

## Railway accident investigation report

Railway operator: Shonan Monorail Co., Ltd.

Accident type: Heavy property loss without casualties.

Date and time: About 09:54, on February 24, 2008.

Location: In the premises of Nishi-Kamakura station, Enoshima Line, Kamakura City, Kanagawa Prefecture.

### SUMMARY

The outbound local 909S train, composed of 3 vehicles, starting from Ofuna station bound for Shonan Enoshima station, Enoshima Line of Shonan Monorail Co., Ltd., departed Shonan Fukasawa station on schedule, 09:50, on Sunday, February 24, 2008.

The train had operated normally until arrived at Shonan Fukasawa station, but the train was accelerated quickly when departing from the station, and after a while, the train was accelerating even though the train driver did not set the one handle master controller in the powering position. The train was in a state of lack of braking force when approaching to Nishi Kamakura station, and in spite of the emergency brake and the security brake operation by the train driver, the train did not stop at the appointed stop position, and the train passed the down track starting signal of the station indicating the stop signal. The train collided with the turnout ahead and stopped disturbing the route of the approaching inbound local 904S train.

On the other hand, the driver of the 904S train, scheduled to cross each other with the 909S train at Nishi Kamakura station, departed from Kataseyama station at about 09:52.30, about 30 second behind schedule, found the 909S train passed the down track starting signal of Nishi Kamakura station at about 60 m short of the station, then he applied an emergency brake and stop the train about 19 m short of the 909S train.

The 909S train and the facility such as the turnout were damaged, but passengers and train crews on boarded in both train, 22 passengers and 2 train crews in the 909S train, and 16 passengers and 2 train crews in the 904S train, were not injured.

### FINDINGS

Summaries of the analysis about the behavior of the train until the accident are as follows.

- (1) It is considered highly probable that, according to the records in the interlocking device, an abnormal powering operation without handling the master controller by the train driver was occurred just after the train departed from Shonan Fukasawa station.
- (2) It was thought as the possible reasons for the abnormal powering operation that the wrong powering command was generated by an intersystem fault, or the VVVF inverter equipped with the 5504 vehicle, the front vehicle of the 909S train, could not recognize the operation of the master controller by the train driver due to the electromagnetic noise, according to the inspection of the vehicle. However, it is considered highly probable that the abnormal powering operation was caused by the VVVF inverter equipped with the 5504 vehicle could not recognize the operation of the master controller by the train driver due to the electromagnetic noise, according to the analytical results of the pictures recorded in the security cameras and the records of the interlocking device.
- (3) It is considered probable that the mechanism, how the VVVF inverter equipped with the 5504 vehicle neglected the operation of the master controller by the train driver due to an electromagnetic noise, was as follows, based on the results of inspection of the vehicle.
  - (a) The high frequency noise, generated in the gate power supply, was superposed on the low voltage body grounding line, i.e., the negative terminal of the power supply.
  - (b) The noise generated in the gate power supply was not grounded sufficiently because of the small cross section of the wires used for the low voltage grounding line and the long wire length between the gate power supply device in the 5504 vehicle and the body grounding point in the 5503 vehicle.
  - (c) The noise superposed on the low voltage body grounding line flowed into the inner

- circuit of the VVVF inverter because the electric potential of the low voltage grounding line of the 5504 vehicle was raised with respect to the potential of the vehicle body, due to the open/close operation of the doors or the braking operation.
- (d) The high frequency noise, flown into the low voltage body grounding line, was superposed on the unused monitor transmission circuit with poor measures against noise, due to the electromagnetic induction inside the 48 core shield cable wired spread in the VVVF inverter casing.
  - (e) The IC in the monitor transmission circuit recognized the superposed noise as the "received data", and the CPU, that process the sequence of acceleration and deceleration, recognized the "received data" as the "error" followed by "start transmission", then generated the wrong interrupting signal.
  - (f) The wrong interrupting signal prohibited the all other interrupting signal, then the sequence of acceleration and deceleration could not be processed by the CPU.
  - (g) As the sequence of acceleration and deceleration did not processed, the commands from the master controller in the driver's desk did not transmitted to the VVVF inverter.
  - (h) As there was some inadequate part in the program to control acceleration and deceleration, it was in the situation that the protection mechanism using the watch dog timer, that restart VVVF inverter after cutting off the main circuit current when the abnormal situation was occurred, such as the sequence of acceleration and deceleration could not be processed due to the wrong interrupting signal, did not work.
  - (i) The VVVF inverter in the 5504 vehicle kept the previous status, in this case "powering", regardless of the operation by the train driver, because the commands by the master controller on the driver's desk did not recognized and the protection system did not work.

