Actions of Vehicle Remodeling for Start of Mutual Run-thru Services of the Tobu Tojo Line

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Summery

Tobu Railway Co., Ltd. carried out mutual run-thru services between the Tobu Tojo line and the Fuku-Toshin line of Tokyo Metro Co., Ltd., the Toyoko line of Tokyu Corporation and the Minatomirai line of Yokohama Minatomirai Railway Company since March 16, 2013. For the mutual run-thru services, we manufactured newly 9 train-sets and remodeled 7 train-sets. This paper reports the outline of remodeling and new manufactured vehicles.

1. Introduction

The railway network of Tobu Railway Co., Ltd. (Tobu) covers Tokyo and four surrounding prefectures, Chiba, Saitama, Tochigi and Gunma. And Tobu has about 463km of railway lines. The main lines which start in Asakusa station are consisted of the three trunk lines, which branch at the eastern part of Saitama and extend to Tochigi, Gunma and Chiba, Those are the Isezaki, Nikko and Noda lines and their branch lines. The Tojo line, the other main line of Tobu, starts at Ikebukuro station and extends through the center of Saitama for northwest. The main function of the Tojo line is commuter transportation of students and business people because their neighboring areas have been developed as residential areas.

The Tojo line was connected with Tokyu Toyoko and Yokohama Minatomirai line via the Fuku-toshin line of Tokyo Metro Co., Ltd. (Tokyo Metro) which was connected with the Tojo line on March 16, 2013, thus the extensive railway network covering the northwest of Saitama to Yokohama has been formed.

Corresponding to mutual run-thru services, railway companies involved in this need to install on-board safety equipment reacting to ground equipment of other railway companies and additional facilities for train crew members. Tobu has modified 16 train-sets for mutual run-thru services. Of which 7 train-sets are new and 9 train-sets have been modified for mutual run-thru services. This article summarizes on-board facilities used in the trains for mutual run-thru services.

2. Outline of vehicles

(1) Outline of train-set

The train-set is 5M5T of fixed 10 cars. Their basic performance is as follows:

1) The maximum speed is 120km/h, acceleration is 3.3km/h/s, deceleration is 3.5km/h/s at normal times and 4.5km/h/s in case of emergency;
2) The leading cars on both ends have CS-ATC/S and door-closing control switch devices;
3) Car 7 has the inductive radio device, and its specifications are such that allow mutual run-thru services with the Tokyo Metro Yurakucho and Fuku-toshin lines;
4) The train radio device installed at driver's cabs is designed with common use specifications for Tobu, Tokyo Metro, Tokyu and Yokohama Minatomirai lines and thus the device was installed simplified, whereas driver's cabs of other trains used for through-operations are cluttered with devices to support such operations;
5) It has been designed in such a way that switching of train radio is recognized on-board automatically with the one-handle type master control key and train radio works properly for each train section.

(2) Integrated safety equipment

Currently, ATS as the safety equipment is operating in the Tobu railway lines. It was necessary to consider following matters in designing the future safety equipment:

1) The future safety equipment will be the T-DATC (Tobu Digital Automatic Train Control) which use the on-board pattern-based continuous speed check method;
2) Since it is preparing to adopt the T-ATS-P (Tobu Automatic Train Stop Pattern) in a depot, the on-board device needs to support this system change.
3) While, at the same time, CS-ATC (Cab Signal Automatic Train Control) is operatingin the Tokyo Metro, Tokyu Toyoko and Yokohama Minatomirai lines.

Since it was needed to support various type specifications meeting to other railway companies including Tobu itself, we carried out that safety equipment was modified to an integrated one and system efficiency was also realized. As specifications used within Tokyo Metro, Tokyu, Yokohama Minatomirai lines are somewhat different, an automatic switching method using the master control key has been adopted.

Since the integrated safety equipment also has crew member support function TTSS (Tobu Transponder Support System), the use of its platform detection function has started in advance to prevent opening of car doors by mistake within Tobu lines.

The equipment is composed of safety control component, transmission component (for receiving rail signals and transponder sending/receiving), relay component (relay interface), check record component (recording of safety information and automatic checking function), speed generator (with phase difference of 90 degrees), ATC receiver, integrated on-board coil (transponder sending/receiving and varying frequency based ATS support), speed-meter (on-board signal pattern speed (red hand) support two-hand type) and so on.

(3) ATO device

Since ATO operations take place within Tokyo Metro lines with the installation of platform doors, etc., it has become also necessary in the Tobu lines to use ATO devices. The ATO system placed on-board is described hereunder.

