Standardization of the Electrical Multiple Units for the Korean Underground Transit System

Kwan-Sup Lee, Jun-Seo Park, Seong-Ho Yun and Yun-Ok Cho,
Urban Transit Standardization Division, Korea Railroad Research Institute.

1. Introduction

The railway system is becoming the most massive transportation method of all ground transportation than ever. It has been constructed for the transportation in the metropolitan or suburban areas, particularly because the system is much superior to others in its all aspects of massive transportation, punctual timing, safety, comfort and environmental friendliness.

Even in despite of an increasing demand for the rapid transit system, most of principal technologies such as the system engineering and the electrical equipment design in Korea has been provided by the foreign manufacturers. Therefore, new core parts or equipment have been introduced whenever a new line was constructed. This resulted in the low maintenance efficiency due to the lack of exchangeability between parts and difficulties in identifying accident causes, which in turn required a certain urgent need in the standardization and localization of EMUs for the Korean subway systems.

With a view to improvements of maintenance and safety capabilities for the vehicles, the government has performed the project for the standardization and development for the urban transit railway system since 1995. This five-year project has been led by the Korea Railroad Research Institute.

The main purpose of this ambitious project is to establish a spectral system of standardizations and developments for the urban transit system which might include standardized specification, performance test criteria, safety criteria, precise diagnosis criteria, and quality assurance system. In addition, this project is to make a development of the traction motor, the inverter and train control monitoring system and to build up the standardized urban transit system to fit to the domestic situation as well. This paper will illustrate some outcomes so far resulted from the project.

2. Domestic Situation

Since the first introduction of the subway on August 1974, subways in Seoul have been in service on No. 1 to No. 4 line in the first phase and No. 5, No. 7 and No. 8 in the second phase, and now No. 9 to No. 12 line in the third phase under plan. Some subway lines have been being completed and further lines are planned in such local metropolitan areas as Pusan, Daegu, Inchon, Daejeon, and Kwangju.

Contrary to the high share of urban transit systems in foreign countries, i.e., around 70%, the share of Seoul metro systems in ground transportation is still 34%. Therefore, it is positively expected that the total service milage will be increased to 651 km from 450 km and the total vehicle volumes to 8,194 from 4,662 in coming five years. Furthermore, light railway transits not in service yet in Korea will be introduced for connecting metropolitan areas, of which milage will be 669 km until the year 2015.

Even though Korea has a long experience in the rapid transit systems since 1974, there has been problems and no accumulated technologies in the integrated system due to the dependence of core technologies in rapid transit systems on the foreign manufacturers. Therefore, there have been problems in efficient maintenance due to the lack of exchangeability between parts provided by the different foreign manufactures. Also, there has been no unified criterion verifying the performance of parts and EMUs.

3. Standardization and Development

To overcome the problems described previously, the Korean government decided to invest 25 million dollars

into the project what is called 'the standardization and development of the urban transit system' motivated by the Urban Transit Law regulated in 1995. Major objectives of the project can be categorized into the following two primary fields:

◆ Establishment of the standardized specification and other associated criteria;

◆ Localization of core parts such as the propulsion system, the train control and monitoring system and the standardized EMU.

3.1 Standardization System

The standardization system in the project is 'a set of documents specifying the criteria in the design, performance test, retirement test, and safety of the EMU, and establishing a quality control system for verifying the parts quality'. The objective in standardization system is to develop following documents:

◆ The standard specification;

◆ The performance test criteria;

◆ The safety criteria;

◆ The precise diagnosis criteria; and

◆ The quality assurance system.

These standardized documents are not made separately, but interact and supplement among themselves for a unified standardized system as shown Figure 1.

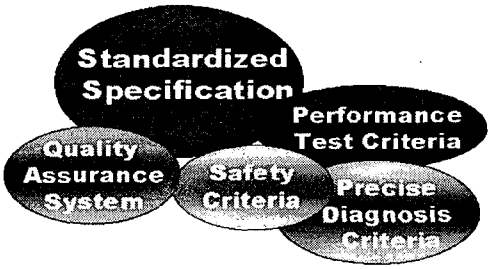

Fig. 1 Standardization System

Figure 2 describes a schematic of the legislative structure related to the urban transit law, based on which they comprise enforcement ordinance together with their own four regulations.

