For discussion
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Legislative Council Panel on Transport
Subcommittee on Matters Relating to Railways

Safety Management Measures for Trains of Guangzhou-Shenzhen-Hong Kong Express Rail Link

Purpose

This paper sets out the safety management measures for trains of the Guangzhou-Shenzhen-Hong Kong Express Rail Link.

Background

2. In January 2010, the Government entrusted MTR Corporation Limited (MTRCL) with the construction of the Hong Kong section of the Guangzhou-Shenzhen-Hong Kong Express Rail Link (XRL). The Government attaches great importance to the safety of the XRL. Since commencement of the project works, the Government has been monitoring the construction progress of the entire project at different levels, including train safety. Information on the safety standards and signaling systems of the Hong Kong section of the XRL adopted by MTRCL is set out at the **Annex**.

Train Design

3. Regulation of railway safety in Hong Kong is all along based on the standards of advanced countries, including United Kingdom, Germany, France, Japan etc. MTRCL is required to submit detailed information to the Electrical and Mechanical Services Department (EMSD) to demonstrate that when the train is operating in actual conditions, its safety performance can achieve the safety level of comparable international standards. Since XRL trains will not only run

in Hong Kong but will also operate in the national high speed rail networks, XRL trains must therefore comply with the national railway safety regulations established by the National Railway Administration of the People's Republic of China as well.

4. The trains of the Hong Kong section of the XRL (CRH380A) Hong Kong section of the XRL adopt EN12663 standard which specifies structural requirements for design of railway vehicles covering the structural strength of the entire train body. EN12663 has been widely used for high speed trains throughout the world. EN12663 requires manufacturers to consider factors such as maximum loads and required service life to ensure that the structural strength of train body is sufficient to meet operational needs.

5. EN15227 standard mainly covers the safety requirements for trains under different collision scenarios. Amongst others, the structural strength of train body must withstand the impact at collision speed of 36 kilometres per hour to minimise the possible injuries that may cause to all people on board. This standard is developed based on the operation modes of railways in Europe. The operation modes of European railways involve railway networks connecting different countries, railway tracks shared use by passenger and freight trains, level crossings at intersection of railway track and other vehicular road, and even railway sections unprotected by any signalling system. According to our understanding, at the time when the international open tendering of the Hong Kong section of the XRL was conducted by MTRCL, all of the tenderers indicated that none of the existing high speed train models could meet the requirements of EN15227 standard.

6. EN15227 standard allows individual railway to conduct risk assessment based on its actual operation conditions and possible collision scenarios, so as to decide what train protection measures are required. This is a practical approach and in line with the spirit of EN15227 standard.

Safety Management Measures for XRL Trains

7. The Hong Kong section of the XRL is totally different from

European railways in that it has adopted passenger dedicated line design, i.e. no mixed operation with freight trains, and the entire line is constructed inside tunnels without any level crossing with highways, thus ensuring situations of collision between train and car, freight train or large obstacle will not happen.

8. It is more important to prevent the occurrence of train incidents than to reduce casualties after the occurrence of incidents. Therefore, "Active Safety Protection" measures are more effective than "Passive Safety Protection" measures. This concept has been adopted by most countries. The safety of modern railway primarily relies on **signalling system protection** to ensure a safe distance between trains being maintained to avoid collision. This is especially important in the design of high speed railway as it would be very difficult for any train design to protect people on board in the event of train collision at high speed.

9. The Hong Kong section of the XRL has adopted Chinese Train Control System (CTCS)[Note] specifications for active protection, including CTCS-3 specification and CTCS-2 specification as multiple back-up systems designed to provide multiple failure defense to ensure operation safety. The design principle of CTCS signalling system is a "fail-safe design", i.e. the train will automatically stop to ensure safety if the system fails.

10. Upon the featuring of media reports earlier this year alleging that the XRL trains were not able to comply with EN15227 standard, the Railways Branch of EMSD has immediately followed up with MTRCL and requested it to clarify with the European Committee for Standardisation (CEN), which is responsible for developing European Union standards, on whether the use of risk assessment is in line with the spirit of EN15227 standard. CEN subsequently confirmed that the use of risk assessment results to develop corresponding safety measures complies with the spirit of EN15227 standard.

[Note] CTCS is the Chinese Train Control System with specifications similar to that of the European Train Control System. The System consists of three levels, of which Level 3 is the most advanced level providing the highest train operation frequency. Under normal operation, the Hong Kong section of the XRL will adopt CTCS-3 signalling system. When CTCS-3 signalling system fails, it will automatically switch to CTCS-2 system for maintaining services.