The three type vehicles were planned for mutual run-thru services with the Fuku-toshin line and needed to install on-board ATO (Table 1). The main control of type 9000 vehicles used since 1987 is chopper control, and type 9050 vehicles used since 1994 adopt VVVF control, type 50070 vehicles used since 2007 also adopt VVVF control. The type 9000 vehicles use the electro-pneumatic switch-type braking method requiring most complicated control in ATO control since brakes need to be applied when the trains are about to stop.

It was decided not to modify the brake control device (7-steps) nor basic braking device (bogie) when introducing ATO. By minimizing the modification of vehicles, the time to complete modification work for mutual run-thru services was shortened.

As a crucial matter on the ATO device of the Tobu vehicles, it is required to control running-time between stations in high dense railway sections and to improve accuracy in stop position at the station to ensure alignment with platform doors. In addition, increased comfort of train ride and reduction of energy consumption were taken

Table 1 Main specification of mutual run-thru services vehicle

Type of car		Type 9000	Type 9050	Type 50070
First year of production		May 1987	Sep. 1994	Feb. 2007
Train unit		6M4T	6M4T	5M5T
Weight(empty)(t)		351	334	290
Train length(m)		200	200	200.26
Control unit		Chopper control	VVVF inverter control	
Brake system		Full electric command brake equipment with regenerative brake		
Performance	Max. speed	110km/h	120km/h	
	Acceleration speed	3.3km/h/s		
	Deceleration speed (regular use)	3.7km/h/s	3.5km/h/s	
	Deceleration speed (emergency)	4.5km/h/s		

into consideration in the design. Specifically, while observing the limit speed and dense schedule, the train maintains coasting operations as much as possible to reduce unnecessary acceleration and deceleration to realize energy-saving operations and minimize shaking of cars to improve comfort for passengers.

Furthermore, since the speed of acceleration and deceleration change in individual trains by external factors such as changes in weather and changes in train vehicle conditions with maintenance impact though they are the same type of vehicles, we made the system that acknowledge the change of characteristics of vehicles at each run and that control it automatically. Thus, even after the regular inspection (general inspection of critical parts), the stop position accuracy is maintained without changing parameters of the ATO device. When the ATO device is replaced, by controlling automatically the change of characteristics, high accuracy in stop position is also maintained.

The ATO operation mode switch has 2 positions of "Normal" and "Restore". When there is a delay, the switch is set to the restore mode to control the train with the operation pattern set in the restore mode and to shorten the running-time between stations.

Right after the system operations had started, the log data was gathered from the on-board device. Out of approx 2,000 valid records, the data of ±45cm apart is of 4 records which indicated the train stopped short of the stop position and none which indicated the train stopped "over". Since the initial target was the ratio of 1% or less for "short" and 0 for "over", the result showed that the original target was met. The cause for "short" was that there were issues in computation of ORP pattern speed and in switching of speed detection axis at the idling time of wheels, and countermeasures have been carried out.

At Wakoshi station where Tobu and Tokyo Metro lines meet, TASC operations have started by Tobu crew members, and the function of the ATO device is used for given train stop position control.

(4) Platform door support system

To prevent customers from falling off the platform or prevent contact accidents, the platform doors have been placed in the Tokyo Metro Fuku-Toshin line, and the trains have been equipped with devices to support the platform doors. Unless opening of the platform doors and train doors aligning, passengers can not enter/exit trains smoothly and safely. The train therefore needs to stop within a certain range of the fixed train stop position, and the system is needed to check the stop position of the train.

One on-board transponder coil is installed in each train-set for the system. We decided its specification as follows:

1) When the train stops at fixed position, it reports to the train driver by flushing a "platform door" lamp and the train has stopped at the designated position "Just", through sending/receiving transmission with the ground coil having power sources;
2) After the train has stopped at the fixed position, by driver's (or conductor's) open door operation, the ground coil receives the door open command;
3) The ground coil sent back to the train the response signal at the same time of platform door open operation and as soon as the response signal is received by the train, train doors opens;
4) When the train stops at the short or over positions from the fixed position, it has been designed so that the platform doors and train doors cannot be opened from the train.

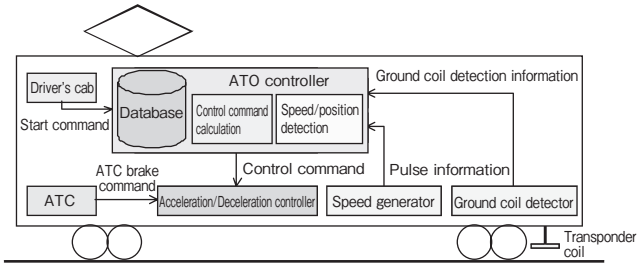

Fig.1 On-board ATO system

Thus, safety and reliable control is carried out without the risk that train doors only open. In case some abnormality happens when platform doors or train doors close, an alarm is sent from the ground to the train while at the same time it is notified to station staff, and safety measures are taken so as not to start the train by no constituting a power running circuit. When the safety on the ground and the safety start of train has been confirmed, the train can start by operating the platform door interlocking/non-interlocking switch.

