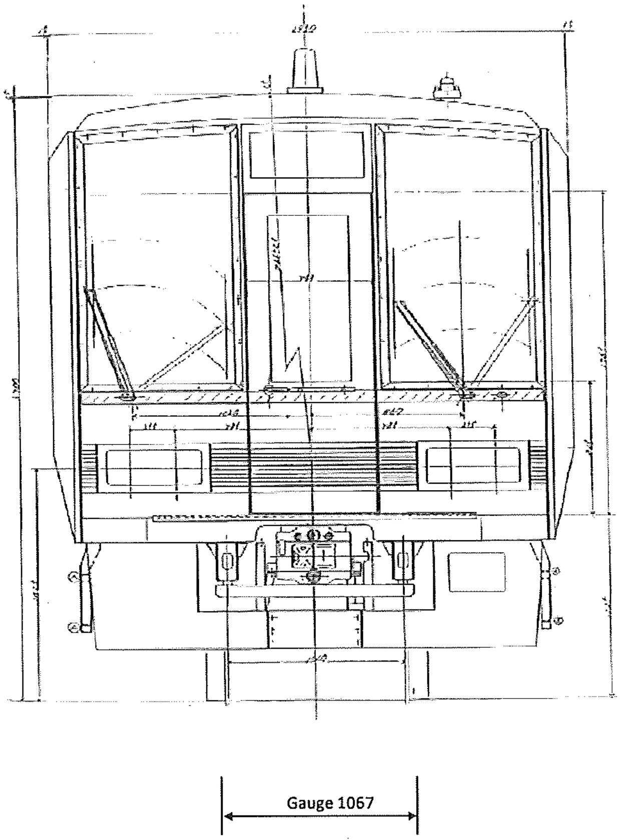
Seventh car (KUHA206-1033)

Main Specifications

Car position in the train	First car	Second car	Third car	Fourth car	Fifth car	Sixth car	Seventh car
Identification number	KUHA207-17	MOHA207-31	MOHA206-17	KUHA206-129	KUMOHA207-1033	SAHA207-1019	KUHA206-1033
Month and year of manufacture	Feb-92	Feb-92	Feb-92	Feb-92	Mar-95	Mar-95	Mar-95
Tare (t)	26.3	35.2	32.2	26.3	37.4	24.8	27.8
Passenger capacity (number of persons)	150	163	163	150	150	163	150
Car length (m)	20.000						
Roof height (m)	3.700						
Car body width (m)	2.950						
Monitor equipment	Old type	Old type	Old type	Old type	New type	New type	New type
EB equipment	Not equipped	—	—	Not equipped	Equipped	—	Equipped
TE equipment	Not equipped	—	—	Not equipped	Equipped	—	Equipped
Backup power supply for the train radio equipment	Switching is necessary.	—	—	Switching is necessary.	Switching is necessary.	—	Switching is necessary.
Backup power supply for the train protection radio equipment	Switching is not necessary.	—	—	Switching is not necessary.	Switching is necessary.	—	Switching is necessary.

Figure 14 – Railway Car Types (3/3)

Front View (KUHA207-17)



Cross Section of the Ordinary Part (KUHA207-17)

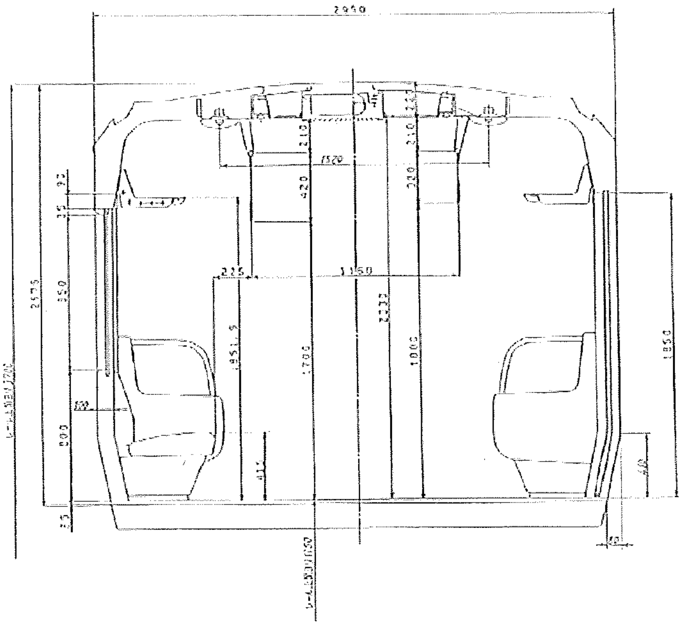
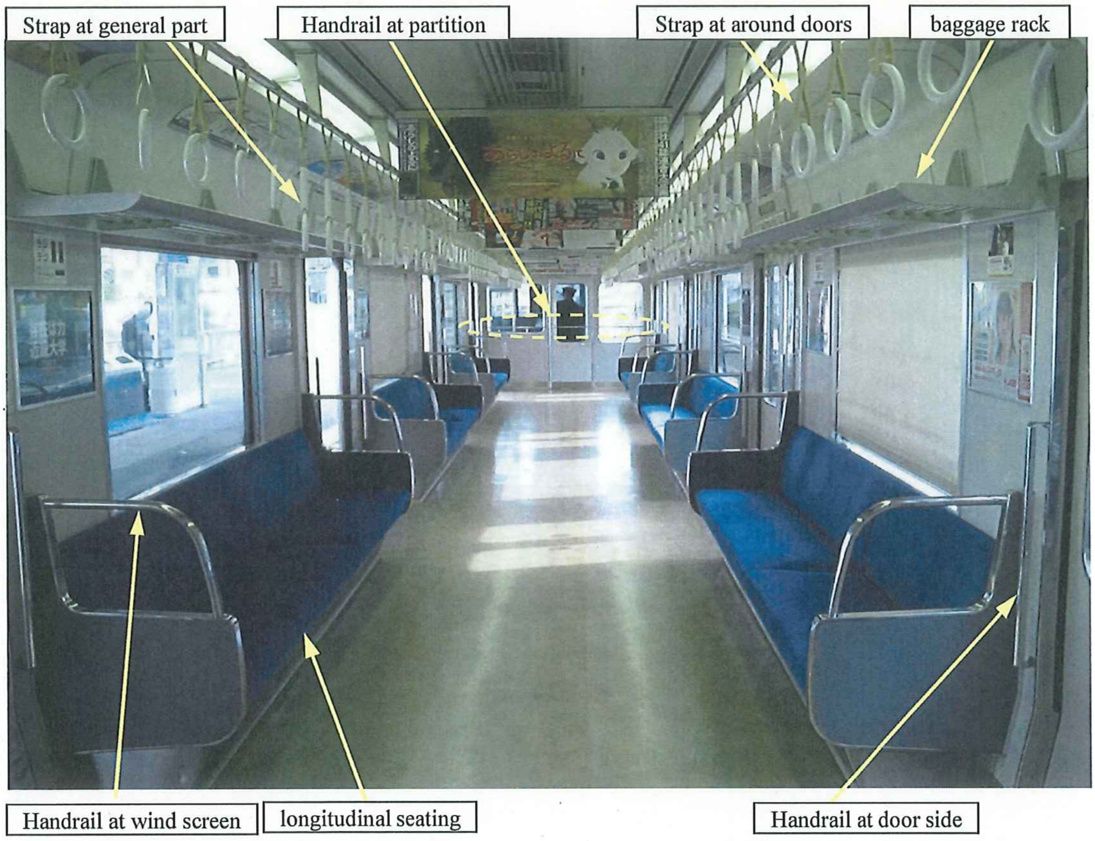
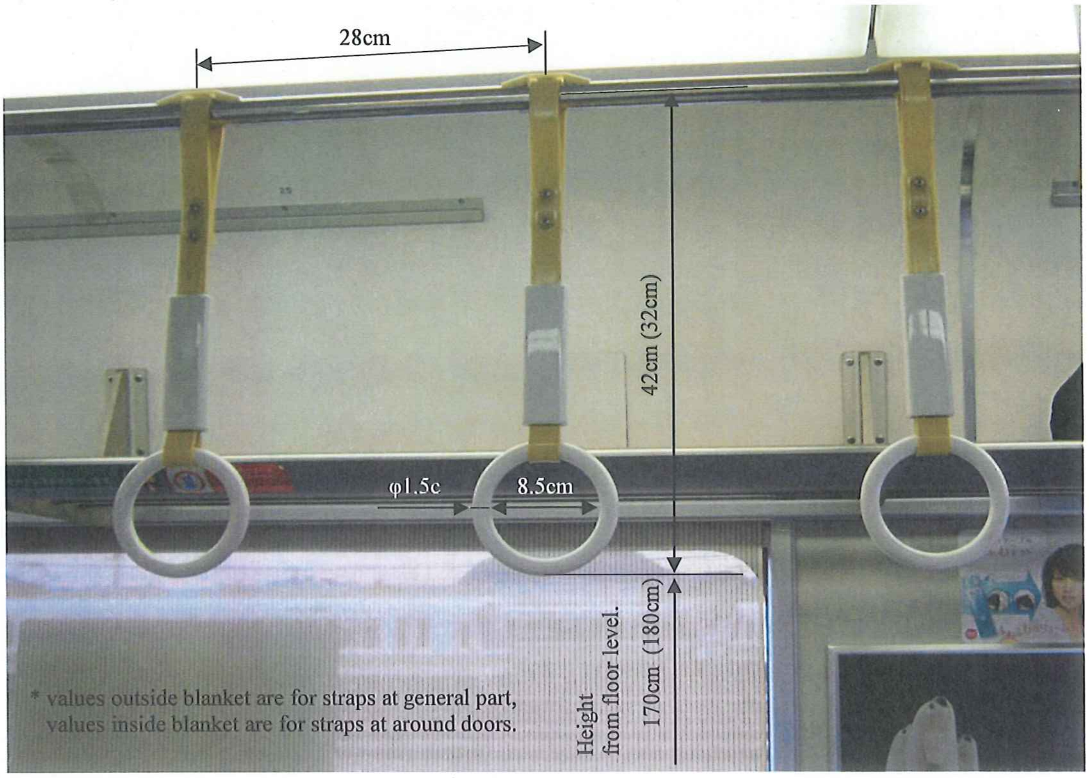


Figure 15 - Overview of the Passenger Room

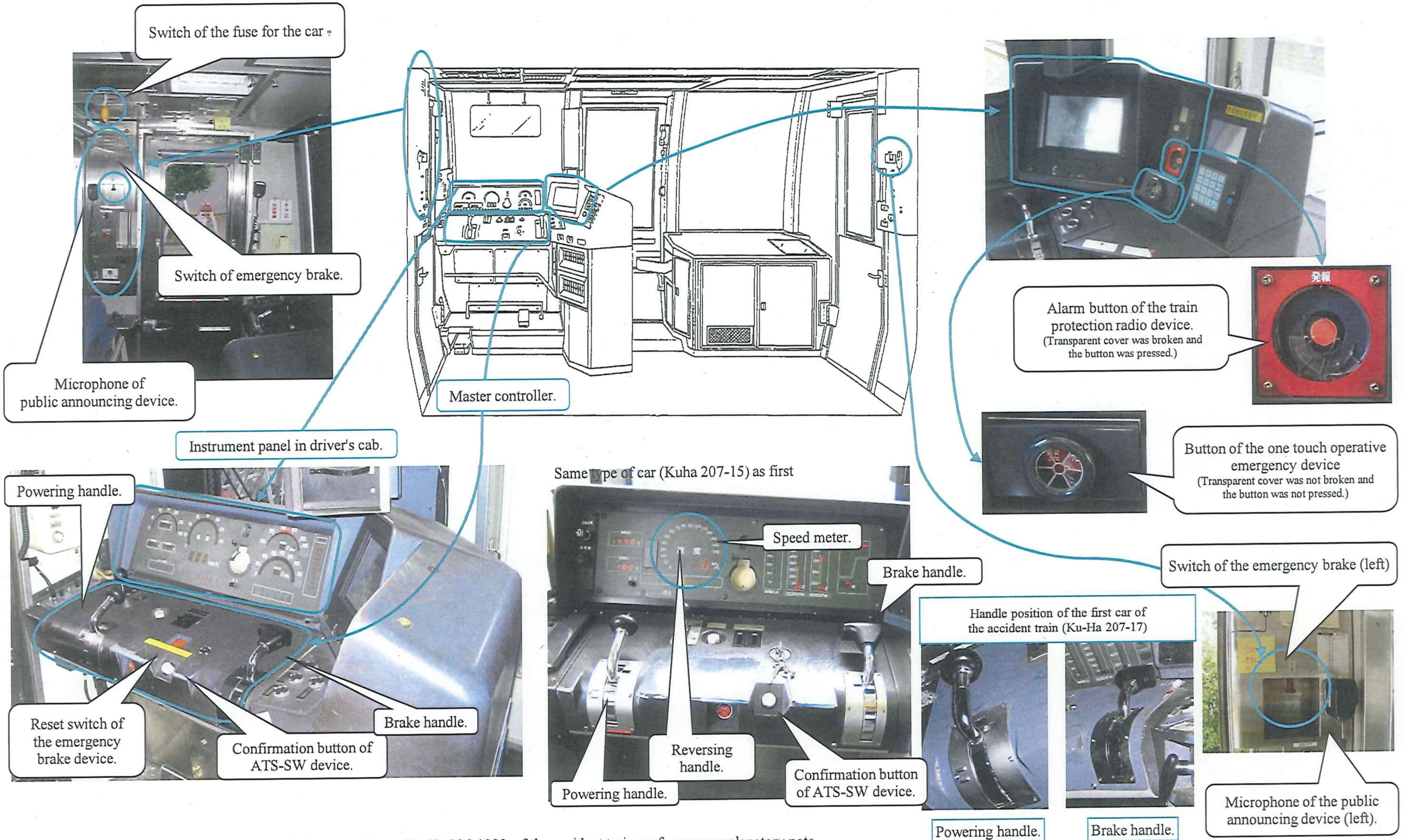
These figures are for the same type train as the accident train.