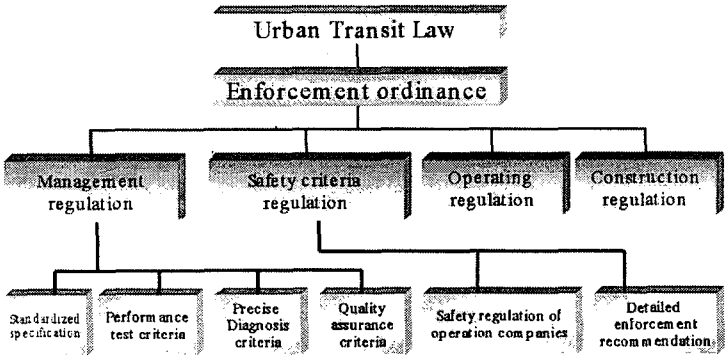

Fig. 2 Legislative Structure

☐ Standard Specification

Standard specification is the recommended specification at the purchase of vehicles which provides minimum requirements for the performances and limits in dimensions. The standardization has been carried out by taking into a comprehensive account parts exchangeability, domestic technical capabilities, trends on the future technology and maintenance efficiencies. It is a sort of guidelines for vehicles suitable to operation conditions in Korean rapid transit systems. This standard specification has already been announced in February

of 1998, which might be revised at the end of 1999.

Standard specification covers the EMUs and the light railway vehicles. Contents are divided into the general part containing application scopes, vehicle formations and types, and the technical part mentioning vehicle operation conditions, performance specifications, main component dimensions. Figure 3 shows the specification structure describing the system level requirements and technical performance level requirements in major components.

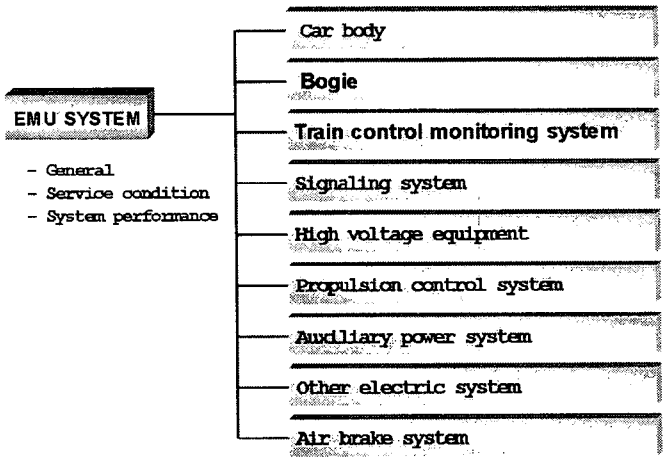

Fig 3. Structure of Standard Specification

Table 1 shows the major specifications. It is particularly noted that limit values are suggested for passenger comforts and noise levels.

Table 1. Principal Standardized Specification

Item		EMU		LRV	
		Large	Medium	AGT	LRT
Power Supply		DC 1,500V	the same as left	DC 750V	the same as left
Rolling Stock	length width height	19,500mm 3,120mm less than 3,600mm	17,500mm 2,750mm less than 3,600mm	9,140mm 2,400mm 3,500mm	12,800mm 2,650mm 3,400mm
No. of passenger		Tc car : 148 (48 seats) M/T car : 160 (54 seats)	Tc car : 113 (42 seats) M/T car : 124 (48 seats)	57	164
Perfor-mance	Max.Acc. Acc. Decel.	More than 100km/h More than 3.0km/h/s normal -more than 3.5km/h/s	the same as left	80km/h 3.96km/h/s 4.68km/h/s	the same as left
Speed control		VVVF inverter blended with regenerative braking	the same as left	the same as left	the same as left
Ride comfort		Less than UIC 2.5	the same as left	the same as left	the same as left
Noise level		Less than 80dB(A)	the same as left	the same as left	the same as left

☐ Safety Regulation

The safety regulation is a compulsory law specifying the minimum requirements for the passenger safety which vehicles should meet, otherwise they are disqualified to run on the line.

