CRH 3 Brake System Failure Mode, Effects, and Criticality Analysis (FMECA)

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Abstract. In the whole structure framework of CRH 3, brake control system is a key part and stands in the core position. Brake control system's normal and stable work directly relates to EMU' safe and reliable operation condition, therefore, the strengthening of monitoring state and fault diagnosis level of CRH 3 internal brake control system are particularly critical. Based on this background, this paper takes CRH 3 brake system failure mode and criticality analysis as research subject, focuses and explores CRH 3 brake system failure mode, and on this basis further analyzes its hazard influence degree to the safe operation of EMU.

FMECA is Failure Mode, Effects and Criticality Analysis. It is an effective method aiming at all possible fault and its model analysis for series of products. It is summarized from a lot of engineering practices, and is mainly based on product equipment failure mode, and adheres to taking the consequences of product or equipment failure as a target for analysis. Specifically speaking, after determining the effect of each fault mode on product device itself, effectively find out the failure, and further confirm the damage (criticality analysis) according to the unified product failure mode severity and the size of the probability of the possible fault.

I. CRH 3 BRAKE SYSTEM

CRH 3 is high-speed rail, whose running speed is faster than the average railway train a lot. Due to the fast speed of EMU, standards for the brake performance, operational stability and the reliability of the brake system, comfort and other series of CRH 3 are also higher and higher. A brief introduction on EMU's brake system basic function and the composition of internal structure is analyzed. EMU brake control system is constituted by the following several parts: electrical brake control system (EBCU), regenerative electro-dynamic brake system (ED brake), electro-pneumatic brake system (EP-brake system), anti-skid devices, towing panel, parking brake and related parts. The service brake of EMU is achieved by the use of two different brake systems, regenerative electro-dynamic brake and friction brake (except when towing). EMU brake control system, in the process of brake, generally uses the method of electric control combined brake, and operates with the combination of main brake mode and regenerative brake. In addition, EMU brake control system also has the following basic functions, including Emergency brake，Security brake，Holding brake，Parking brake，Towing brake，Wheel Slide Protection，Passenger emergency brake，main compressor start-stop control function, door control function, system state record function, fault diagnosis, and early warning function.
Figure 1shows Brake System architecture for CRH 380 (single car).

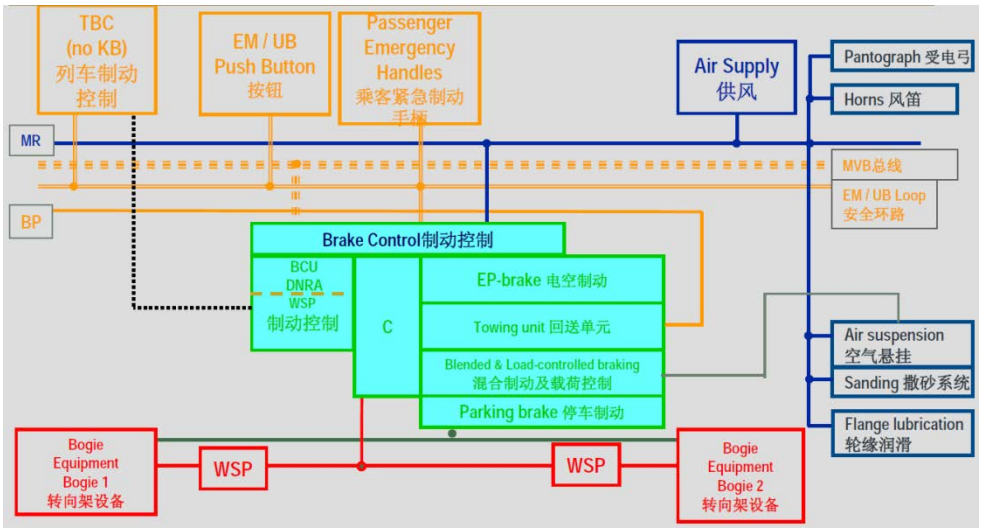

Figure 1 Brake System architecture for CRH 380 (single car)

In Figure 1, brake control is a core component of the whole system and brake system has two main controlled bodies: one is EMU drivers, and the second is the automatic control device installed in the system. In this case, it can produce and transfer corresponding brake signals, and at the same time be responsible for the calculation and distribution of brake force by different kinds of brake ways. In Figure 1, in the middle of the work principle block, there is a brake control unit, which controls the whole brake system together with TBC, EM push button, passenger emergency handles, etc.

II. THE COMMON FAILURES IN EMU BRAKE SYSTEM

About EMU brake and control system, take CRH 3 brake system as an example. In general situation, EMU brake system fault diagnosis basically includes three parts, respectively brake control and brake system monitoring and anti-skid protection, etc. In fault diagnosis, brake control system fault diagnosis respectively includes CRH 3 vehicle control, monitoring and fault diagnosis system. The following Table 1 shows the basic situation of CHR 3 brake system common emergency failures.