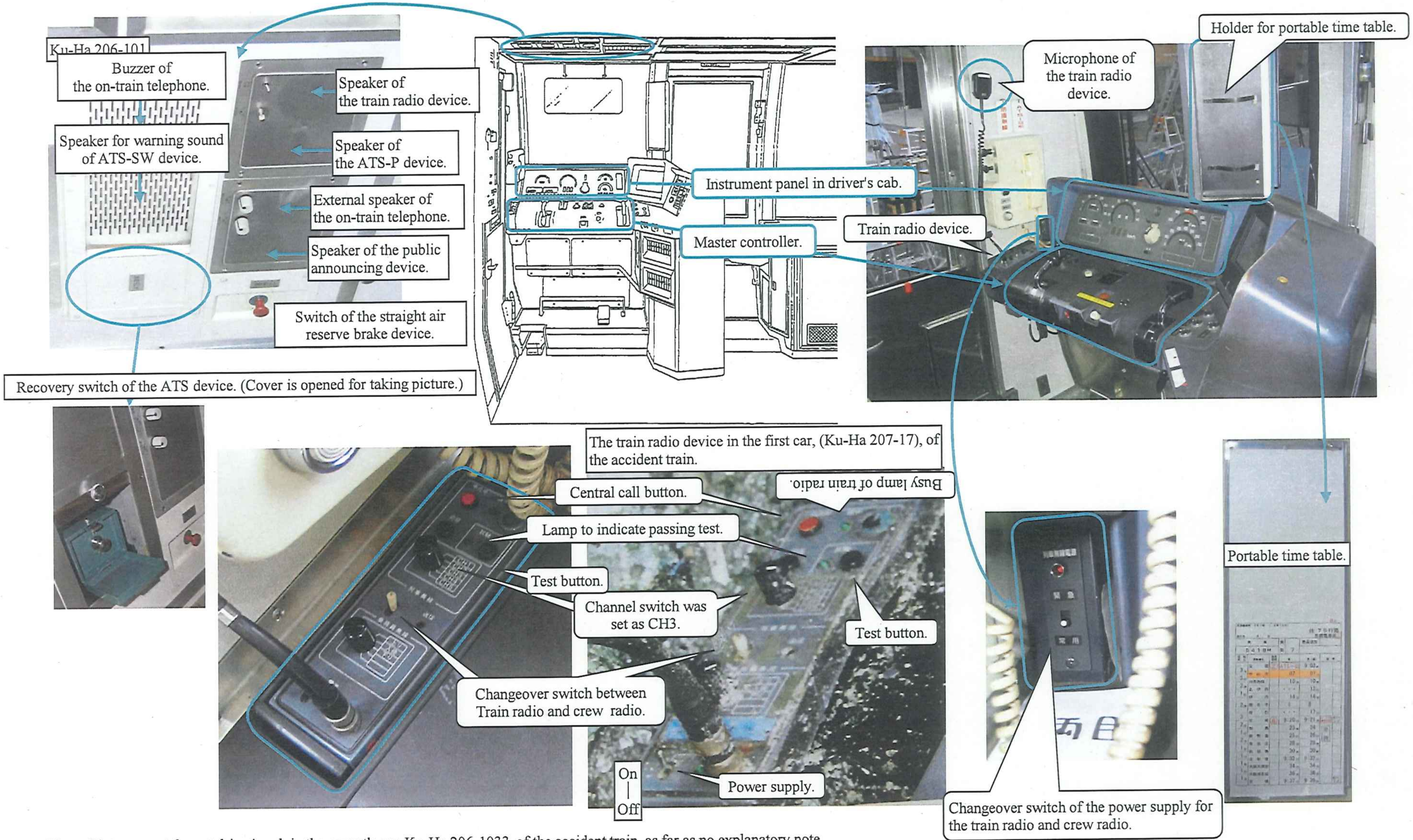
Strap at around doors and general part.

Figure 16 - Layout of the Equipment in the Driving Cab (1)



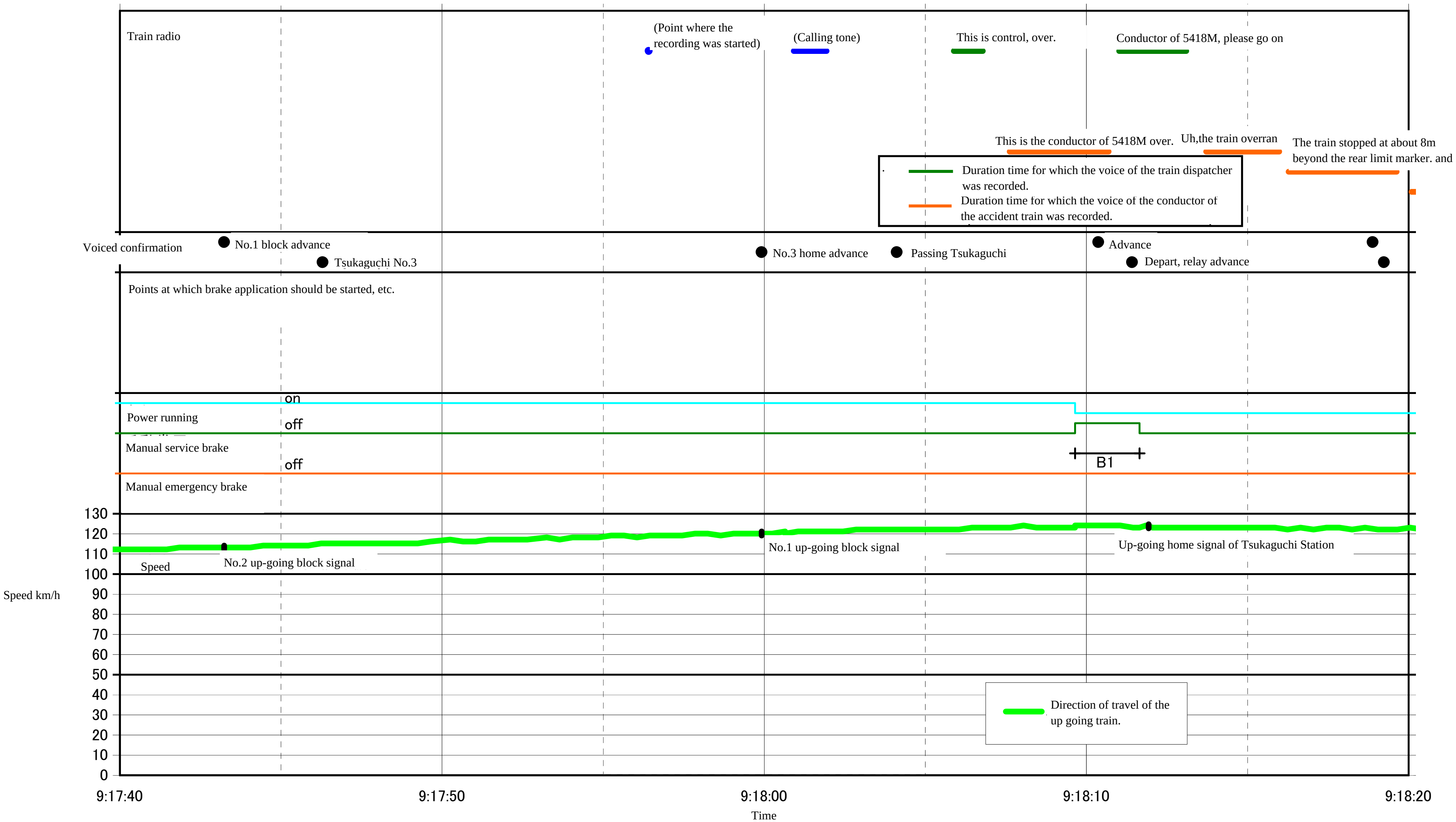
Note : Pictures are taken at driver's cab in the seventh car, Ku-Ha 206-1033, of the accident train, as far as no explanatory note.

Figure 16 - Layout of the Equipment in the Driving Cab (2)



Note : Pictures are taken at driver's cab in the seventh car, Ku-Ha 206-1033, of the accident train, as far as no explanatory note.

Figure 24 -(Time-based) Record of Train Operation (in the Vicinity of the Accident Site) 1/3



* Because there is no record of voiced confirmation by the train driver of the accident train, main ones of the voiced confirmation events specified in "Operation" are shown (the same applies in the following sheets).

* Recording start time was adjusted from the recording start time of the communication record "204T091757a" saved in the long-time recording device.

Figure 24- (Time-based) Record of Train Operation (in the Vicinity of the Accident Site) 2/3

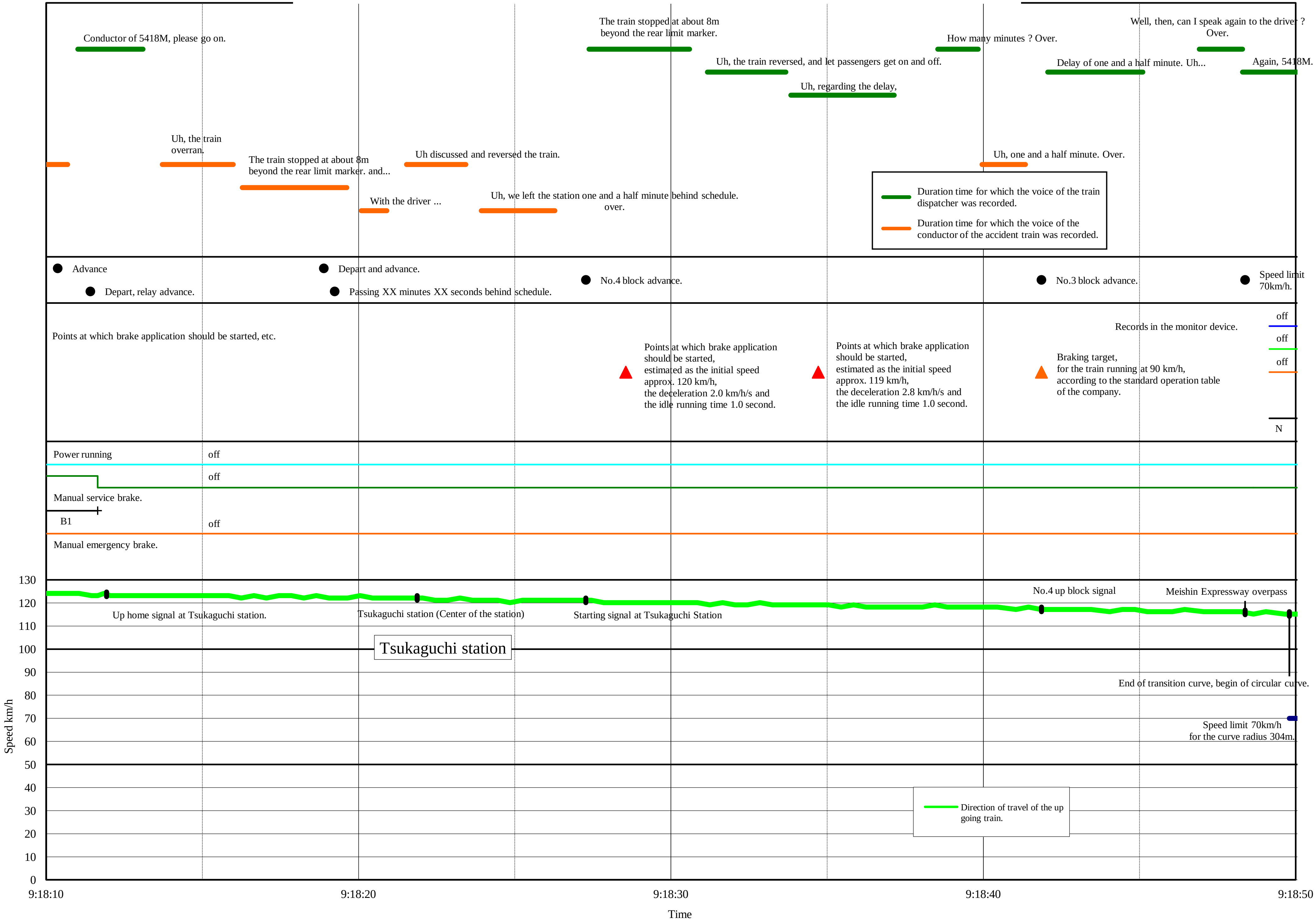


Figure 24 -(Time-based) Record of Train Operation (in the Vicinity of the Accident Site) 3/3

