Design and manufacture of high-voltage disconnector test equipment for Harmony series high-power electric locomotives

Jun Liu*, and *Xingyu* Zhang

Technology Research Center, Shujiatun Locomotive Depot, China Railway Shenyang Bureau Group Co., Ltd, Liaoning, China

Abstract. With the continuous improvement of the maintenance technology system of harmonious high-power electric locomotives, the quality requirements for the maintenance of important parts are getting higher and higher. Based on the traditional manual detection of the performance of the high-voltage disconnector, it can no longer meet the current status of advanced maintenance. According to the relevant requirements of the maintenance of parts and components in the Harmony Electric Locomotive Maintenance Regulations of the State Railway Group Co., Ltd., a design scheme of the main function test equipment for the high-voltage disconnector had been given, the technical application and verification indicators in the design scheme discussed, and the test equipment manufactured. Combined with the actual production conditions, the developed test equipment can meet the relevant indicators required by the regulations, and has been put into use in production.

Keywords: Harmonious electric locomotive, High-voltage disconnector, Controlling function, Test equipment.

1 Introduction

High-voltage isolating switches are widely applied in electrical systems in the power industry, which are used in conjunction with high-voltage circuit breakers. when high-voltage equipment has voltage and has a working load, it can switch circuits. It is an extremely important switching appliance for isolation. Harmony series high-power electric locomotives have become the main traction equipment for railway transportation in the country, and the high-voltage disconnector as an important part of the high-voltage electrical system of this locomotive has been mainly used to control the on-off of the 25KV main circuit of the electric locomotive, and isolated it when the pantograph and roof insulator fail. According to the industry standards implemented in the advanced maintenance process, as

* Corresponding author: liujune-0801@163.com

PISDP and 2PIS kinds of disconnectors of Harmony series electric locomotives, which are suitable for 50Hz rated frequency, 110V control voltage and 28-30KV rated voltage, a series of problems in the process of maintenance high-voltage isolating switch test equipment has been designed and manufactured.

2 Design requirements for high-voltage disconnector test equipment

2.1 Regulations on maintenance technical regulations of HXD electric locomotives in railway industry of China

The C5-level repair cycle of the harmony electric locomotives running on trunk line is 1.2.9 billion meter or no more than 6-year. The C6-level repair cycle is 2.2-1.8 billion meter or no more than 12 years. PISDP or 2PIS type high-voltage isolating switches are in good condition and function normally. The main indicators are as follows:

I. It can be closed in place, the dynamic and static contacts are good, and the contact resistance is not greater than 400μΩ;

II.The contact resistance value of the contacts of electric shock appliances is not greater than the specified value (200 mΩ if no specified value).

III.The transmission mechanism is flexible and reliable. The solenoid valve, transmission cylinder and air pipeline are not allowed to leak.The solenoid valve and interlocking contacts are in good wiring condition and function.

2.2 Function and performance test

Ensure that the railway industry standards are implemented during the overhaul of the HXD type electric locomotive high-voltage disconnector, the test process of high-voltage disconnector is generally implemented in the industry.

2.2.1 Logic function detection

The resistance value measurement test method is adopted. The resistance measured when the main contact and the knife closed lead to the main contact and the knife form a current loop. The normally open contact resistance of the auxiliary contacts A and B of the interlocking contact box and the contact resistance of the main contact are measured; when the main contact is disconnected from the knife, the normally closed contact resistance of the auxiliary contacts A and B of the interlocking contact box are measured. The normally open and closed contact resistance is less than or equal to 200mΩ, and the contact resistance between the main contact and the knife is not more than 400μΩ.

2.2.2 Action performance detection

Use the switch-open and switch-close test method. Under the three working conditions of standard, low voltage and high voltage, the main contact and the knife are opened and closed for 20 times, and the effective times of the action are detected.

During the standard test, the air pressure is controlled at 540-560 KPA. When the voltage is lower than 540 KPA. The two-position electric-control valve works and the air pipeline started. The air charging solenoid valve in the two-position electric control valve acts to open the compensation pipeline to automatically supply air so that the air pressure rises to 560KPA; When the voltage is higher than 560KPA, the air release solenoid valve in the

two-position electric control valve acts to open the air duct to automatically exhaust air so that the air pressure drops to 560KPA.

During the low-voltage test, the wind pressure is controlled at 340-360KPA.When the voltage is lower than 340KPA. The air charging solenoid valve in the two-position electronic control valve operates, and the compensation pipeline is opened to automatically supplement the air so that the wind pressure reaches 360KPA; When the voltage is higher than 360KPA, the air release solenoid valve in the two-position electric control valve acts to open the air duct to automatically exhaust air so that the air pressure drops to 360KPA.