Tab 1 Emergency failures of CHR 3 brake control system

CHR 3 brake system fault	CHR3 brake system fault introduction	Fault analysis
Insufficient brake	This failure phenomenon is mainly with system prompt insufficient brake force, resulting in timely relay action, and finally causes EMU urgent brake	Failure occurs because of various reasons, including circuit fault, system view system reveal fault, or BCU problem and EP valve failure problems, etc
Brake system device bad transfer	When CHR 3 drivers brake, because of brake control device failure or bad data signal transmission, it is likely to cause insufficient brake force	This fault is because of loosen optical connector connect plug, or the bad plug line contact. Of course, it also can be caused by terminal device interface board fault
The brake does not relieve	Mainly when ease train brake, BC pressure residues over 40 kpa BCU detection relay excitation, output non-relieved signals. In this case, the whole CHR 3 cannot automatically release the signal, that is, brake unease fault	This failure occurs because of four aspects, respectively BCU fault, EP valve fault, sensor failure, and relay valve malfunction
Brake control device failure	When this failure occurs, brake control declines and sliding control is unable to proceed	Because brake control is the core key component of the system the brake force failure reason is single, which is brake control unit equipment problems, such as equipment aging, lack of maintenance and performance damage

Table 2 Damage (accident) caused by train brake (control) system malfunction (partial statistics, nearly ten years)

No.	Accident time	Accident place	Accident reasons	Damage
①	2006 - 1 - 21	Lhasa Chokorgyel Station	Train crash because of brake failure	1 killed and eight wounded
②	2006 - 4 - 20	Xinjiang Kuitun Station	Train subversion because of brake failure	1 killed and 2 injured
③	2008 - 12 - 24	Henan Hebi Qi County	Double fault, the train cannot alleviate, brake device fault	The whole train got in fire, resulting in Jing-Guang train line interruption for X hours

III. EMU BRAKE SYSTEM FMECA ANALYSIS

FMECA analysis method has been introduced in detail, and it is failure mode, effects, and criticality analysis and is also the widely used way applied in CRH 3 in China at the present stage for the analysis of brake system fault diagnosis. The analysis process of FMECA failure analysis includes the following steps: the first step is to define the minimum standard requirements of system function and work; The second step is mainly to formulate brake system function and the construction of reliability block diagram, chart, and the structure of mathematical model, along with relative text illustration; The third step further confirms, identifies and analyzes the basic principles, and the relevant documents needs to be analyzed in the working task; The fourth step is to find out the fault mode through the above analysis, and at the same time also get to know the reason and influence; Fifth, again find out reasonable brake control system fault detection and isolation method measures; Step six is to design preventive measures after finding the method to as much as possible prevent fault events; Step seven is again to determine the fault damage under the events; Step eight is to estimate the failure probability of brake control system and its devices; Step nine is to put forward suggestions; Finally, start the operation.

Continue to take CRH 3 brake system as an example for system fault diagnosis and criticality analysis. First is to put forward its task, and its main task is to provide brake force which is needed by safe operation of CRH 3. Brake force is the guarantee of smooth and reliable running trains. Second is to make block diagram, including analysis and description of each function unit and corresponding work tasks and relationship, etc. in CRH 3 brake system. Based on this, determine the block diagram. Third is to determine the analysis level, including what the system need, how to achieve the desired results, and the available degree of design data, etc. Then make FMECA analysis on the system, focusing on failure mode and criticality analysis, and eventually form formal FMECA analysis report. The concrete analysis includes components like safety valve, electric empty transform, b11 pressure adjustment valve switch, VM14 solenoid valve, etc. Take valve components for example, its function within the entire EMU brake control system are mainly to ensure the pressure needed for brake control system performance work. Based on this, classify faults and analyze its failure mechanism, including the corresponding description of failure consequences, internal cause and external cause analysis, etc.

IV. CONCLUSION

In the new period, with the continuous development of domestic economy and science and technology progress, high speed railway construction has also made great achievements. Along with the widespread popularization of CRH 3 across the country, the safety problem of train operation also gets more and more attention of the society from all walks of life. The first problem needed to face now is how to ensure safe and reliable operation of CRH 3? It is also the technical characteristic and difficulty involved in the research field in our country at present stage. In CRH 3 framework, brake control system is in the internal core position and is a key part. The brake control system's normal and stable work directly relates to the safe and reliable operation of the EMU condition. Therefore, strengthened state monitoring and fault diagnosis level in CRH 3 structure internal brake control system is particularly critical.

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