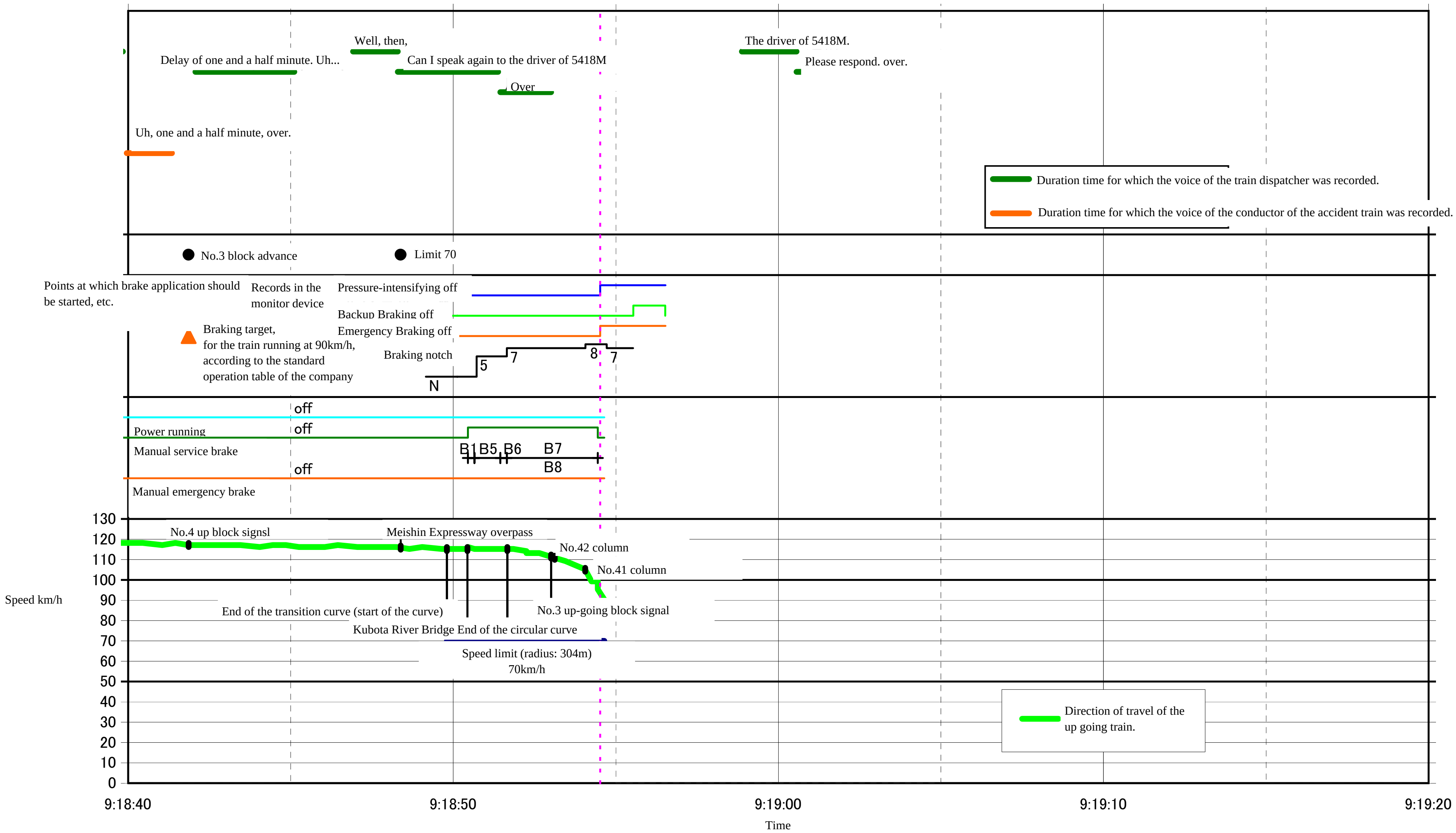
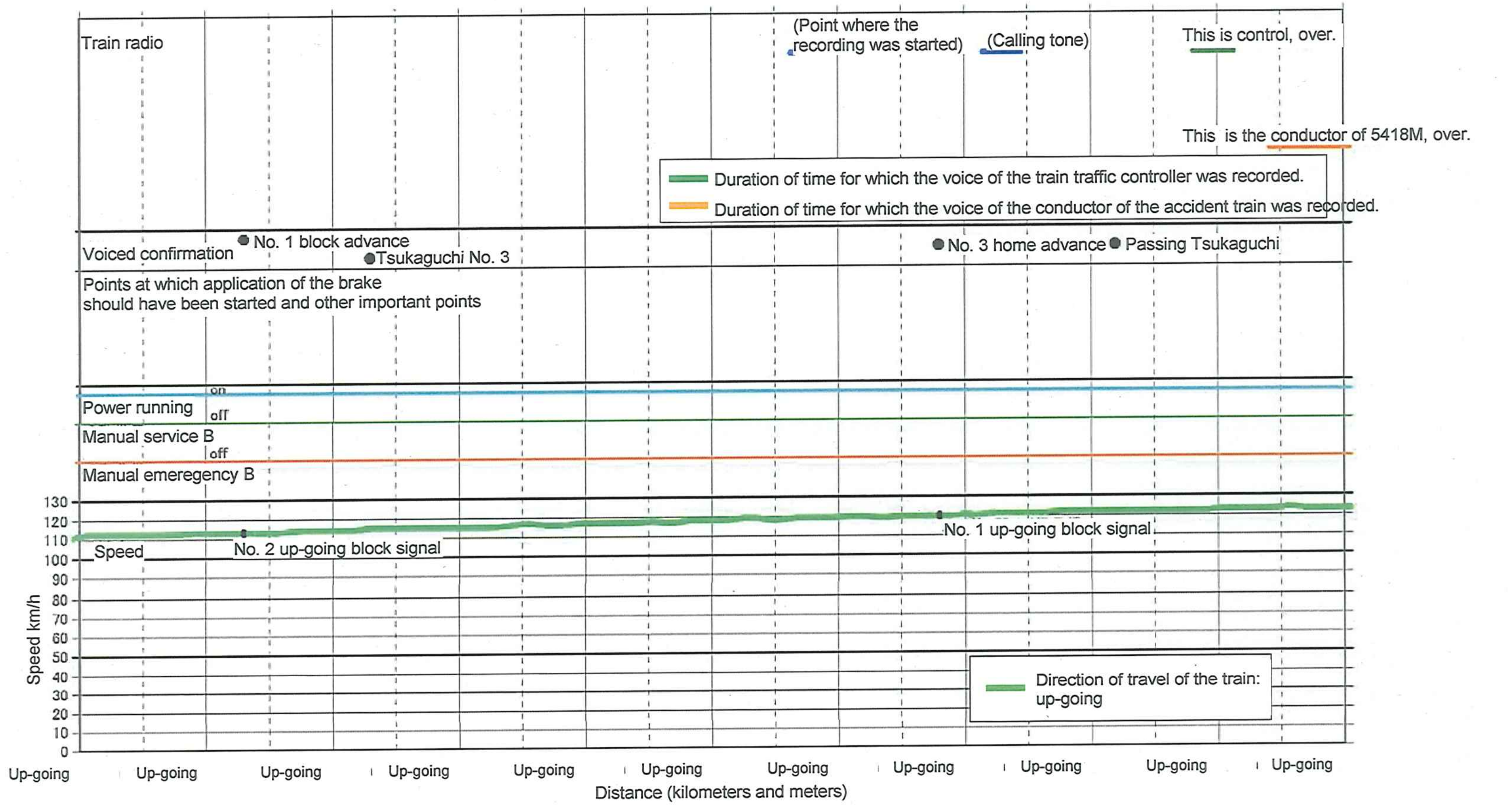


Figure 25 - (Distance-based) Record of Train Operation (in the Vicinity of the Accident Site) 1/3



* Because there is no record of voiced confirmation by the train driver of the accident train, main ones of the voiced confirmation events specified in "Operation" are shown (the same applies in the following sheets).
* Distance (in kilometers) to the (point where the recording was started) was calculated from the recording start time of the radio exchange record "204T092140a" saved in the long-time recording device, with corrections made to the startin

Figure 25 - (Distance-based) Record of Train Operation (in the Vicinity of the Accident Site) 2/3

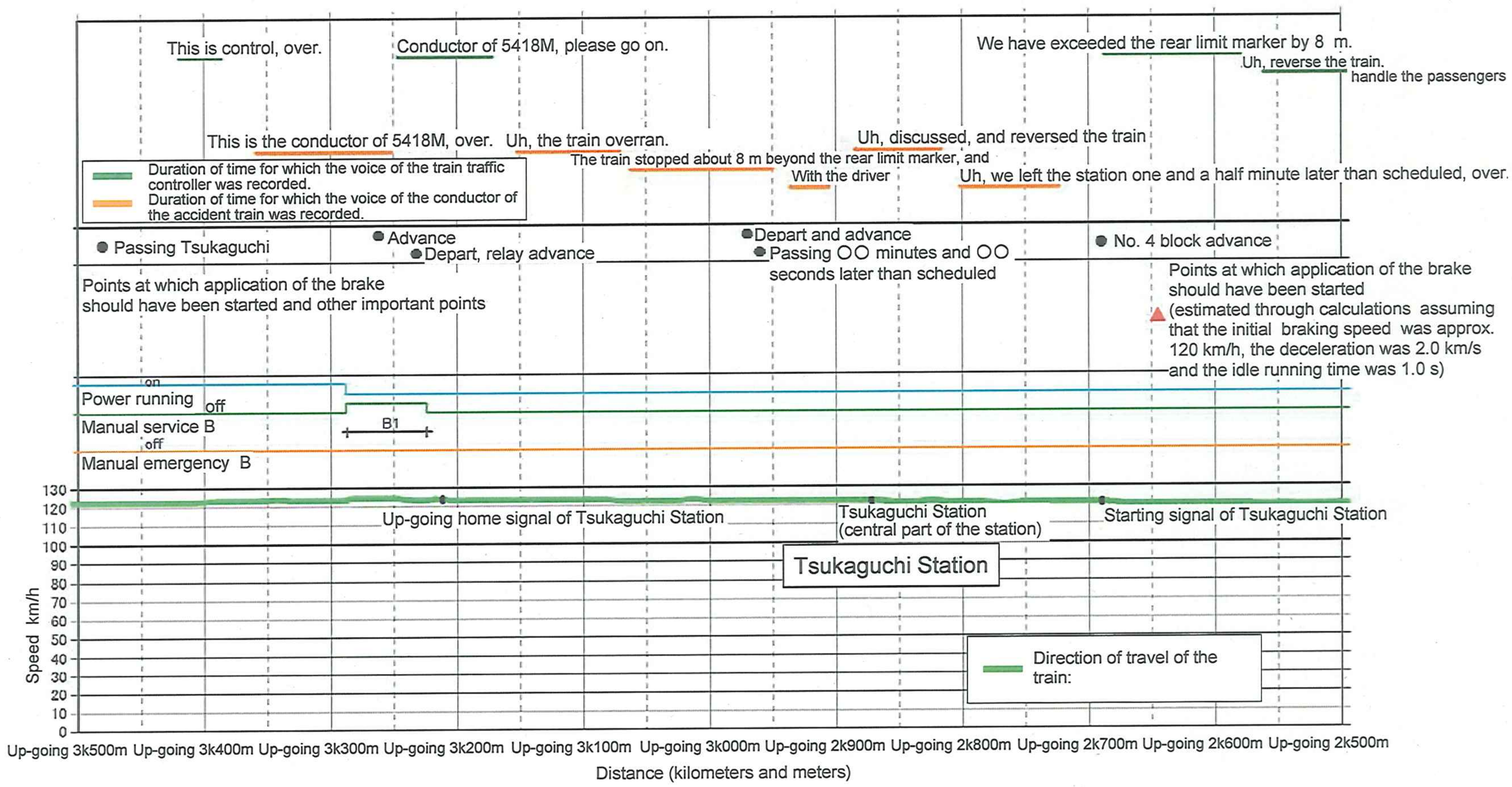


Figure 25 - (Distance-based) Record of Train Operation (in the Vicinity of the Accident Site) 3/3

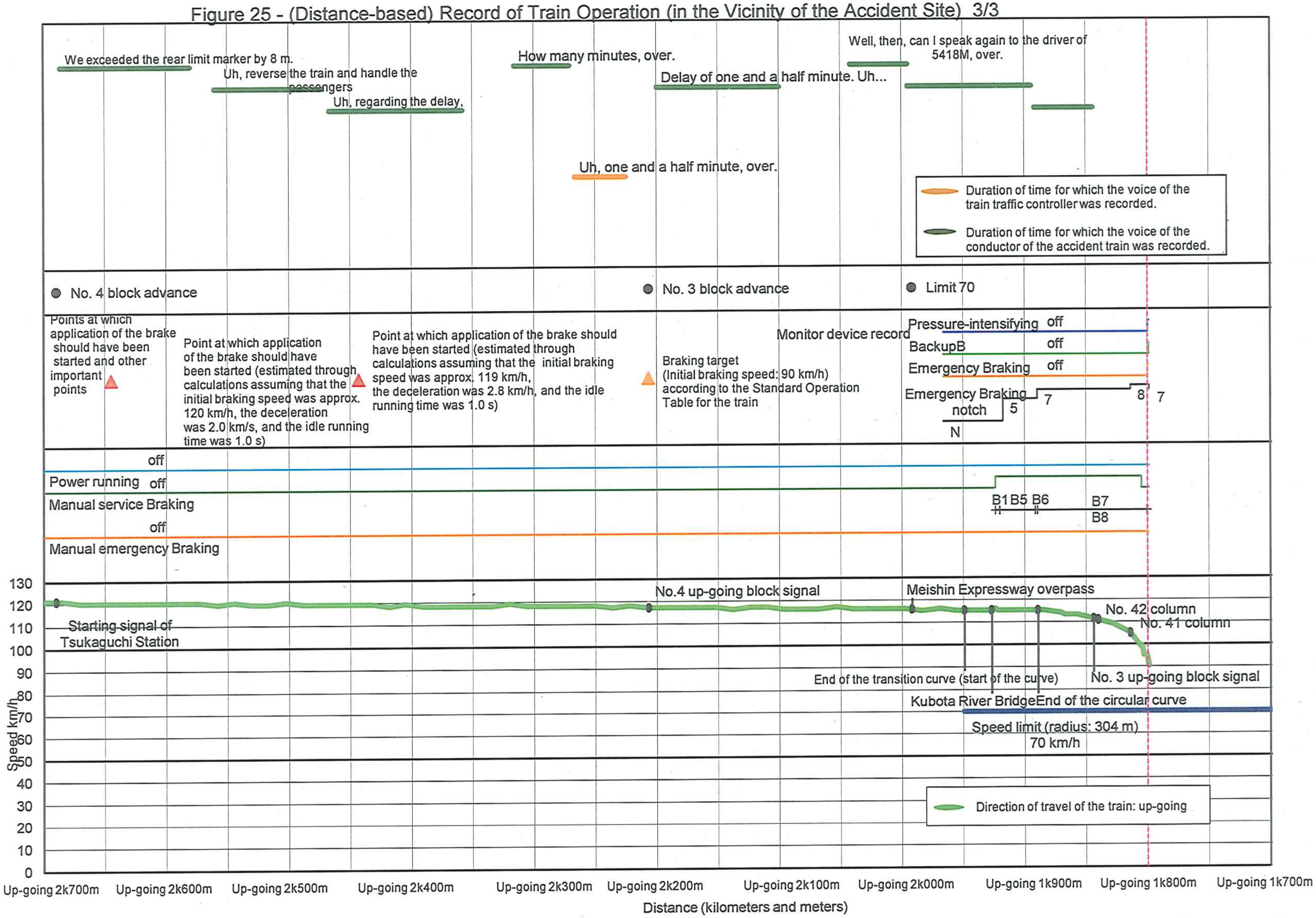
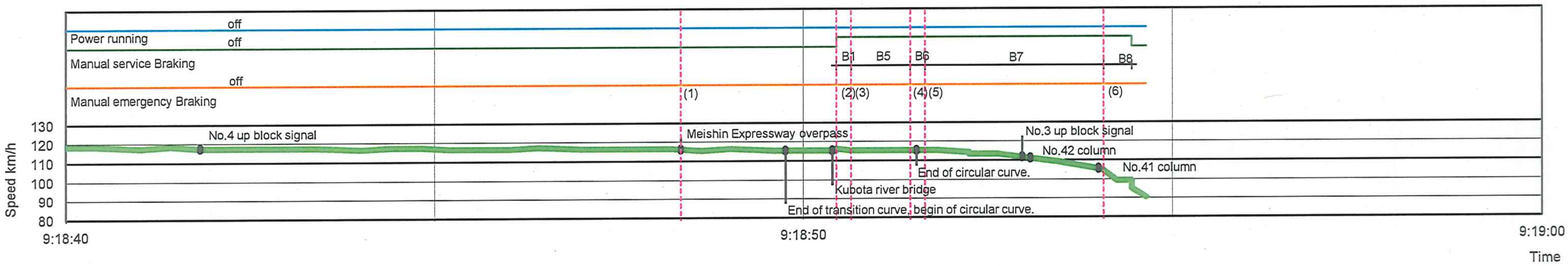