Figure 4 shows the contents of the safety regulation. It covers general rules of the interfacing capability

among tracks, signals and safety guidelines for vehicle gauges, fire, collision, and 8 individual equipments. The final version will be announced by the end of 1998.

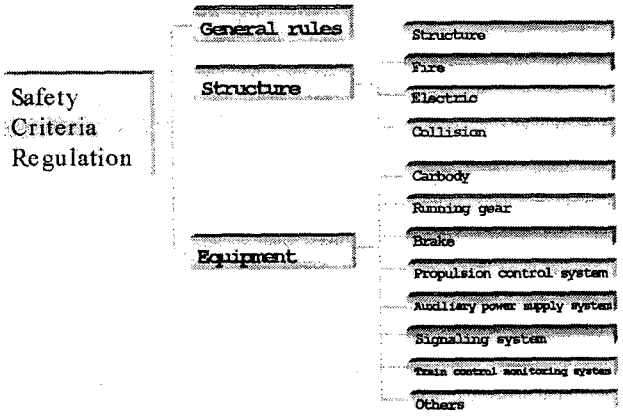

Fig. 4 Contents of Safety Criteria

☐ Performance Test Standard

Korean urban transit law requires that car manufacturers or anyone who wants to import and sell cars should pass the performance test criteria specifying the car structures, dimensions, and performance.. Performance test standard is a document specifying the requirements the testing methods, procedures, and evaluation criteria to evaluate the car performances.

Figure 5 shows the structure of the performance test standard. It is composed of three test phases: equipment tests for 6 major items; completed vehicle tests composed of 8 test items and service line tests composed of 14 test items. During the construction of the performance test criteria, documents for the test methods, procedures, analysis and evaluation has been unified. Test criteria have been based on the international standards such as IEC and UIC.

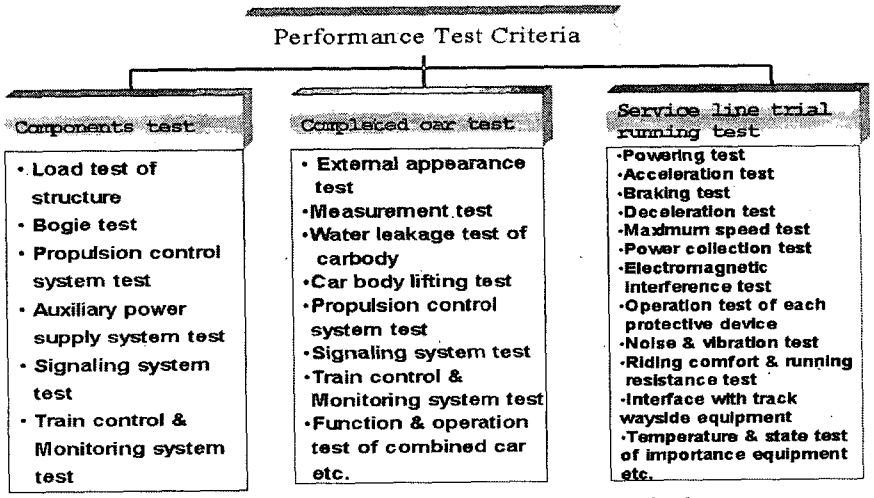

Fig. 5 Structure of performance test standard

☐ Precise Diagnosis Standard

The precise diagnosis standard is a document specifying the criteria that the vehicle should meet for the extended use after 25 years of life expectancy services. It is composed of checking items, evaluation methods, and the reporting methods. It is required that specified checking items be selected for the corresponding items, and a test report be constructed as the given format with the test criteria and evaluation for the checking items.

Figure 6 shows the structure for the precise diagnosis standards as follows:

◆ General items on the diagnosis time and the choice of test equipment;

◆ Checking items and their checking methods;
◆ Inspection or test items for individual checking points;
◆ Evaluation methods; and
◆ Reporting method.

Rolling stocks and bogies are recommended to be investigated by using nondestructive inspection methods and the rest to be diagnosed by the manufacturer's method. Additionally, a evaluation report on the conditions of vehicles, safety aspects, performance and residual economic values is recommended to be constructed from a viewpoint of maintenance, comfort, mechanical difficulty and safety.

