THE MAINTENANCE OF THE HSST VEHICLES

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ABSTRACT: Three years passed since the opening in March 2005 the Tobu-Kyuryo-Line (nicknamed "Linimo"), the first permanent commercial line employing the HSST urban maglev technology. As the original developer of the HSST technology, our company, Chubu HSST Development Corporation, has been engaged by Aichi Rapid Transit Corporation, the operator of the line, to provide technical support to various maintenance functions of the system, one of which is the four yearly heavy inspections of the Linimo vehicles. This paper describes the activities conducted during the Heavy Inspection, with highlights on the differences of the HSST vehicles from conventional railway vehicles.

1 INTRODUCTION

Tobu Kyuryo Line (also nicknamed “Linimo”) is the first commercial line using the HSST urban maglev technology. It was opened in March 2005. So far, more than 30 million passengers have been transported by the Linimos without any safety incidents. A detailed description of the HSST vehicles can be found in *Hibi & Saito* (1). Since the opening of the line, the HSST vehicles have been maintained by the Aichi Rapid Transit Corporation, the Operator of the line. As the original developer of the HSST technologies, while our company, Chubu HSST Development Corporation, has been providing technical support to various maintenance functions of the system, one of which is the heavy inspection of the Linimo vehicles. This is an extensive inspection and maintenance programme performed every four years.

Figure 1. HSST vehicle (Linimo vehicle)

In this paper, we describe the tasks carried out during the Heavy Inspection, as well as the conditions of the vehicles after three years of extensive use. A high level comparison with other conventional transit technologies is also provided.

2 TYPES OF VEHICLE INSPECTIONS

The following vehicle inspections are required under the law of Japan (the law of Ministry of Land, Infrastructure, Transport and Tourism).

2.1 Daily inspection

- This is to be conducted every morning before beginning of passenger service. This inspection is conducted with the vehicle power on.
- In this inspection, the function of each piece of equipment including hydraulic brakes, compressor, and power-supply units, etc.) is automatically checked with the results reported to the on-board Train Integrated Management System (TIMS). Human resources saving is achieved as all information are available on the display screen of the TIMS, be it a confirmation of all equipment are in a good condition or a report on abnormality, which would require further attention.

2.2 Weekly Inspection

- This inspection is to be conducted every 7 days.
- In this inspection, in addition to the automatic check conducted under the Daily Inspection, wear-

ing parts including pantograph shoes and brake pads are checked against their wearing limits, and replaced as necessary.

2.3 3-monthly inspection

- This inspection is performed every 3 months.
- In this inspection, in addition to the tasks performed in the weekly inspection, insulation test of electric circuit, inspection and cleaning of equipment in each equipment box, and functional inspection of signal security equipment are conducted.

2.4 Intermediate inspection (Heavy inspection)

- This inspection is performed every 4 years or every 600,000 km of running, whichever occurs first.
- In this inspection, the modules are removed from the carbody for inspection. Inspections include overhauls of major electric equipment such as pantographs, VVVF inverters, Power Supply Units and LIMs, module structure, braking system, and other important equipment and subsystems such as compressors, relays and air-suspension system.

2.5 General inspection (Heavy inspection)

- This inspection is performed every 8 years.
- As for this inspection, the number of subsystems to be checked is more than the intermediate inspection. Air-conditioning system and door system are inspected in this inspection.

Aichi Rapid Transit Corporation performs all Daily, Weekly and 3-monthly inspections using their own resources, while our company is performs the Intermediate and the General Inspections for the purpose of examining the state of the equipment after extensive commercial operations and to assess their rate of deterioration.

3 PROCESS OF HEAVY INSPECTIONS

Aichi Rapid Transit Corporation has a total of 24 Linimo cars of 3 cars ×8 formations. It schedules to perform heavy inspection on 6 cars every year in order to match the approximately 4 yearly Intermediate Inspection cycle.

Although it is only 3 and a half years since the commencement of revenue operation (March 2005), the commencement of heavy inspection for the vehicles has been advanced to 2006 in order to even out the workload of the maintainers, and to ensure all vehicles have gone through the heavy inspection process before four years lapsed.

The process and the content of the heavy inspections are described as follows.