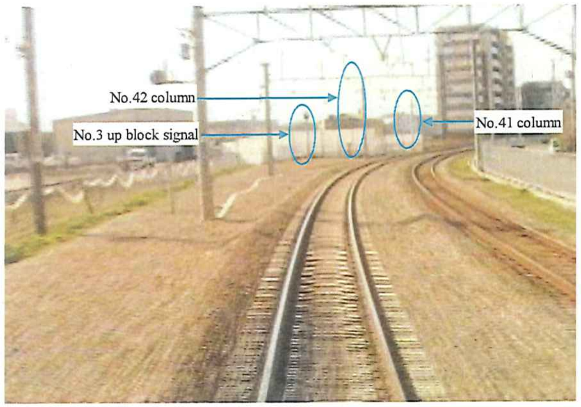
Figure 26- View from the Driving Cab of the First Car in the Vicinity of the Accident Site


(1) View from Meishin Expressway overpass, at around 1k992m


(3) View from the point where service brake B5 notch was applied, at around 1k919m.


(5) View from the point where service brake B7 notch was applied, at around 1k888m.





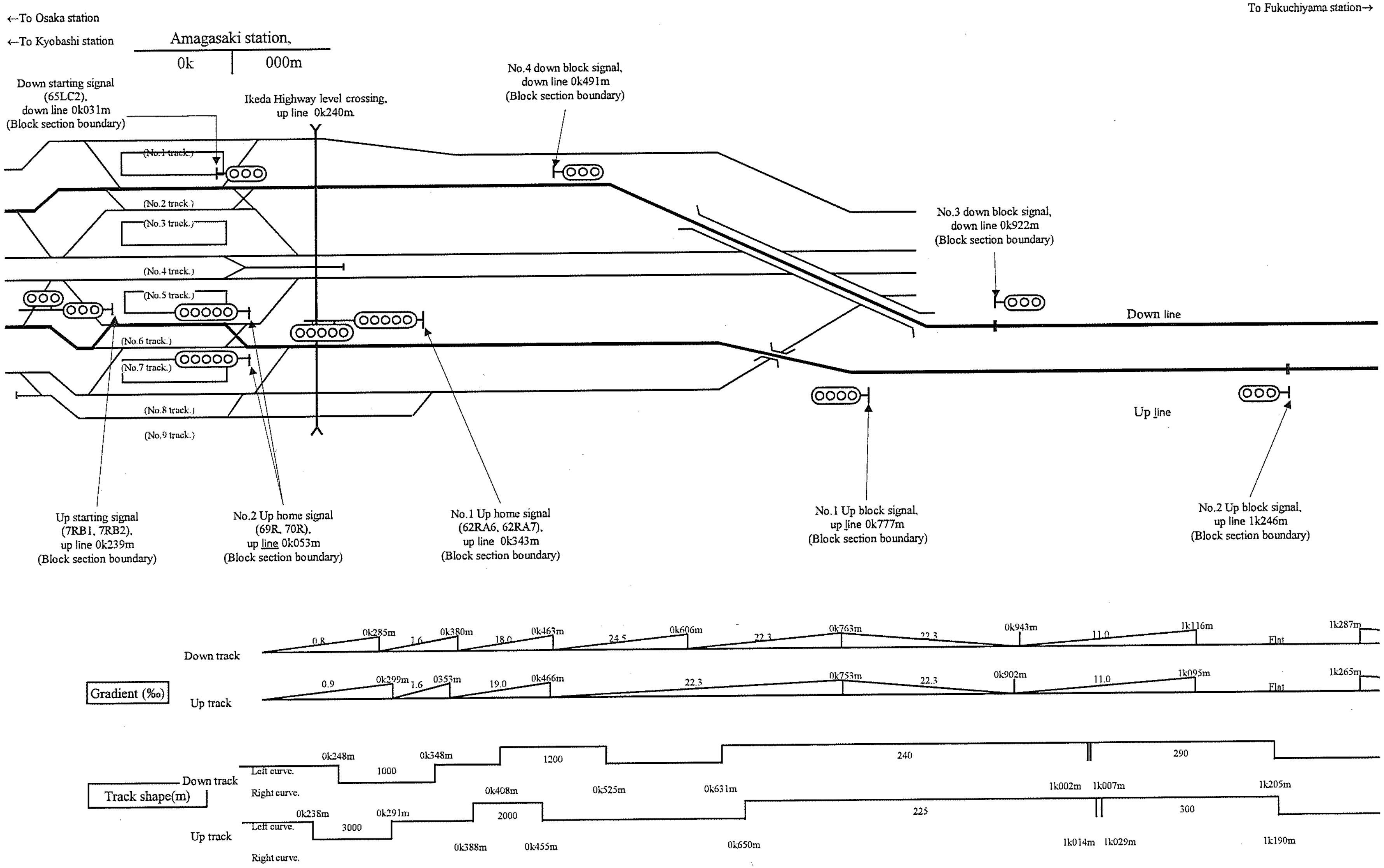
(2) View from the point where service brake B1 notch was applied, at around 1k923m.


(4) View from the point where service brake B6 notch was applied, at around 1k890m.


(6) View from the point where service brake B8 notch was applied, at around 1k812m.

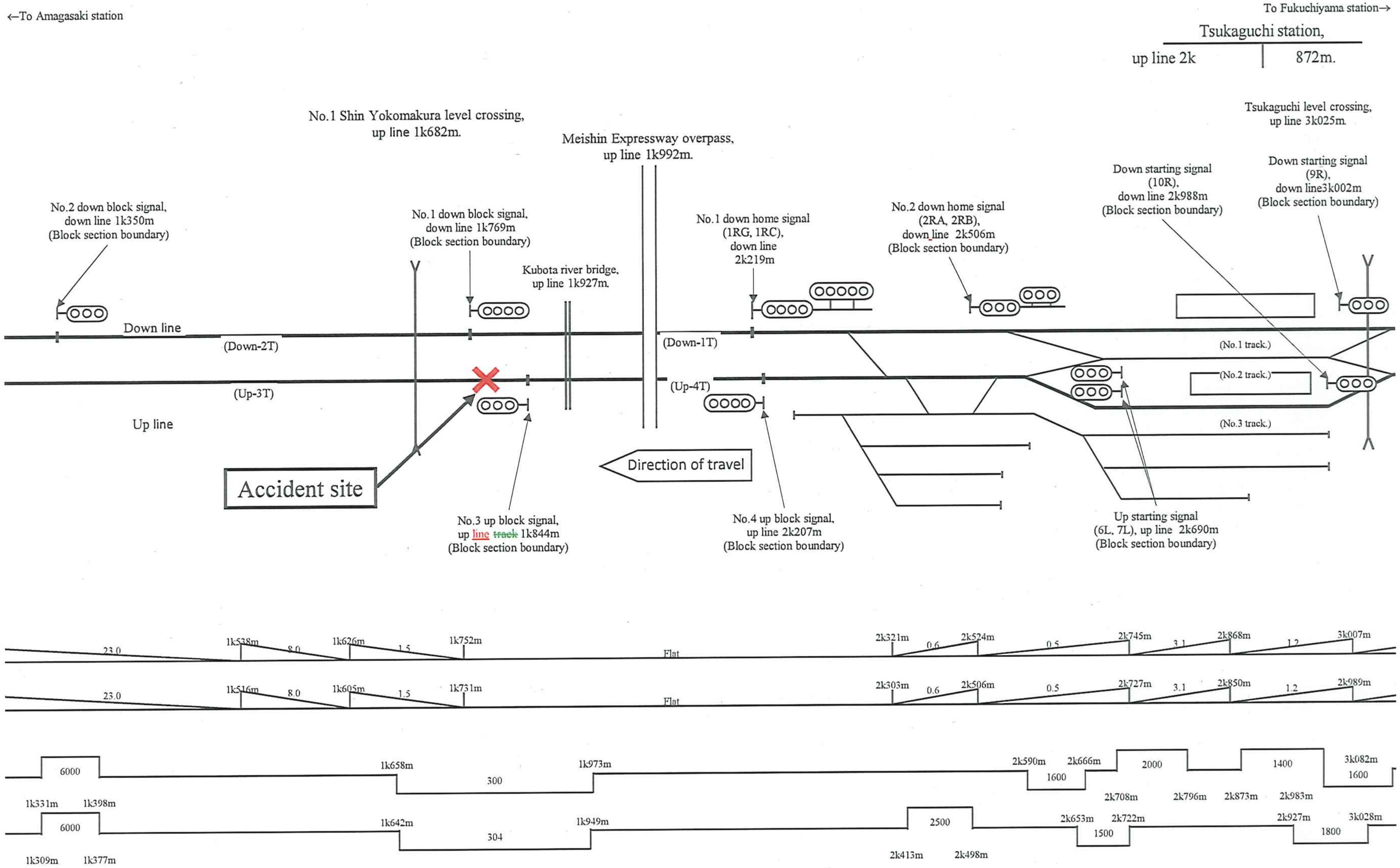
These pictures were taken from the train different from the accident train, after the accident. Kilometerages indicated above may include a margin of error.

Figure 27 - Simplified Diagram of the Tracks and Signals of the Fukuchiyama Line (between Amagasaki and Takarazuka Stations) (1/8)



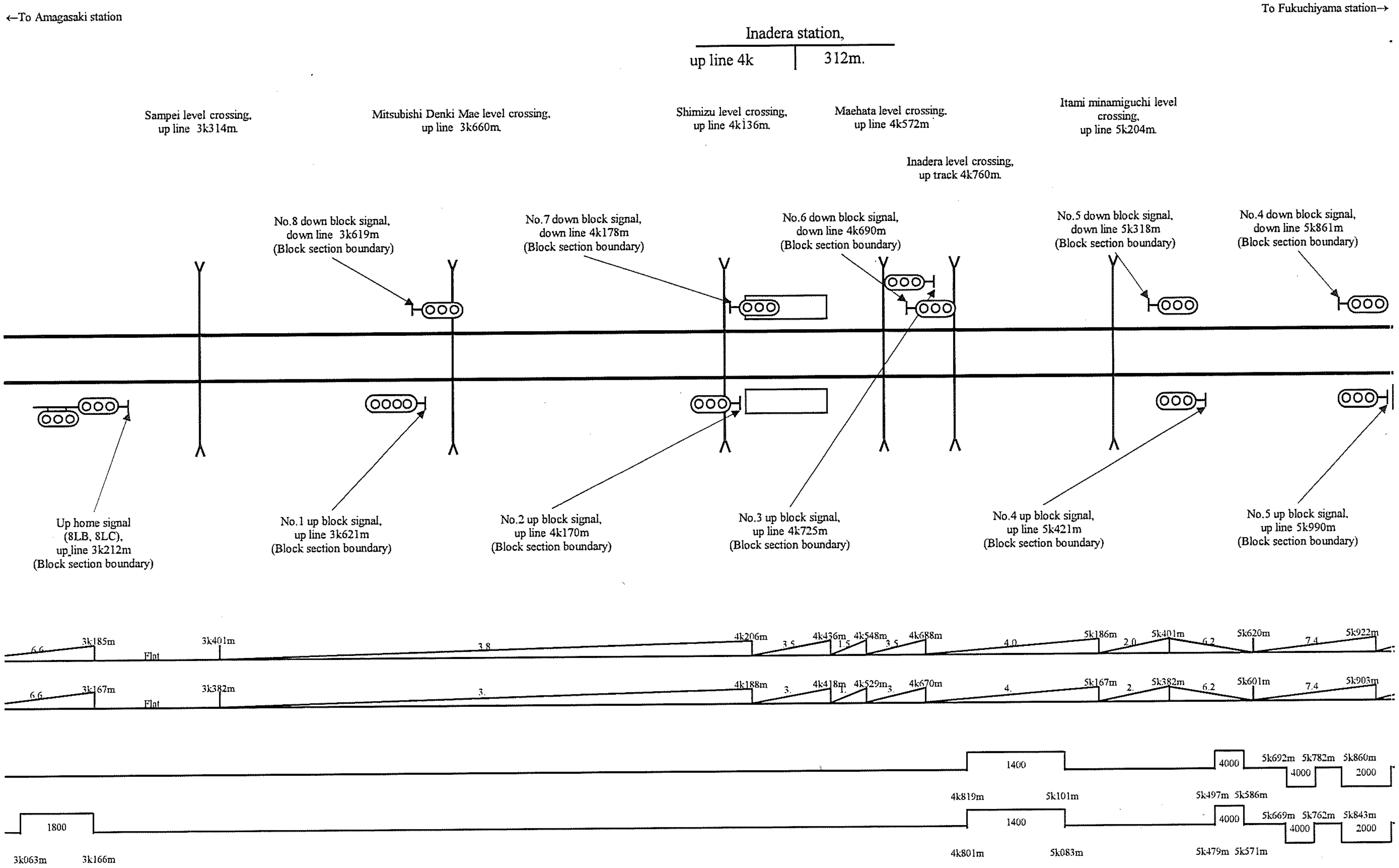
The numbers of kilometers are measured values as measured from Amagasaki Station' s origination point.