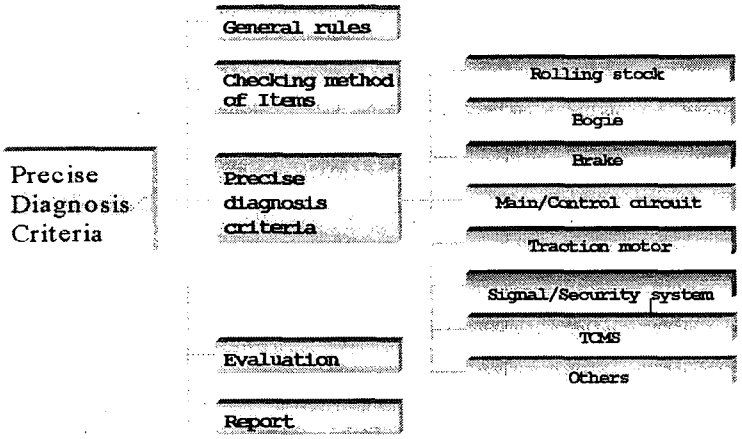

Fig. 6 Structure of precise diagnosis standard

☐ Quality Assurances system

The quality assurance system is a document to construct a quality control system related to the items for the quality control, test criteria, and procedures to secure the safety and performances of parts, equipments, or devices.

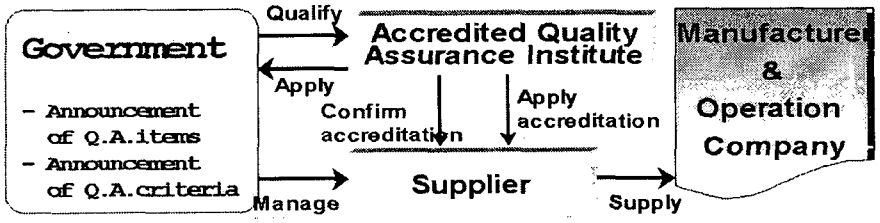

Fig. 7 Quality control process for the parts of EMUs

Figure 7 shows the structure of the quality control. It is recommended by law that the vehicle manufacturers use vehicle parts certified by the quality control system.

A brief explanation can be given for Figure 7. Parts manufacturers are recommended to provide parts certified by the quality assurance system to car manufacturers or operation companies. The quality assurance system thus can be said to select items to need certification and to establish related criteria. Door engine, for example, is one of the 45 selected items for certification. Final version for the quality assurance system will be completed by the end of 1999.

3.2 Core Technology Development

EMU technologies can be classified in the following engineering field: system engineering, propulsion systems, the system control and monitoring, rolling stocks and bogies, brake controls, and manufacturing and design. A part of technologies for the mechanical system engineering concerning the rolling stocks and bogies has been developed in the domestic. However, the technologies for the electrical system engineering concerning

propulsion systems and the system control and monitoring are yet to be developed further for the reliable application. To improve the technical capability, a multidisciplinary work is being conducted among governmental institutes, universities and manufacturers. The draft design has just accomplished and in progress is its detailed design. A short outline is mentioned in the following.

☐ Propulsion System Development

The system, converting the electrical energy into the mechanical, consists of traction motor and control inverter. Even if it is important equipment for controlling traction powers, a few technological accomplishment is made on account of a little experience on design and manufacturing. In present, this urgent situation makes the system to be developed.

▶ Traction Motor Development

The target item is a 3 phase induction motor having its own excellent maintenance feature, which technical dimensions are AC 1,100 V, over 200 kW and natural cooling type. In developing so, the slot assembly, the high frequency analysis, cooling and insulation characteristics, and mechanical dynamics is being performed initiating from a concept design. Currently, optimization studies on the high speed switching, electro-magnetics, cooling and insulation linked to IGBT inverter interfaces is done, while at the same time its performance is experimentally checked using the inertia load apparatus.