11. In the light of media report claiming that the Chinese manufactured CRH3 high speed train could meet EN15227 standard, which MTRCL asserted otherwise, EMSD has sent staff to visit the National Railway Administration of the People's Republic of China, China Railway Corporation and the three Mainland high speed train manufacturers (including the successful tenderer CSR Qingdao Sifang Co. Ltd., CNR Changchun Railway Vehicles Co. Ltd. and Tangshan Railway Vehicle Co. Ltd.) in April and May 2014 and discuss with the staff of these organisations to understand the safety design of Mainland high speed trains. Having confirmed with the concerned organisations, none of these three manufacturers had adopted EN15227 standard for production of high speed trains, including the CRH3 high speed train.

12. EMSD has also checked with the high speed train manufacturers in France, Germany and Japan to ascertain whether their trains are in compliance with EN15227 standard. According to replies received, only the Velaro D high speed trains of Siemens, which were put into operation in 2013, is able to meet the requirements. The maximum speed of Velaro D is 320 kilometres per hour, which falls short of the maximum speed of 350 kilometres per hour for XRL trains.

13. The probability of CTCS-3 and CTCS-2 signalling systems failing simultaneously is rare. Even under such situation, the operation of the high speed trains will be automatically suspended by the system. The Operations Control Centre in Shek Kong must follow strict codes of practice in allowing train drivers to operate line of sight driving at slow speed to maintain limited services under safe conditions.

14. MTRCL has conducted risk assessment based on the guidelines of EN15227 standard. EMSD has received the risk assessment report and a train collision analysis report submitted by MTRCL, and is now vetting these reports in detail. EMSD has also requested MTRCL to appoint an independent consultant to review the train collision analysis report prepared by the train manufacturer, so as to prove the safety performance of the train at different collision speeds. MTRCL has actively cooperated with EMSD, and EMSD is awaiting MTRCL to submit the required review report. EMSD has urged MTRCL to

establish the future train operation and management modes (including an appropriate line of sight driving speed), based on the actual operating conditions in Hong Kong as soon as possible, in order to prove that the XRL train can achieve a safety level equivalent to that of EN15227 standard in actual operation, and to submit the details to EMSD for approval.

15. Prior to the opening of the Hong Kong section of the XRL, new trains have to pass three types of testing, including Factory Acceptance Test, System Integration Test and On-site Test, to ensure that they meet the required international safety level. The Highways Department and EMSD will assign staff to witness the conduction of the tests to ensure that they are properly carried out.

Transport and Housing Bureau
Electrical and Mechanical Services Department
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Annex

Legislative Council Panel on Transport
Subcommittee on Matters Relating to Railways

Safety Management Measures for the Hong Kong Section of the Guangzhou-Shenzhen-Hong Kong Express Rail Link Trains

INTRODUCTION

This paper serves to provide to the Legislative Council Panel on Transport Subcommittee on Matters Relating to Railways relevant information about the safety management measures for the Hong Kong Section of the Guangzhou-Shenzhen-Hong Kong Express Rail Link ("XRL") trains, and to provide a brief description on how the trains and signaling system work together to ensure safe operation of the XRL.

BACKGROUND

2. The MTR Corporation Limited ("the Corporation") is entrusted by the Government on the construction of the XRL, including the procurement of high-speed trains.

3. Safeguarding railway operational safety is of the top priority of the Corporation in managing the XRL project.

4. Procurement of the XRL rolling stock follows a consistent open, fair and impartial procedure and also complies with the stringent requirements of the WTO Government Procurement Agreement. Representatives from the Highways Department also participated in the procurement process.

5. Nine high-speed trains have been procured for the XRL project. All trains procured must comply with the relevant technical and functional requirements prescribed in the contract. The train structural requirements of the newly ordered high-speed trains comply with

European Union's EN12663 standard, a European Standard which has been widely adopted worldwide in high-speed trains, covering the structural strength and resilience of the carbody.

6. The contract was awarded to CSR Qindgao Sifang Co., Ltd. through an international open tendering process.

TRAIN SAFETY STANDARDS

7. All the XRL trains are required to meet the relevant international safety standards, including EN12663 standard for the design of carbody structure.

8. EN12663 is a widely adopted international standard for the design of the carbody of railway vehicles introduced by the European Union (EU). The standard states that the structural requirements shall be assessed based on the following criteria: (a) maximum loading consistent with normal operational requirements; and (b) to achieve the required service life. The standard also mentions the need to incorporate appropriate safety margin when considering the design parameters to allow for possible uncertainties, such as loads, material (processes, time/ageing, operating environment, etc.), manufacturing processes and analytical accuracy, to provide structural integrity to the occupied areas in a collision-type accident.