Figure 27 - Simplified Diagram of the Tracks and Signals of the Fukuchiyama Line (between Amagasaki and Takarazuka Stations) (2/8)



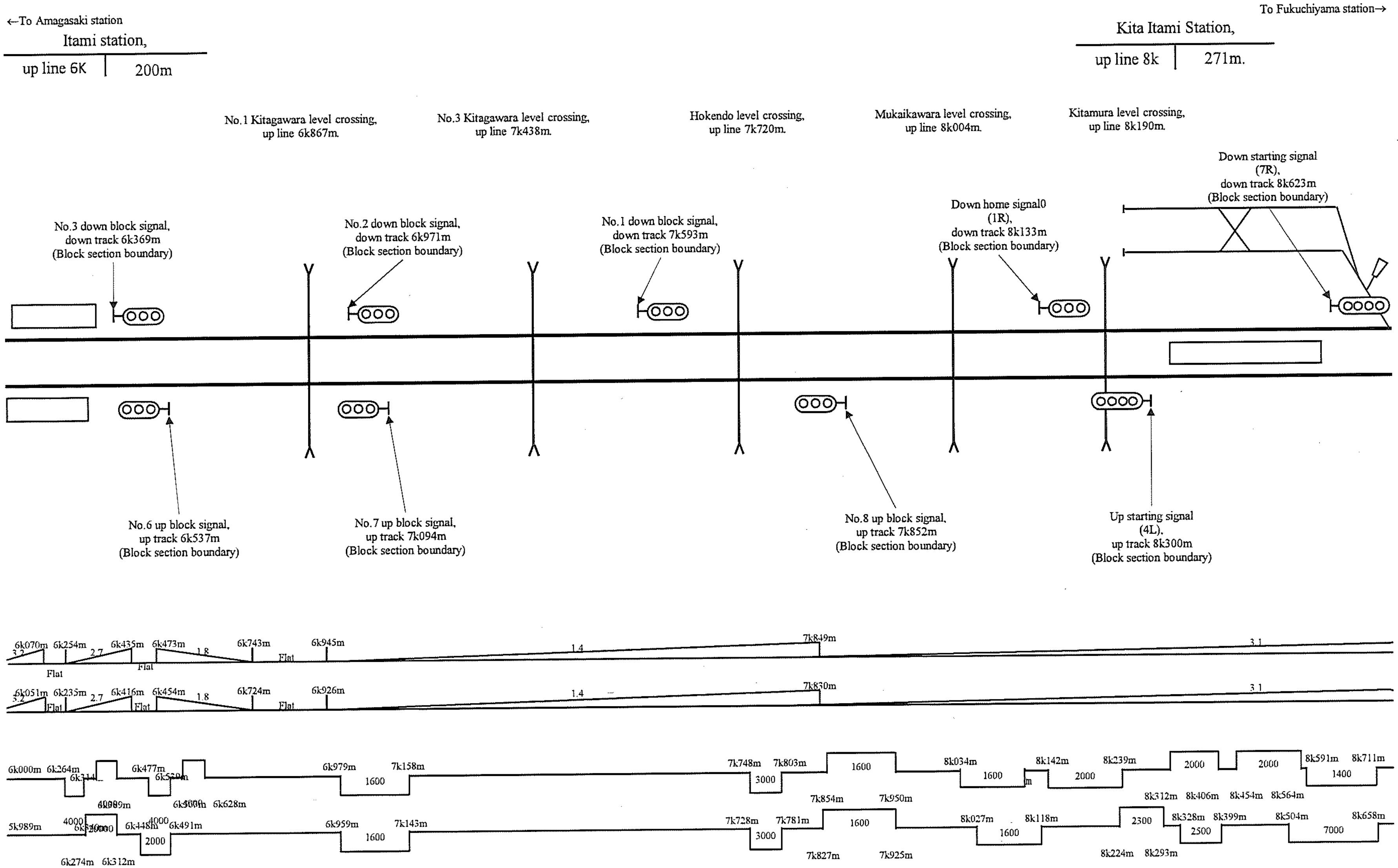
The numbers of kilometers are measured values as measured from Amagasaki Station's origination point.

Figure 27 -Simplified Diagram of the Tracks and Signals of the Fukuchiyama Line (between Amagasaki and Takarazuka Stations) (3/8)



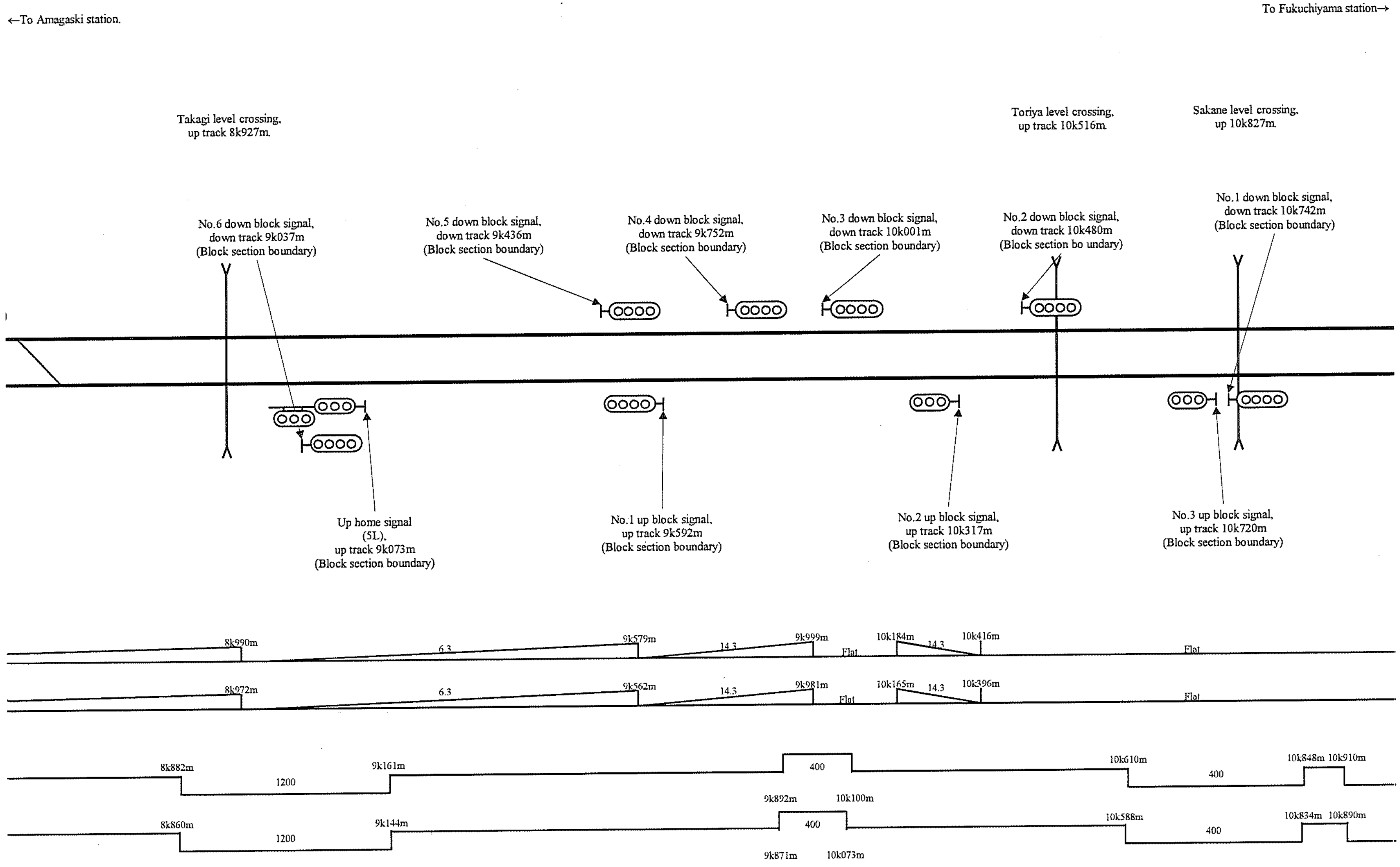
The numbers of kilometers are measured values as measured from Amagasaki Station' s origination point.

Figure 27 - Simplified Diagram of the Tracks and Signals of the Fukuchiyama Line (between Amagasaki and Takarazuka Stations) (4/8)



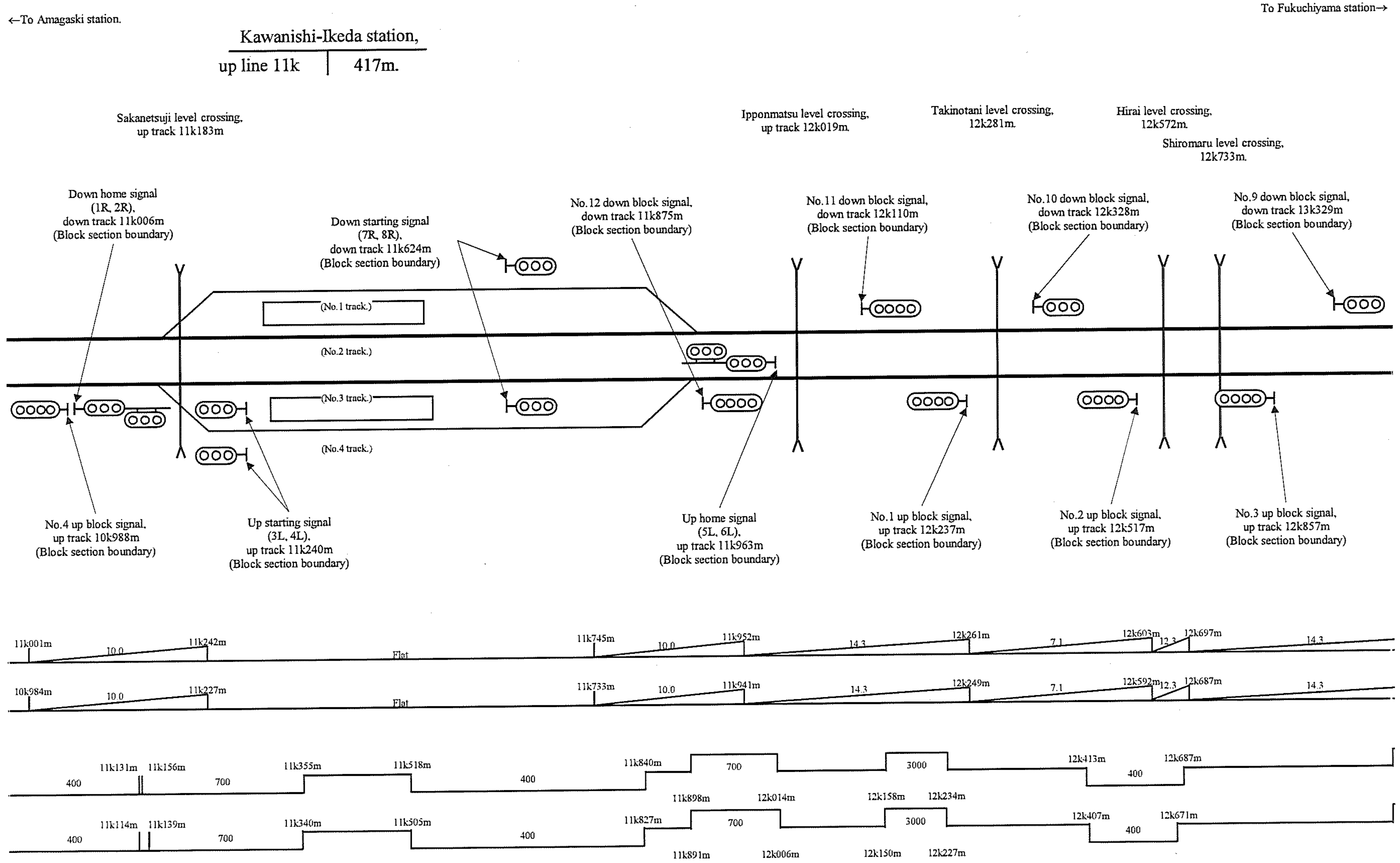
The numbers of kilometers are measured values as measured from Amagasaki Station' s origination point.