▶ Propulsion Control Inverter Development

The developed inverter is made possible to drive under high speed switching and low power voltage control by such applications as natural cooling, more than 1,100 KVA at rate output and IGBT element. A way of controlling vehicles is to control 4 motors with single controller, i.e., 1C4M type. The pulse width modulation is selected as a controlling method based on the DSP so as to improve its reliability and maintenance efficiency. Transient phenomena and adhesive controls occurred in the 1C4M type is examined. Mounted on the standardized EMU, the inverter will be checked for its performance once again.

☐ Train Control & Monitoring System Development

This equipment plays a central role in monitoring and controlling the propulsion system, air conditioner and passenger service equipment and so on. Based on domestic available protocol standards, developments of the train control module are made depending on the train formation

☐ Standardized EMU Development

The vehicle is for proving various criteria and the reliability for the standardization program. Throughout a concept design to the TPS analysis and structural analysis, the vehicle with specifications of DC 1,500 V and 4 cars per train unit is developed using aluminium applied to the rolling stock. The computer program is developed to study on main factors affecting passenger comfort and derailment and these results are compared with those using the commercial package, Vampire. Fig. 8 shows the exterior part of the aluminium rolling stock to be manufactured in near future.

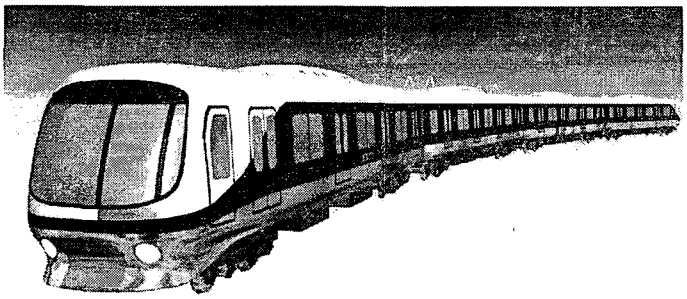

Fig. 8 Korean Standardized EMU

4. Project Process

The KRRI is responsible for the project management which jobs are about decisions on the railway policy, announcements of related criteria, and simultaneously are about conducting research on main equipment development together with academic and governmental institutes. Operation companies are in charge of enacting those criteria. The resulted standardization document is fixed up to make public after reviewing processes at a board of screening and judgement. For each core technology development, a board of project operation examines its feasibility.

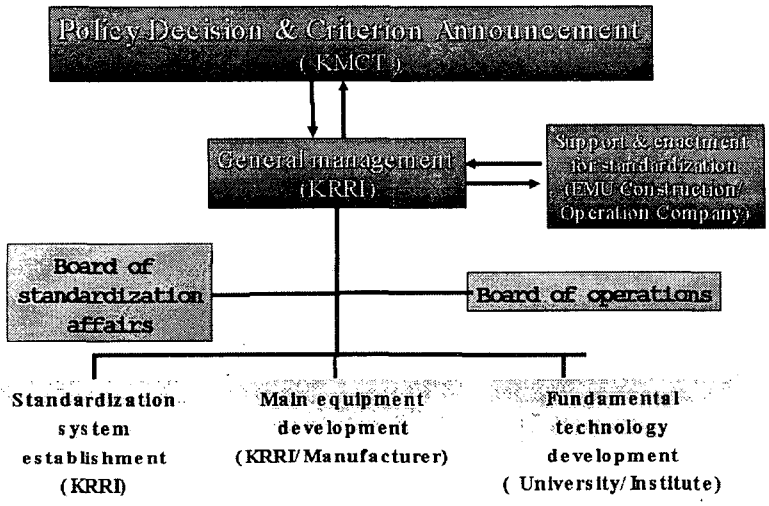

Fig. 9 Project Process

5. Conclusion

A brief explanation has been given in the paper for the project of standardization and development for the urban transit system in Korea being carried out by our institute. One of the project outcomes is the standard specification available to the public now. This year is the fourth year of the five year term project, by the end of which major works will be finished such as safety standards, the performance test, the precise diagnosis. Each draft of those criterion codes is in the finishing stage and its detailed documentation is in progress.

Also, manufacturing designs associated with developments of the standardized EMUs regarding the propulsion system, the control and monitoring system, and core technology has been accomplished. Standard EMUs will be manufactured and tested by the end of 1999. Through the development and performance test of standard EMUs, the validity and suitability of the standard documents will be proven at the end of 1999.