## PROBABLE CAUSES

It is considered probable that the train, that approached to Nishi Kamakura station in the status of the insufficient deceleration, passed the down track starting signal indicating the stop signal, collided with the No.46 turnout that was not yet cleared the route, disturbed the route of the crossing train, and damaged the facility such as the turnout, etc., because the required decelerating force could not be obtained by applying the brake due to one of the two VVVF inverter set equipped with the train, had been operating in powering mode by its malfunction, and the train driver continued the train operation even after he noticed abnormal situation of the train.

It is considered probable that one of the VVVF inverter malfunctioned because the VVVF inverter equipped with the vehicle had insufficient measures against noise in the low voltage vehicle body grounding line and easy to be effected by the superposed noise on the negative terminal side of the low voltage circuits, the unused monitor transmission circuit had no proper measures against noise, and the control program for acceleration and deceleration had some inadequate part.

## OPINIONS

In view of the results of this accident investigation, the Japan Transport Safety Board expresses its opinions to the Minister of Land, Infrastructure and Transport as follows, pursuant to Article 28 of the Act for Establishment of the Japan Transport Safety Board.

It is considered highly probable that the accident was induced by the insufficient decelerating force in the braking operation because the VVVF inverter kept the powering mode operation as the handling operation of the master controller by the train driver was not recognized due to the effect of noise. Therefore, the Minister of Land, Infrastructure and Transport should take required measures about the following items.

- (1) It is considered somewhat likely that the train driver is hard to notice an abnormal

phenomena because there will be no sign such as unusual sound or smell in the vehicles when the train continued powering regardless of the handling operation of the master controller by the train driver, due to the abnormal processing by the software in the railway vehicles using software to control acceleration and deceleration such as the vehicles equipped with the VVVF inverter. Therefore, it should be informed well enough to the train drivers that the train should be stopped immediately when the abnormal powering or lowered braking operation were recognized, with notifying the summary of this accident as a sample. Here, the method that the driver can apply in an emergency, and the method to cut off the main circuit certainly to secure the braking force when the software processed abnormally, should be informed as the method to stop the train immediately.

- (2) The railway operators, the vehicle manufacturers and the manufacturers of electric apparatus for railway system should have the common information about malfunctions etc., of the electronic devices and apparatus based on power electronics such as VVVF inverter, and should accumulate the knowhow for prevention of troubles, against the problems by the electromagnetic noise in the railway system. In addition, the synthetic examination should be implemented about the appropriate methods for the grounding and wire installation in the vehicle using the electronic apparatus or the apparatus based on power electronics, and for the problems concerning electromagnetic compatibility, EMC.
- (3) A careful examination should be performed to design the function such as the watch dog timer etc., which is important to secure safety of the system operation certainly in case of the abnormal processing, when the acceleration/deceleration control, the brake control and the safety equipment etc., for trains were performed by software.
- (4) There are many cases that the trouble by the abnormal processing of the software or the temporary defects of the electronic parts were restored easily without remaining signs of the defects by the reset operation etc., in the vehicle in which the sequence of acceleration and deceleration is processed by the software such as the vehicle equipped with the VVVF inverter. So that it is considered somewhat likely that the investigation of the causes of troubles are difficult when the trouble did not reappeared. Then, it should be considered to introduce the function to record the operation of the train driver and the corresponding behaviors of the vehicle in the individual device, for the vehicle that the sequence of acceleration and deceleration is processed by software, to improve the level of investigating causes of this kind of troubles.