(5) Devices to support mutual run-thru services

Within the Tokyo Metro Fuku-Toshin line, one-man train operations takes place and therefore devices for it are adopted in the Tobu trains as well.

- One-man/two-men switching SW
  Handle-type SW to switch between one-man/two-men operations manually
- Door opening/closing SW (on driver's cab desk-top)

Photo 1 Train radio (common use)

Photo 2 CCTV device

Push-button type (one-shot type)
- Buzzer SW to prompt passengers getting on and off (on driver's cab desk-top)
  Push-button type (one-shot type)
  On-board⇔ ground switching (tumbler SW)
- Headlight flash control unit (in driver's cab LCD screen)
  For type 3 protection support, with key operations, headlights continue to control brightness
- SW to electrically lock/unlock the door between train crew and passenger room
  Lock during one-man operations (unlock in case of emergency)
- Emergency communication device (Communications with operation dispatcher type)
  Crew room reset type
- Public announcement system for train driver
  Millimeter radio reception
- Train radio (common for three railway companies) (Photo 1)
- Platform monitoring CCTV (four 6-inch screens) (Photo 2)
- Dead-man device (operation dispatcher notification type)

(6) Station overrun prevention system (Ps/Pcom)

Within the Tokyu Toyoko line, the train overrun prevention system observing Tokyu Corporation's specifications is used. This system has following functions:

1) It receives the station specific information such as "train direction", "ground coil number" and "line section code" from two Ps ground coil installed at each station, and each train decides whether it needs to stop at the station or not;
2) When needing to stop at the station, the train lights the "stop station" indicator lamp on the driver's cab;
3) At the same time, the train stop pattern is created and it is checked against own train speed;
4) By opening train doors after the train stoped, the emergency brake is not operated by canceling the stop pattern;
5) When the train speed excesses "station stop" pattern speed or when combined with Pcom ground coil during generating the pattern, emergency brake is applied to prevent station overrun;
6) When the train is operating in out-of-service, train doors are not opened and the pattern is reset by stop station detection.

On the ground side, the Pcom ground coil receives from the train the information such as "train type", "operation number" and "affiliation", and outputs the information to train operations management. The function is also available to output such information to ATC backward protection and railway crossing control information. This function is controlled by the functions of the above mentioned ATO transponder transmission device and by a part of integrated safety equipment within the Tokyo Metro line.

(7) Update of monitoring equipment

Through the monitoring equipment with a 10.4-inch color LCD touch panel display as a man-machine interface, displaying/recording and setting of operation status and trouble status of various devices, which are connected to the monitor, are carried out as well as controlling lights of the passenger vehicles and headlights. Front lights which had traditionally been hardware with indicators in the driver's cab, are now changed so that their statuses are displayed on the screen. Some functions may now be set up on the screen by replacing push-buttons. Thus wiring in the driver's cab was simplified and the time to complete the construction work was shortened.

Information management of on-board devices is managed using the LCD screen. When the monitoring device is started after power switch is turned on, the initial menu screen is displayed shown "Normal", "Inspection and repair", "Brightness adjustment" and "Backlight off". The brightness of four levels can be changed with touch screen.

Train crew support functions were also carried out as described below: When "Normal" is selected on the initial menu screen, a normal screen is displayed allowing train crew to control and display normal operation status. Together with the displaying of the status of doors (opening/closing) and status of emergency communication, "destination setting", "guidance setting", "headlight on/off" and "door status" are displayed with touch keys. The touch key to control the status of room light is also displayed. In case of emergency, the alarm sounds for 5 seconds and the screen is changed to the emergency screen automatically. The status of accident is displayed, and logs are recorded.

(8) Others

On type 9000 vehicles, in addition to work required for mutual run-thru services we carried out other renovation works to improve customer service. The main purpose of this renovation was to renew interior of the vehicles, to improve seat capacity, and to enhance "barrier-free". While minimizing the period of works and changes of rigging, the renovation was done to make the service equal compared to that of type 50070 new vehicles.

・Renovation of passenger seats

By changing the color of regular seats to blue and the color of priority seats to light green, it has become easier to differentiate regular seats and priority seats. A new pole was installed in front of 7-passenger long seat and at 4:3 position of it so passengers standing before the seat may hold on it for their safety in case of emergency braking or when the train rocking. In addition, bucket seats are adopted to encourage passengers to sit at proper positions.