Figure 27 - Simplified Diagram of the Tracks and Signals of the Fukuchiyama Line (between Amagasaki and Takarazuka Stations) (5/8)



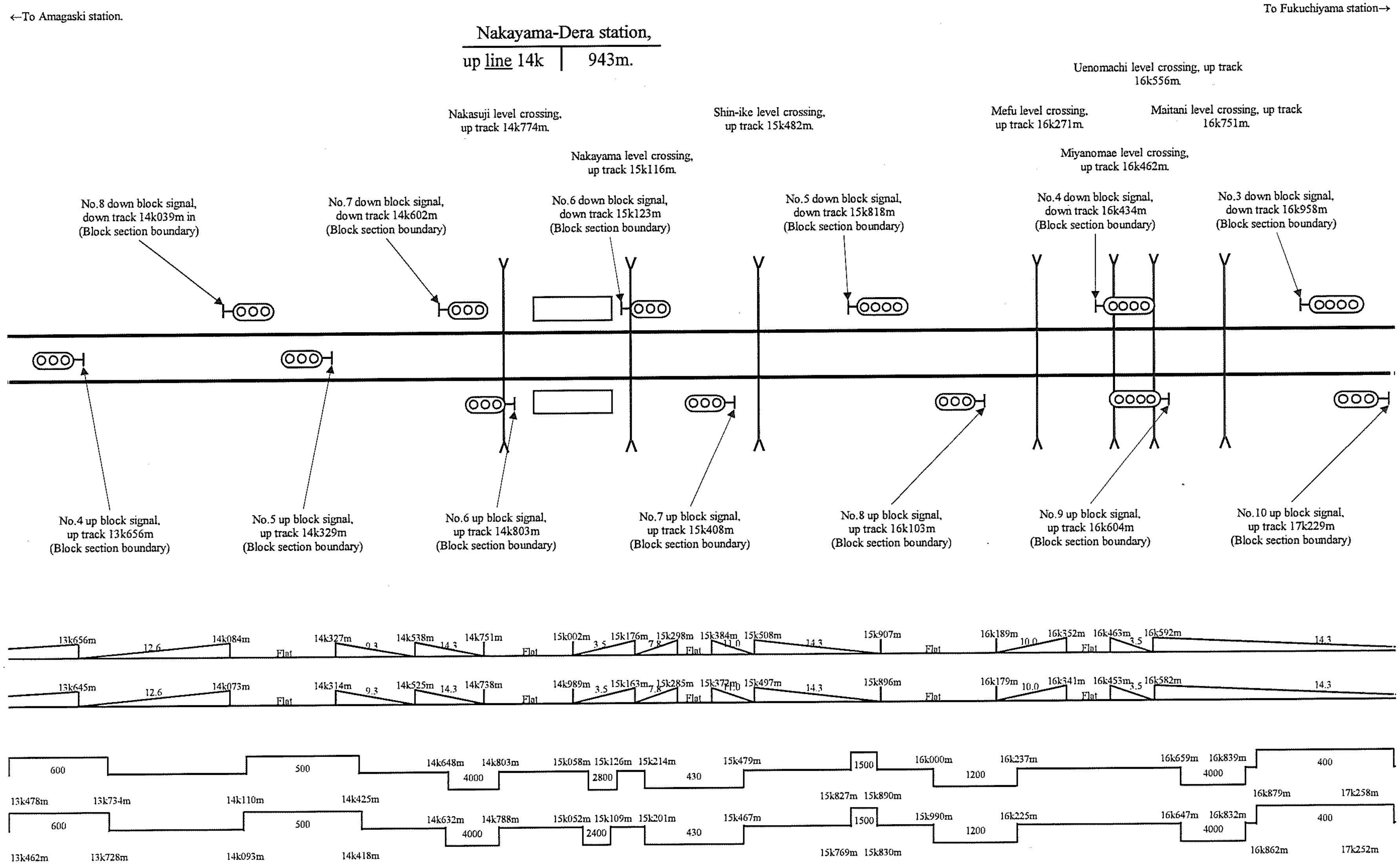
The numbers of kilometers are measured values as measured from Amagasaki Station' s origination point.

Figure 27 - Simplified Diagram of the Tracks and Signals of the Fukuchiyama Line (between Amagasaki and Takarazuka Stations) (6/8)



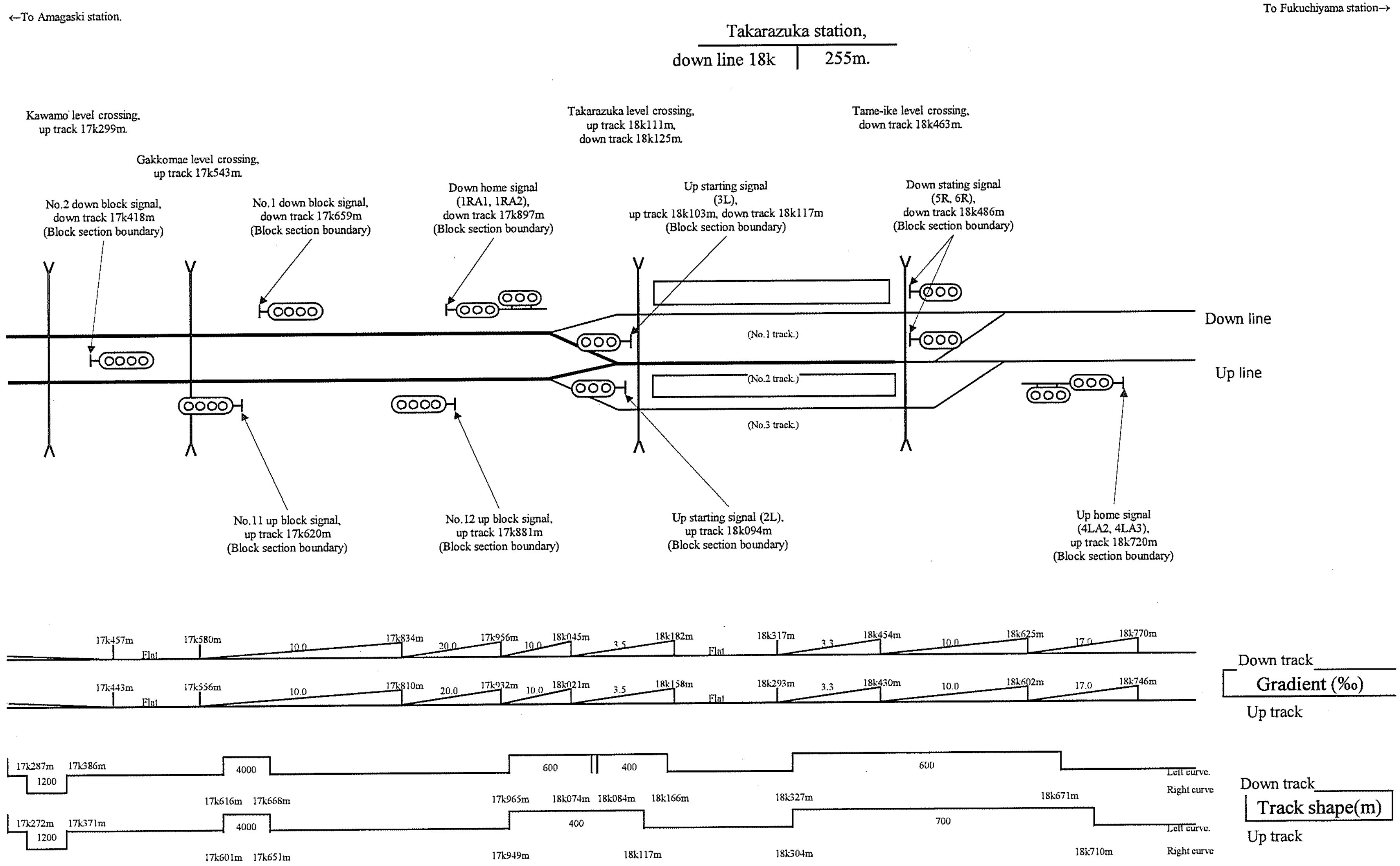
The numbers of kilometers are measured values as measured from Amagasaki Station' s origination point.

Figure 27 - Simplified Diagram of the Tracks and Signals of the Fukuchiyama Line (between Amagasaki and Takarazuka Stations) (7/8)



The numbers of kilometers are measured values as measured from Amagasaki Station' s origination point.

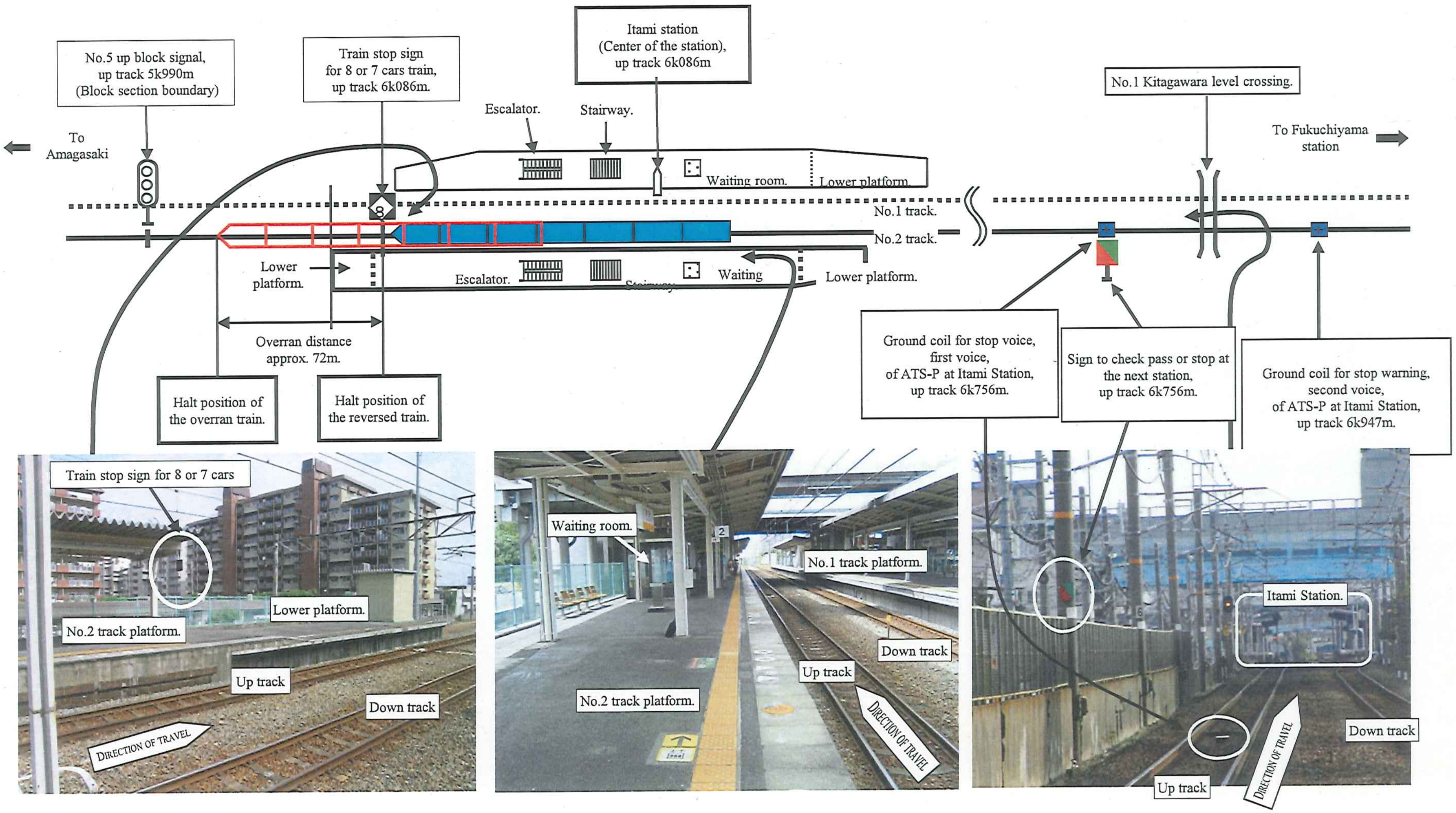
Figure 27 - Simplified Diagram of the Tracks and Signals of the Fukuchiyama Line (between Amagasaki and Takarazuka Stations) (8/8)



The track shape of the down track at Takarazuka Station indicates the No. 1 track. The track shape of the up track at Takarazuka Station indicates the No. 3

The numbers of kilometers are measured values as measured from Amagasaki Station' s origination point.

Figure 29 - Simplified Diagram of Itami Station.



Kilometerages indicate measured values from the origin at Amagasaki station.

Figure 32 - Record of the On-the-job Trips Made by the Accident Train's Driver ((2) The Day of the Accident)

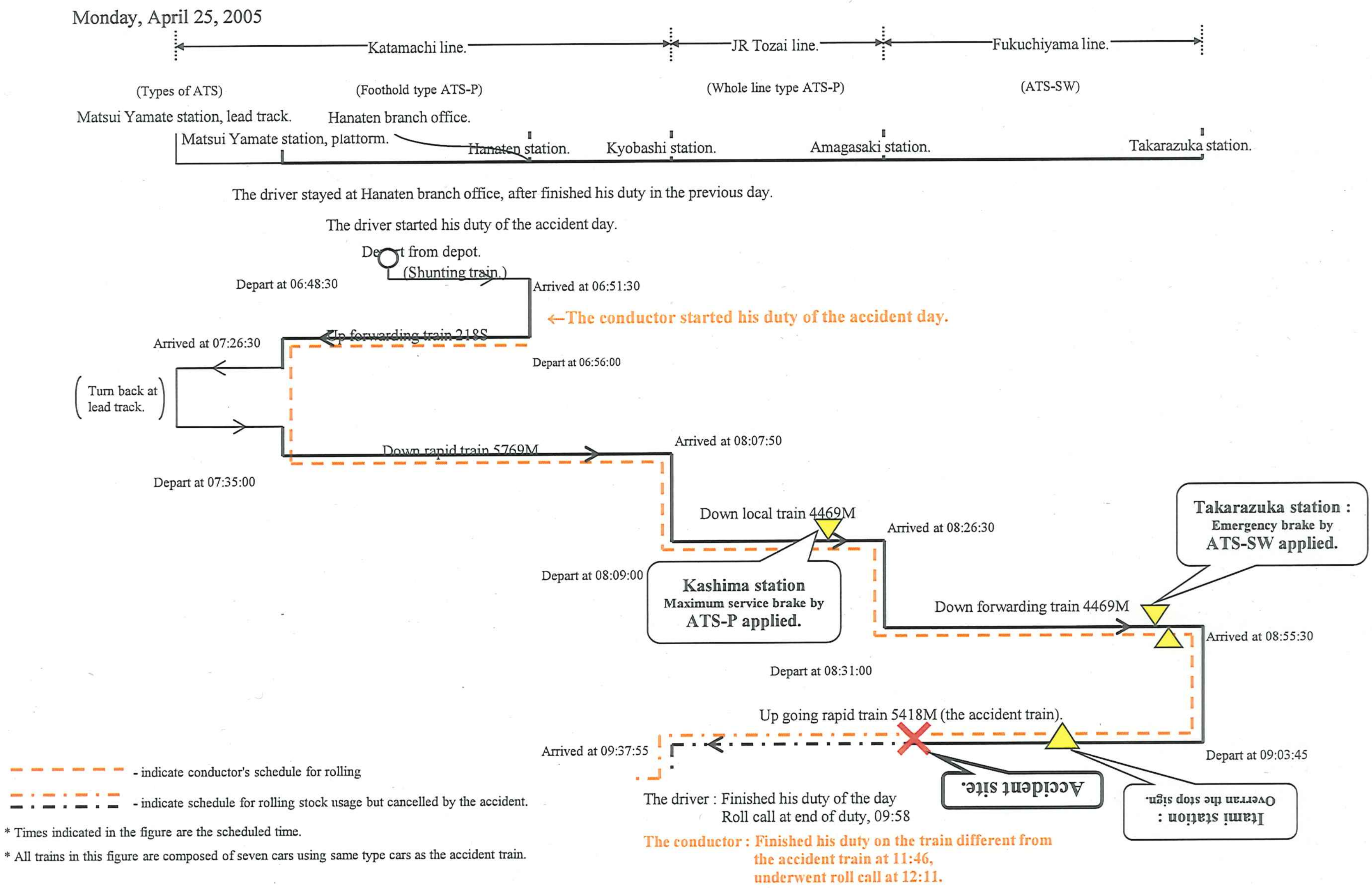


Figure 55 - Numbers of People in the Individual Cars Who were killed and Injured in the Accident Train.