9. EN12663 describe the requirements for demonstration of carbody strength and structural stability, stiffness and fatigue strength that the carbody structure design shall achieved. For example, for demonstration of carbody strength and structural stability, the standard stipulate that it shall be demonstrated by calculation and/or by testing, that no significant permanent deformation or fracture of the structure as a whole / of any individual element / of any equipment attachment, will occur under the prescribed design load cases.

10. The standard defined detailed requirements for the design load cases, including longitudinal loads for vehicle body (compressive force at buffers, compressive force below buffer, compressive force applied

diagonally at buffer attachment and tensile force at coupler attachment), vertical loads (maximum operating load when lifting and jacking up the train), all kinds of proof loads at interface (such as body to bogie connection, equipment attachments and joints of articulated units), general fatigue load cases for the vehicle carbody, fatigue loads at interface as well as the vibration modes.

11. EN15227 standard for train crashworthiness was published in 2008 to address the safety framework specific for the railway operating environment in Europe for light rail system, sub-urban trains as well as high-speed rail. This standard is compatible with the requirements of EN12663. Whilst EN 12663 stipulating requirements for the structural integrity to the occupied areas in a collision-type accident, EN15227 sets **additional passive safety requirements for structure** to address the specific railway operating environment in Europe. EN15227 define the following categories of railway vehicles: coaches and mixed train units; metro vehicles; tram trains and peri-urban tram; and tramway vehicles. In addition, the following design collision scenarios were defined for each category of vehicle: (a) collision of identical train unit; (b) collision with wagon/mixed traffic regional train; (c) collision with 15 tons deformable obstacle or 3 tons rigid obstacle; and (d) collision with small low obstacle. According to these vehicle types and these 4 possible collision scenarios, EN15227 provide for the design of the carbody structure to comply with the passive safety requirements, including overriding height; survival space and deceleration limit/collision pulse. Based upon each categorisation of railway vehicles and the 4 collision scenarios, it is considered that EN15227 provide for the cases **where provision of proactive safety measures**, such as the automatic train protection system by signaling, **is not available** or railway with mixed mode operation or with level crossing. In case of a collision, passive safety measures shall be provided in railway vehicle design to enhance the safety of occupants inside the train. The carbody structure requirement for train crashworthiness at 36km/h specified in EN15227 is only for slow driving conditions, not a protection for collision in high speed.

12. EU's EN15227 standard is mainly for the environment and unique operation conditions in Europe (with some of the lines without any protection by signaling system or in share use of tracks with other road

vehicles), where a passive rather than a proactive train safety protection measure is adopted to reduce the impact from collision with another train to the minimum. Various scenarios are defined mainly based on the environment in EU countries, while railway institutions may, according to local requirements and scenarios, to develop specific solutions for implementation. According to the handling solutions recommended in the Annex A of EN15227, railway institutions may (a) make reference to relevant local regulations and/ or (b) to proceed with a risk assessment.

13. When the international open tendering process for the XRL trains started in 2011, the Corporation did note that the EN15227 standard began publishing in Europe. However, there was no mature high-speed train model design based on this standard nor one that met the requirements of this standard at that time. Considering that the EN15227 standard is more relevant to the operation mode in EU, including operations in different countries, share use of tracks by passenger and freight services, junction with road vehicles as well as no signal system protection in some sections, which has relatively higher operational risks. This is entirely different from the high-speed rail system in Hong Kong and the Mainland which operates entirely on dedicated tracks and tunnels. Having assessed the future operation requirements and technical risks, the Corporation considered adopting the existing mature product is more suitable and less risky than asking suppliers to develop a new high-speed train model. It is understood that the existing trains operating in the Mainland, including CRH3 model, are not designed and produced in accordance with EN15227 standard. The Corporation contacted manufacturers in the Mainland and China Railway Corporation again in mid-2014 for updates, but the same message was conveyed that the national system in the Mainland is different to those in Europe in terms of dedicated lines, protection by multiple layers of signaling system, etc., thus EN15227 is not applicable; while all CRH train models, including CRH3, have not adopted this standard.

14. Dedicated lines and high level of proactive protection are adopted by the high-speed rail in Hong Kong and the Mainland, which is different from the unique environment and operation modes in Europe (with some of the lines without any protection by signaling system or have to share tracks with road vehicles). The XRL trains will not only be running

within Hong Kong, but also connecting with the National High-speed Rail network. The XRL trains comply with international safety standards as well as the Mainland railway safety requirements set by the National Railway Administration.