The flow of the heavy inspection is as shown in the figure below.

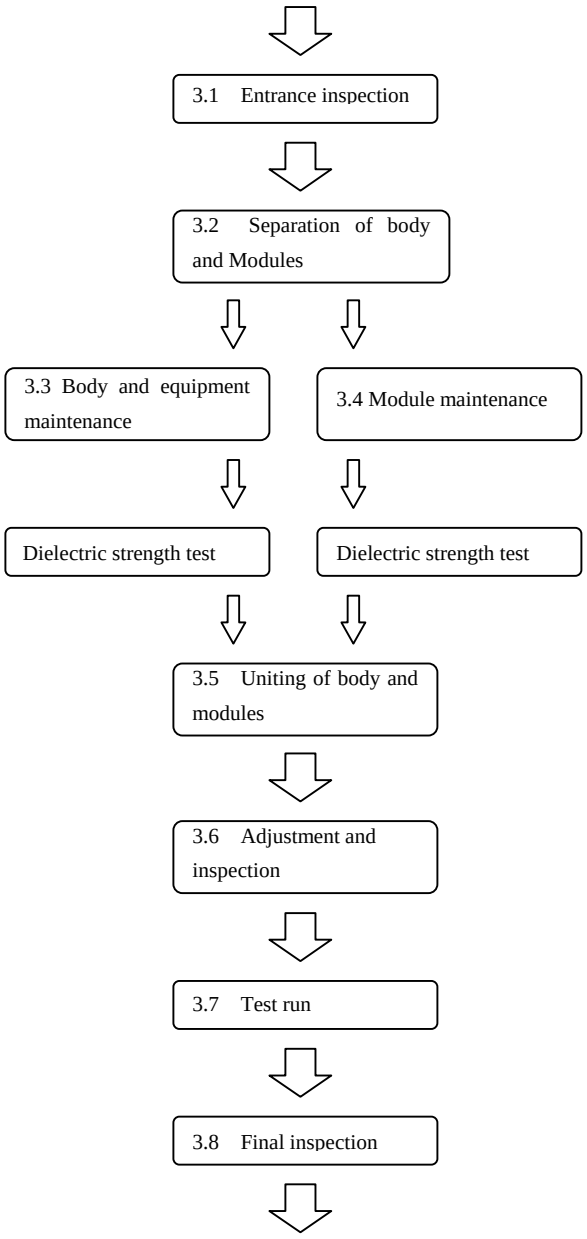

Figure 2. Flow of the heavy inspection

3.1 Entrance inspection

Entrance inspection begins with an all round visual inspection of the vehicle exterior and the measurement of the antenna heights for confirmation of its properly installation. This is then followed by the cleaning of the underframe area and the equipment boxes. Since HSST is of a mainly non-contact type operation and the usage of mechanical brake is rela-

tively little, and that the vehicles run on raised concrete pedestals, underframe area dust accumulation is extremely small in comparison with conventional rolling stock.

3.2 Separation of body and modules

Prior to the separation, the three cars of a train are first uncoupled from each other and all electric wiring, hoses and antennas are detached prior to the separation of the carbody from the modules. The separation of the body and the modules is done car by car by using a 15t crane. The carbody is then put on pillars for further work. The modules are then removed from the track via the end of the track and transported by a lifting crane to the module-dock for further work.

Figure 3. Separation of body and modules

3.3 Body and equipment maintenance

3.3.1 Levitation device
Only external visual inspection and functional check are performed.

3.3.2 Main controller (VVVF inverter) and power supply unit
External visual inspection and function check are performed. Additionally, cooling fan modules are replaced and filters are cleaned.

3.3.3 Train protection system
Various train protection system including ATC (Automatic Train Control system), ATO (Automatic Train Operation equipment), IR (Inductive Radio equipment), and VEL (Velocity detection system equipment) installed on the Linimos are checked functionally and overhauled as necessary by the original manufacturers every 8 years.

3.3.4 Hydraulic brake equipment
Major hydraulic brake equipment such as hydraulic pumps, control valves and accumulators are removed and overhauled every 4 years while the brake callipers are removed from the modules and overhauled every 8 years.