(Unit : person.)

Car	Dead [Except the train driver.]			Injured			Total
	Total number.	Male	Female	Total number.	Male	Female	
First car	42	26	16	49	28	21	91
Second car	57	28	29	75	39	36	132
Third car	3	—	3	157	21	136	160
Fourth car	—	—	—	102	52	50	102
Fifth car	—	—	—	70	39	31	70
Sixth car	—	—	—	58	27	31	58
Seventh car	—	—	—	41	19	22	41
Unidentified boarded car number.	4	4	—	10	2	8	14
Total	106	58	48	562	227	335	668

* Cited police information as of June 5, 2007.

* Numbers in the table do not include passengers left from the accident site by the reason of no injury, etc.

Figure 70 - Results of Component Analyses of the Sample of Adhering Materials Taken from Railway Cars etc. (1/3)

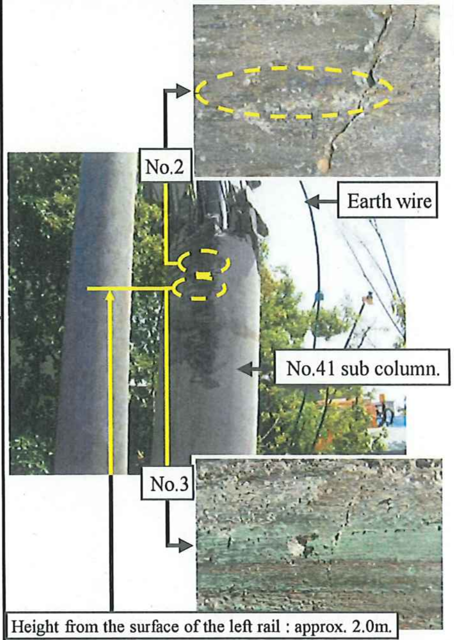
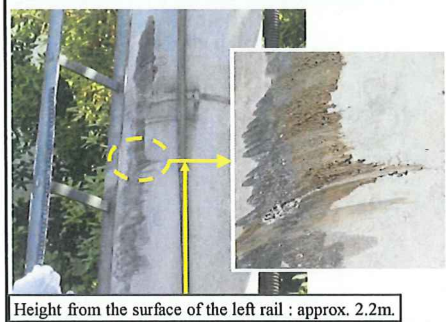
No.	Name of the sample.	Sampled part.	Appearance, etc.	Summary of analyzed results.	Supposed material.	Supposed part	Situation of sampling.
1	White powders stuck on the rail.	Surface of the left rail in the up track between No.88 and No.89 sleepers.	White powder.	SiO_2 Fe_2O_3 Al_2O_3 Na_2O K_2O CaO Quartz Feldspar Mica Clayey mineral.	Granite	Ballast	
2	Scratched pole.	No.41 sub column, up track 1k814m.	Stuck by scratching.	Fe Cr Si Ca Al Ni	Stainless steel.	150	
3	Materials scratched and stuck to a pole.	No.41 sub column, up track 1k814m.	Green adhesive material stuck to a pole.	Homogeneous spectrum with the vinyl tube covering earth wire installed in No.41 sub column.	—	Vinyl tube covering earth wire installed in No.41 sub column	
4	Materials scratched and stuck to a pole.	Pole located at about 3m distant from No.41 sub column, in direction to Fukuchiyama station.	Brown adhesive material stuck to a pole.	Homogeneous spectrum with roof sheet of a car.	—	Roof sheet.	
5	Materials scratched and stuck to fence.	fence near the No.156 sleeper.	Black or bronze colored glossy stuck materials in flaky shape.	Fe O Cr Si Al Ni Ca C	Stainless steel.	Car body.	

Figure 70 - Results of Component Analyses of Adhering Materials Taken from Cars etc. (2/3)

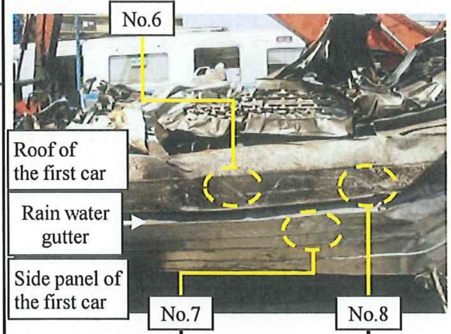
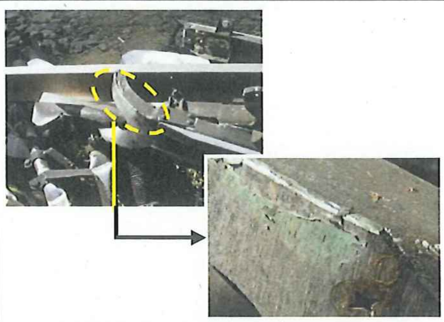
No.	Name of the sample.	Sampled part.	Appearance, etc	Summary of analyzed results.	Supposed material.	Supposed part	Situation of sampling.
6	Materials stuck to the first car.	Upper part of the rain water gutter at upper rear of the left side third door of the first car, the most front position where stuck materials had been found.	Green stuck material.	Homogeneous spectrum with the vinyl tube covering earth wire installed in No.41 sub column.	—	Vinyl tube covering earth wire installed in No.41 sub column.	
7	Materials stuck to the first car.	Upper part of the rain water gutter at upper rear of the left side third door of the first car.	Green stuck material.	Homogeneous spectrum with the vinyl tube covering earth wire installed in No.41 sub column.	—	Vinyl tube covering earth wire installed in No.41 sub column.	
8	Materials stuck to the first car.	Upper part of the rain water gutter at upper rear of the left-side third door of the first car.	Gray powdery stuck material.	Homogeneous spectrum with mixed vinyl chloride tube covering earth wire installed in No.41 sub column and stain on the roof.	—	Vinyl chloride tube covering earth wire installed in No.41 sub column.	 
9	Materials stuck to the pantograph.	Rear pantograph on the second car fallen near the No.41 sub column.	Green stuck material in filmy shape.	Homogeneous spectrum with the vinyl tube covering earth wire installed in No.41 sub column.	—	Vinyl tube covering earth wire installed in No.41 sub column.	
10	Materials stuck to the skirt.	Dent at left side of the skirt of the first car.	White stuck material.	$Ca(OH)_2$ $CaCO_3$ Quartz Feldspar Mica	Cement, frame	Concrete	

Figure 70 - Results of Component Analyses of the Sample of Adhering Materials Taken from Railway Cars etc. (3/3)

Compared element analysis between scratched side part of the No.41 sub column and the head of referred pantograph.

Sample. / Element	(1) Material stuck to side surface of the edge of pantograph head	(2) Coating onside surface of the pantograph head.	(3) Auxiliary contact strip	(4) Principal contact strip.	(5) Coating on horn.	Scratching vestige at the side of No.41 sub column
C	○	○	○	○	○	○
O	○	○	○	○	○	○
Ni						
Fe	○		○	○		○
Cu	○	○	○	○		
Na						○ *
Mg		○	○			○ *
Al	○	○	○	○		○ *
Si	○	○	○	○		○ *
S	○	○		○		○
Mo	○	○		○		○
Ar			○			
Cl	○					
K						○ *
Ca						○ *
Sn				○		
Ti		○			○	○
Mn			○			
Zn			○			○

○ : Detected element. * : Elements usually contained in concrete poles.

Situation of sampling scratched stuck materials.

Referred pantograph head.

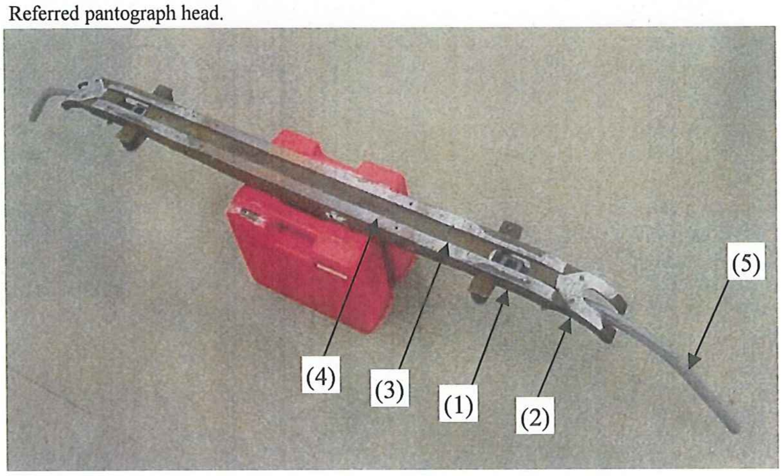
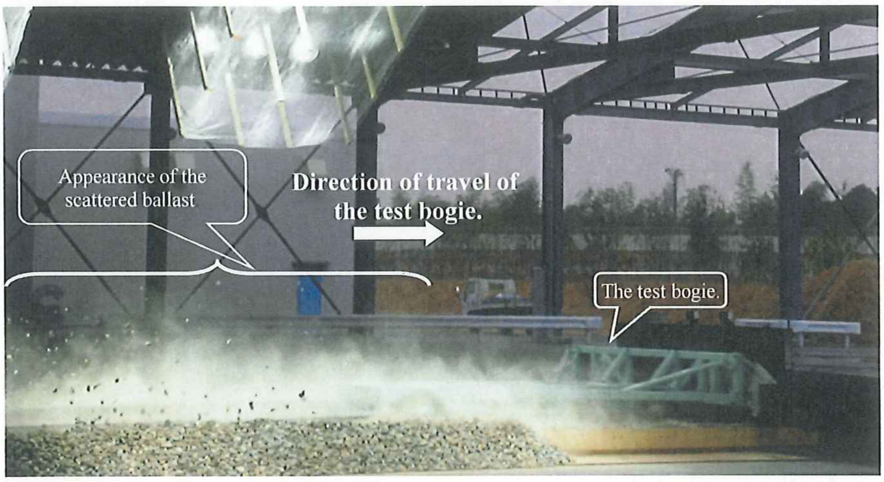
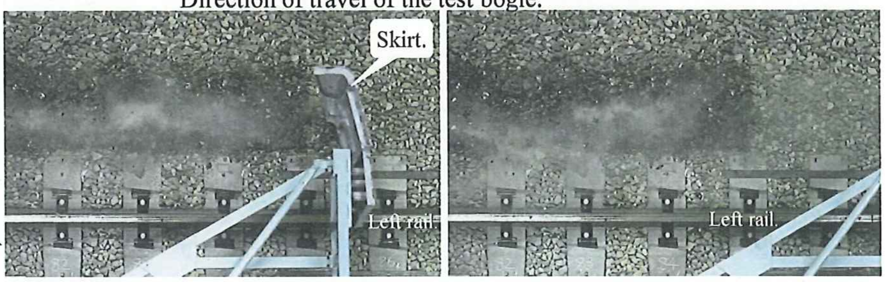


Figure 71 - Ballast Scattering Test Results etc. (2)



1. Appearance of the scattered ballast when the grouting agent for ballast was applied.

Direction of travel of the test bogie.



2. Appearance of the scattered ballast when the grouting agent for ballast was not applied.

Direction of travel of the test bogie.

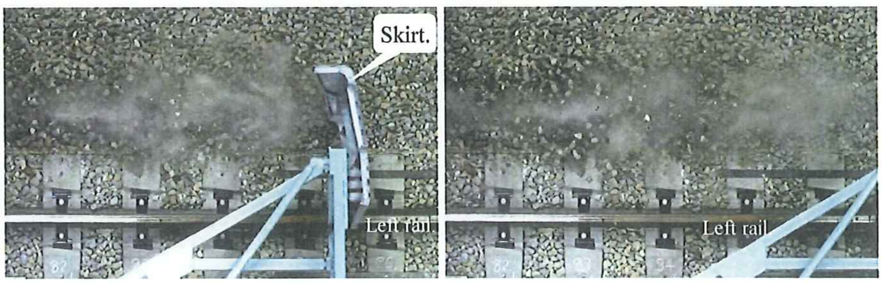
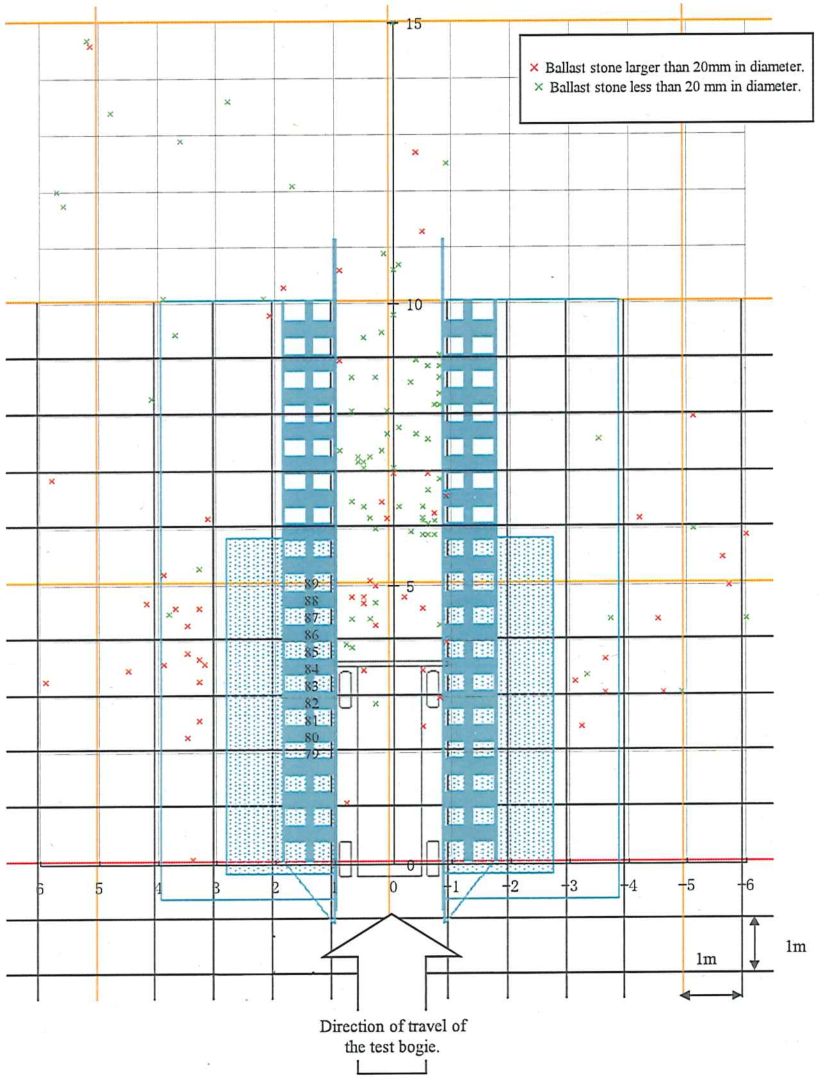


Figure 71 - Ballast Scattering Test Results etc. (3)

Ballast distribution after the grouting agent for ballast applied test at speed of 115 km/h.