15. The safety management system of the MTR operation system is in compliance with requirements in EN50126[1] (Railway applications - The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)). With reference to the operating characteristics and system configurations of the XRL (including proactive and passive safety equipments and measures), a collision risk assessment on train had been carried out. A review by independent safety advisor had also been conducted to confirm that the existing system is up to relevant safety standards. The concerned review report has been submitted to relevant government departments for review.

16. In fact, high level of proactive protection and strictly regulated operation have been adopted in Hong Kong and the Mainland to control operational risk, compliance with the principles and handling solutions under EN15227 standard.

17. In terms of the coupler, the same model as that for CRH3, namely "European Type 10" has been adopted for XRL trains which is equipped with anti-climb design features including preventing overriding and energy absorption devices. The Corporation has been supervising closely the design and manufacturing process; and has adopted monitoring measures and Independent Safety Assessment process at the above project stages to ensure the trains being designed and built will be in compliance with international safety standards and Mainland railway safety requirements.

[1] The European Standard EN50126 provides the railway industry with comprehensive management process which will enable the implementation of reliability, availability, maintainability and safety. The approach defined in this standard is consistent with the application of quality management requirements contained within the ISO 9000 series of international standards.

SAFETY PROTECTION FUNCTION OF THE SIGNALING SYSTEM

18. In addition to the structural integrity of the train carbody, protection by the signaling system plays an even more important role in railway operational safety for the high-speed rail. The signaling system regulates safety distance between trains to prevent collision.

19. The XRL is equipped with a comprehensive signaling system. The signaling system regulates through real time detection of trains location and respective speed in order to ensure safety distance are maintained between trains. The signaling system is also equipped with automatic train protection functions, which will issue deceleration command to train drivers in case of speeding or distance from the former train too closed. Emergency brake will be applied when necessary. To ensure safety, 'fail-safe' principle is adopted for the design of signaling system with XRL to automatically stop the train in case of system/equipment failure or system errors.

20. The XRL is a comprehensive and integrated system consisted of dedicated route, train, signaling system and other relevant components. To achieve seamless integration with the Mainland high-speed rail network and to ensure operational safety, the signaling system of the Hong Kong section of the XRL shall comply with the Mainland's, i.e. the CTCS (Chinese Train Control System) specifications which is set with reference to the ETCS (European Train Control System) specifications. Both specifications have the similar safety requirements. The XRL (including HK section) adopts CTCS-3 system (equivalent to ETCS-2) with communications-based train control specifications, as well as the track circuits-based train control CTCS-2 system (equivalent to ETCS-1) specifications. The multi-layer and redundant backup systems adopt independent and different technology on transmission mode, controlling principles as well as independent trainborne and trackside signaling equipment which will provide the railway with multiple protections. The function of the signaling system is to ensure the safety distance is maintained between trains. The safety record and standard of high-speed railway systems adopting proactive protection mode, including Japan are extremely good.

21. To ensure a high level of reliability and safety of the high-speed rail services and most importantly, the integration with other railway systems for the high-speed rail operation, integration test and related drills will be conducted during the pre-opening period to ensure it will meet and operate to the stringent safety and performance requirements. In extreme cases that manual operation is required, the emergency procedures will include restricted speed operations to ensure adequate safety distance are provided between trains to prevent collision.

TESTING BEFORE OPERATION

22. Testing to be conducted at the Guangzhou-Shenzhen section, during non-operation hours, is to confirm that the XRL trains are compatible for running in this section. The remaining tests can be carried out in the Hong Kong section. The arrangement for the testing at the Guangzhou-Shenzhen section is currently managed by China Academy of Railway Sciences for the coordination with the Guangzhou Railway (Group) Corporation.

23. Before trains are delivered to Hong Kong, they will be arranged to complete type-tests at the manufacturer's factory and the Mainland section to ensure relevant requirements stipulated in the contract and for the national high-speed trains were fulfilled. The design of the XRL trains is similar to trains operating in the Mainland. Upon completion of the required tests in the Mainland, the trains are expected to be recognised in principle by relevant Mainland administration and able to run in the National High-speed Rail Network. This could shorten the required testing period for the Guangzhou-Shenzhen section.

CONCLUSION

24. Six to nine months for the integrated testing and related drills and exercises on the Guangzhou-Shenzhen-Hong Kong section has been reserved before XRL opening which is considered sufficient to ensure overall train reliability and railway safety.

25. Electrical and Mechanical Services Department (EMSD) will thoroughly assess all testing reports submitted by the Corporation, and participate in on-site tests to ascertain relevant guidelines have fulfilled before the XRL trains are approved for service. Upon passenger service, EMSD will continue to monitor XRL railway operations to ensure its safety performance is in compliance with international standards. The Corporation will provide full support to jointly safeguard railway safety.

MTR Corporation Limited
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