3.3.5 Pneumatic equipment
Linimos use compressed air for door operations and air suspensions.

Overhaul of the air compressors and the air dryers are conducted during this heavy inspection.

3.4 Module maintenance

Maintenance of the modules and their attached equipments are performed as follows:

3.4.1 Module
Visual inspection, re-greasing, and replacement of worn out parts.

3.4.2 LIMs and magnets for levitation
Visual inspection and dielectric strength test.

3.5 Uniting of body and modules

First of all, the modules are arranged to the appropriate positions along the track. The carbody is then repositioned on top of the modules by making use of the 15 t lifting crane. All wirings and hoses between the carbody and modules are then reconnected.

3.6 Adjustment and inspection

After uniting between body- modules is completed, the vehicle power supply is turned on, and each piece of equipment is adjusted and inspected.

3.6.1 Hydraulic brake equipment adjustment
The adjustment and the functional inspection of hydraulic brake equipment are done on the vehicle.

3.6.2 Integrated inspection
All train protection systems are performance tested with a special tester. This is then followed by an integrated test with the train borne TIMS to ensure that these equipment are communicating with each other satisfactorily.

3.7 Test run

When all static tests are completed, test runs are carried out both within the depot and on the main line. The functional inspection of the ATC and IR, and the

functional inspection of the automatic operation with ATO are performed during this stage.

3.8 Final inspection

A final inspection is performed after all static and running tests are completed.

4 ADVANTAGES OF THE HSST FROM A VEHICLE AND GUIDEWAY MAINTENANCE PERSPECTIVE

A high level comparison between HSST, APM, Monorail, and EMU (excluding high speed Shinkansen) is provided below (based on the law of Japan).

Table. Comparison of vehicle maintenance for different systems

	HSST	APM	Monorail	EMU
Inspection cycle	4 years or 600,000km	3 years	3 years	4 years or 600,000km
Wheel (Tire) exchange	None	Tire exchange within 2 years and rotation within 6 months	Tire exchange within 2 years	Wheel exchange within 8 years and grinding within 2 years

APM: Automated People Mover

EMU: Electric Multiple Unit

Under the law of Japan, monorails and APMs are required to carry out heavy inspection every 3 years (4 years for the first heavy inspection from line opening).

The HSST vehicle has the characteristics of "contact-less" operation and it has no running or guidance wheels. It therefore has the advantage of much lesser wearing parts in comparison with other conventional "wheeled" systems.

As shown in the table above, APM, Monorail and EMU require replacing wheels or tires in a certain period in addition to the heavy inspection while no wheel or tire change for the HSST.

The HSST contact-less characteristics give a great advantage to the guideway maintenance.

In general worn rails of the conventional railways require a lot of maintenance works such as replacement or grinding, which increase the maintenance cost. Owing to the contact-less operation, the operation experience of the Tobu Kyuryo Line shows that the HSST track is almost maintenance free.

5 CONCLUSIONS

The Linimos have seen more than three years of service since the opening of the Tobu Kyuryo Line. The first heavy inspection of the vehicles confirmed that the all equipment is functioning correctly and the rate of deterioration is less than what has been predicted. Based on the conditions of the equipment inspected, we conclude that carrying out heavy inspection at 4 years interval will not adversely affect the reliability of the vehicles and that further extension of the maintenance cycles are feasible. The results of this Heavy Inspection reassured the Operator of the Tobu Kyuryo Line, Aichi Rapid Transit Corporation that the reduction in maintenance requirements and the long term reliability of the HSST vehicles will meet or surpassed what have been predicted at the beginning of the project.

This first Heavy Inspection of the HSST vehicles has not been an easy task as we did not have any real life precedent of carrying out heavy inspection for the HSST vehicles after extensive use. However, through this exercise, we have accumulated considerable amount of knowledge on the operation conditions of various equipment of the vehicles, and have been able to optimise the maintenance techniques and requirements. Furthermore, we will continue to explore means to improve on the maintenance efficiency and all our findings will be fed back to the design team for further product improvement.

6 REFERENCE

1. O. Hibi & K. Saito, "Summary of automatic operation of Linimo and achievement in opening year", The 19th International conference on magnetically levitated systems and linear drives, Dresden, Germany, September 13-15, 2006.