(1) Ballast distribution when the lower edge is lower than the surface of ballast by 30 mm.



(2) Ballast distribution when the lower edge is lower than the surface of ballast by 50 mm.

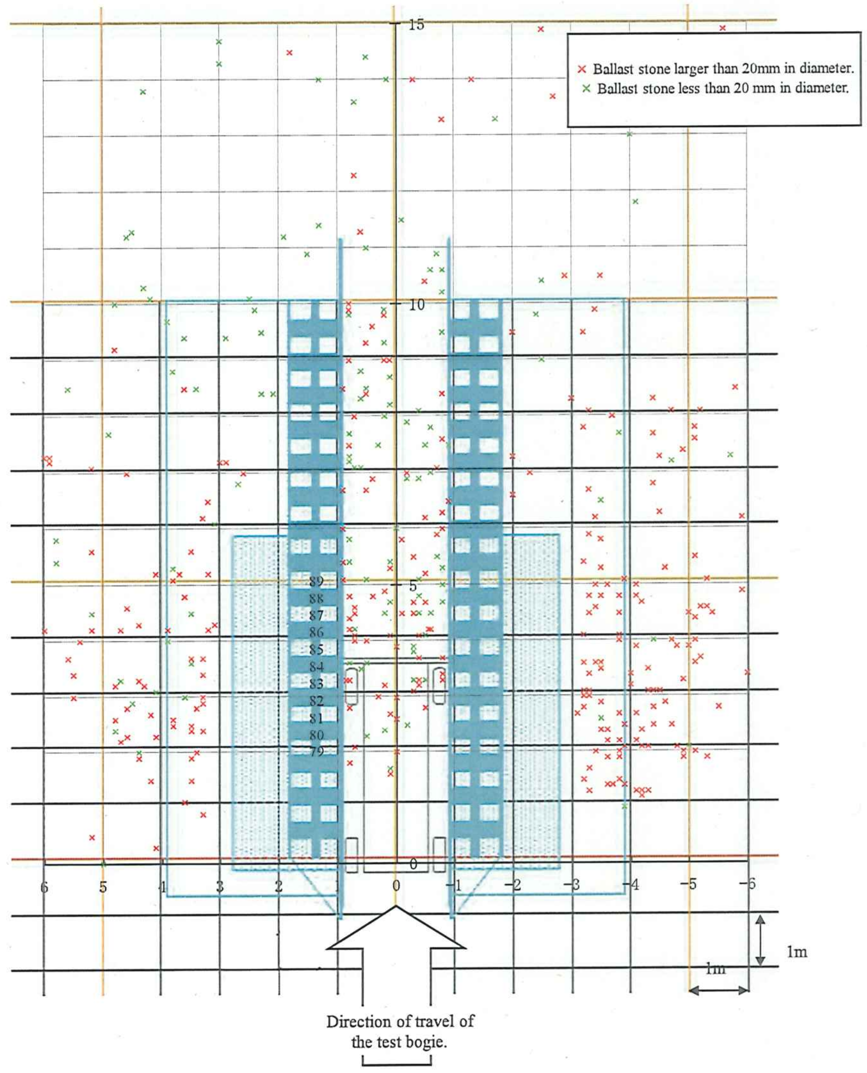
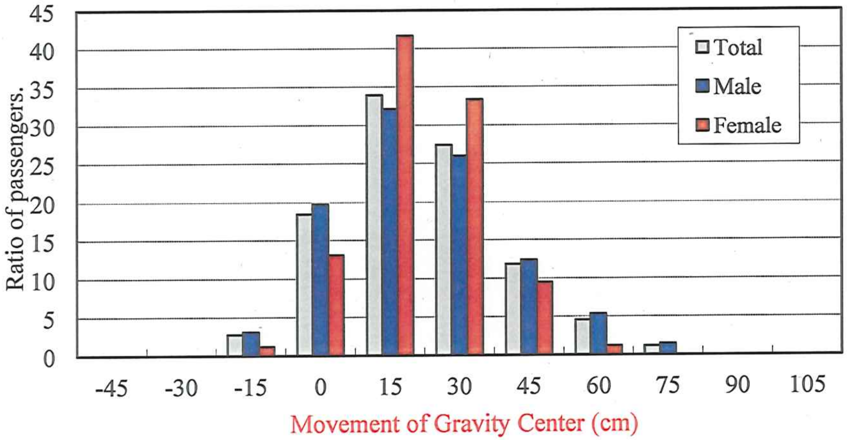
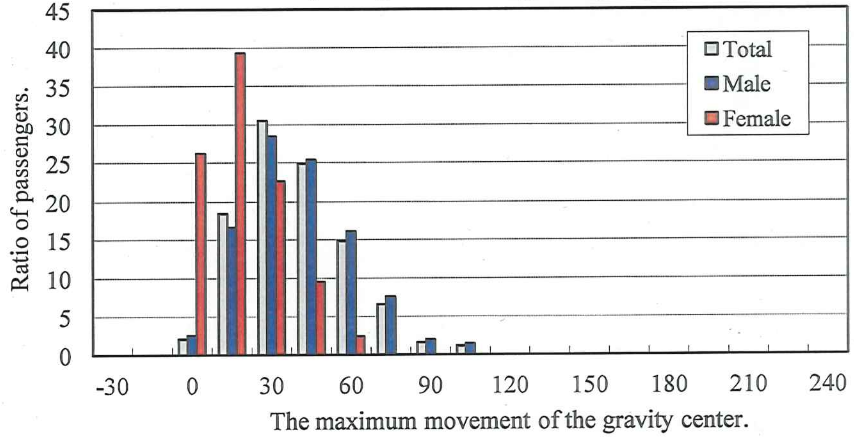


Figure 72 - Results of the Test to Reproduce and Measure the Shifts of the Centers of Gravity of the Passengers in the Individual Railway Cars.

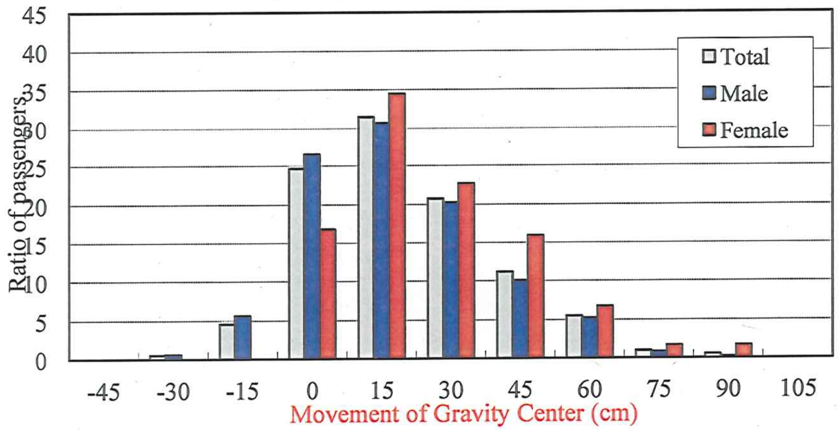
Distribution of movements of the gravity center
1.88 second after the car body started to incline.
(Passengers are standing holding straps.)



Distribution of the maximum movements of the gravity center
during 4 second after the car body started to incline.
(Passengers are standing holding straps.)



Distribution of movements of the gravity center
1.88 second after the car body started to incline.
(Passengers are standing without holding straps.)



Distribution of the maximum movements of the gravity center
during 4 second after the car body started to incline.
(Passengers are standing without holding straps.)

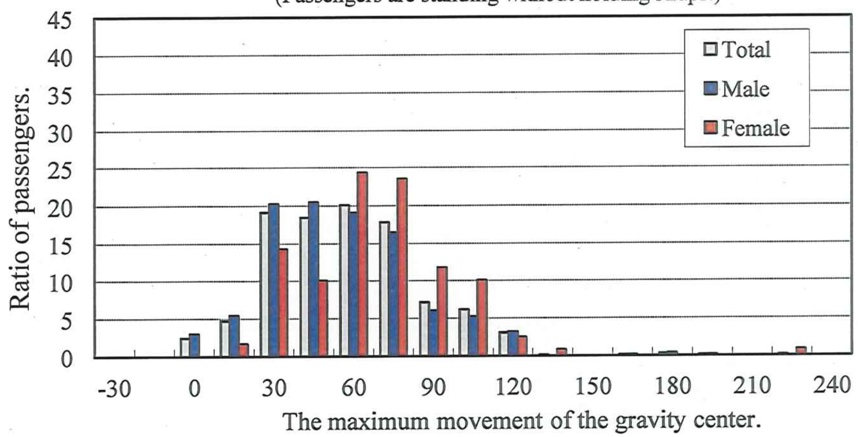
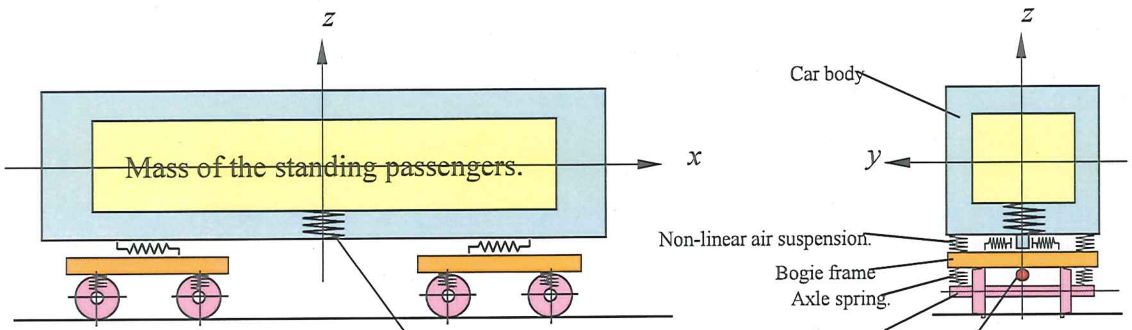
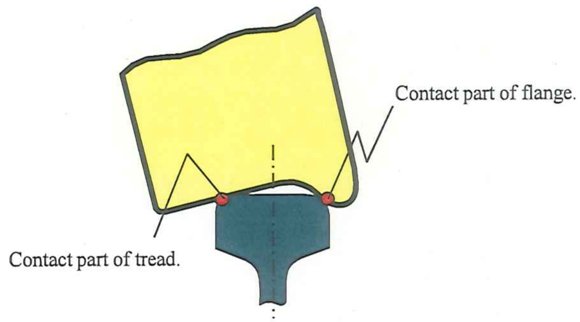


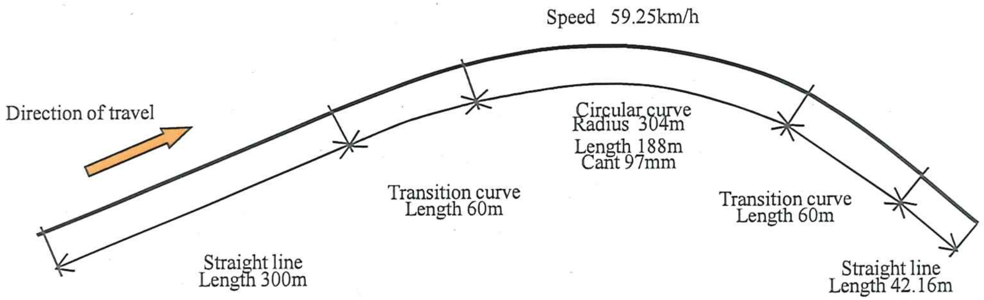
Figure 73 - Overview of the Computer-based Derailing Simulations



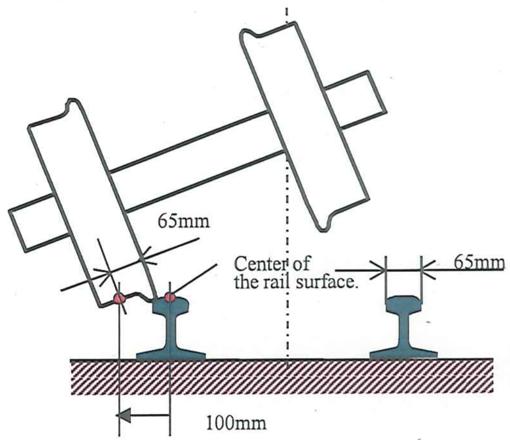
Outline of car model (movement model of standing passengers)



Contact model between wheel and rail used in simulation.



Track model used in simulation.



Judgment condition for derailment :
Tread center of left wheel displaced more than 100mm with respect to the center of left rail surface.

Figure 74 - Simulated Changes in the Postures of the Railway Cars in the Train up to the Moments of

Conditions for simulation.	
Speed	115km/h
Onboard passengers	93 (45 passengers were seated.)
Adhesion coefficient between wheel and rail.	0.3
Set up value of the differential pressure valve of air spring	98kPa (designed value)

* Car bodies in the figure are cross sectional view observed from the rear end to direction of travel.
* Kilometerages below cross sectional view of car bodies indicate the position of the first wheelset in the front bogie.