・Sliding door opening section

The pole at the sliding door opening is colored in yellow as well as the floor mat at the opening, so they become more visible.

・New space for a wheel-chair (Photo 3)

Two places were newly installed for wheel-chairs in each train-set. The emergency communication devices placed at these spaces are set low so that they may be used even when sitting on wheel chairs.

・Modification of the sliding door

Sliding door placed at the car interconnection areas have been modified so that they get closed automatically and do not remain open.

・New skirt for both leading cars

At the lower part of the front of the leading cars, a skirt has been placed to protect devices placed under the floor in case of railway crossing accidents.

・Remodeling of emergency ladder (Photo 4)

The train is equipped with an emergency ladder so passengers may exit from the leading cars in the tunnel in case of emergency. The handrail has been placed to the ladder for increased safety for passengers in case of emergency.

・Devices in crew cabins

Windshield wipers have been replaced with electric motor wipers with washers having 3 different modes (intermittent, low speed and high speed). A foot-pedal type switch electronic honk has also been installed. If pressed lightly, an electronic honk is sound, if pressed hard, a pneumonic honk is also sound simultaneously.

・Pantograph

Pantographs changed to single-arm ones which are more effective

Photo 3 Emergency communicator at wheelchair space

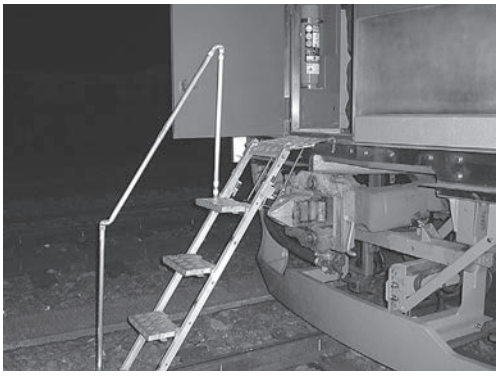

Photo 4 Emergency ladder

when the snow fall, and have forced pantograph raiser devices. So even if there is a risk of disconnect due to snow at the top of pantograph, by pressing a button at the driver's cab, pantographs are pushed upward and downward hardly by a power of air cylinder, and it can knock off the accumulated snow.

3. Closing remarks

In launching the mutual run-thru services, we implemented new devices and deployed new systems which had never been used by Tobu. Furthermore, we have incorporated valuable comments from our customers along the lines. And by designing vehicles based on know-how on train maintenance, which the maintenance group had accumulated, thus, the train modification has enhanced consideration to the neighboring environments, improved passenger safety/comfort, improved maintainability and reduced train maintenance cost.

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To the Readers

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Let us celebrate that the Summer Olympic Games of 2020 was decided to be held in Tokyo. It will be a happy and exciting event especially for us post "1964" Tokyo Olympic generations. Compared with other candidate cities, one of the most praiseworthy points is "unprecedentedly compact operation of the Games at the center of a big city." Railway services, which will play a crucial role during the Games, currently carry about 25,700,000 passengers a day in Tokyo Metropolitan Area. This huge capacity of railways is supported by Japan's advanced railway technology.

By the way, Japan is the most "aging country" in the world and those aged 65 or more account for a quarter of the population. This aging society with fewer children is an ongoing issue and railway services including accessible design for all passengers should be consistently improved to catch up with the "aging". Moreover, railway users will request more comfortable, convenient, usable, and accessible railway services more than ever before with diversification of the sense of values and lifestyles due to economic maturation.

On the other hand, economic expansion will be hardly expected like the former days when railway companies enjoyed uninterrupted passengers growth. This is not only for the railways but also for other transportation modes. Then railway must struggle in more competitive transportation market to keep its share. However, if we offer attractive and high quality railway services for various users, railway transportation will win the competition and can continue to be sustainable. One of the measures to gain the service level of railway is to grasp the user needs exactly and to keep up efforts to evolve railway technology.

I believe that the development of railway technology will be also helpful for the future global expansion of Japan's railway business. While environmental problems have been catching global attentions, we believe that Japan's railway system can be the best solution in the world.

The magazine of "Japan Railway Engineering (JRE)" contains Japan's latest railway technologies by Japanese distinguished research institutions, railway companies, makers, public entities, etc. I hope that JRE will continue to introduce valid information to railway engineers in the world for realizing more sustainable railway.

Japanese Railway Engineering (JRE) Single copy in Japan: ¥ 1,620

Published Quarterly by **JAPAN RAILWAY ENGINEERS' ASSOCIATION(JREA)**
Tani Bldg., 28-6, Kameido, 1 chome Kohtoh-ku, Tokyo 136-0071, Japan
Chairman : Kiyomi HARAYAMA
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Printed in Japan