During the high-voltage test, the wind pressure is controlled at 690-710KPA.When the voltage is lower than 690KPA. The air charging solenoid valve in the two-position electronic control valve operates, and the compensation pipeline is opened to automatically supplement the air so that the wind pressure reaches 710KPA; When the voltage is higher than 710KPA, the air release solenoid valve in the two-position electric control valve acts to open the air duct to automatically exhaust air so that the air pressure drops to 710KPA.

2.2.3 Air tightness test

The pressure-holding test method is applied. Firstly, the wind pressure at the beginning and ending are measured when the high-voltage isolation switch is closed, then the leakage amount within 1 minute is calculated. If it is less than or equal to the standard, it is qualified. During the pressure-holding test, when the air pressure is less than 580KPA, The air charging solenoid valve in the two-position electric control valve operates to make the air pressure reach 580KPA, then test started. When the wind pressure is high at 580KPA, the air discharging solenoid valve in the two-position electric control valve will act to reduce the wind pressure to 580KPA, then test started.

3 Design of high-voltage disconnector test bench

3.1 Target function of the bench

According to the design requirements of the high-voltage disconnector bench, combined with the actual maintenance operation, the following functions are needed.

I. It has the function of measuring resistance values not greater than 200 mΩ and 400 μΩ;

II. Driving the main contact action and counting are must.

III. The function of controlling air pressure is provided;

IV. The judgment functions of test independence, overall control, and test result are to have;

V. The functions of automatically forming records, archiving and printing are possessed.

3.2 Functional unit design

On the whole, four units are designed, which are opening and closing test, pressure holding test, resistance value measurement and test bench state control. Each unit implements the designed experimental function.

3.2.1 Opening and closing test unit

There are three counting sub-units under different working conditions of standard, low pressure and high pressure. Each sub-unit includes standard times, valid times and test results judgment, and independent sub-unit control functions are set. As shown in Figure 1.

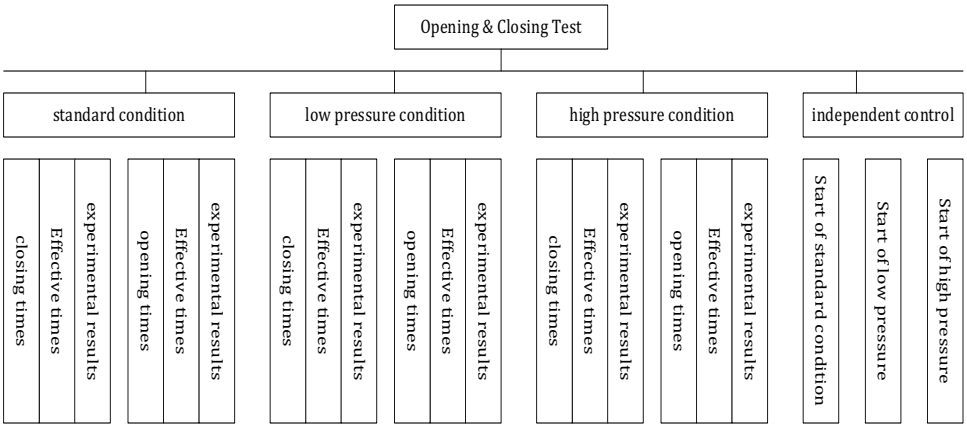

Fig. 1. Opening and closing test unit.

3.2.2 Pressure holding test unit

There are two sub-units in the closed and opened state of the main contact and the knife. Each sub-unit includes the control of the starting and ending air pressure and leakage. Given the standard judgment result, an independent sub-unit test control function is set, as shown in Figure 2.

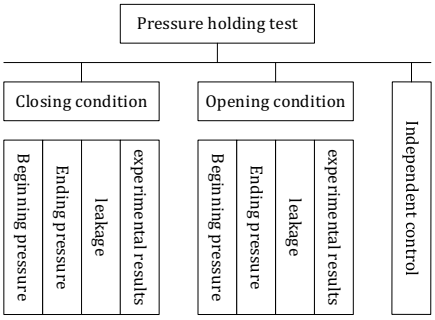

Fig. 2. Pressure holding test unit.

3.2.3 Resistance measurement unit

When the main contact and the knife are closed and opened, the open and closed resistance values of the auxiliary contacts A and B, the closed resistance of the main contact, and the independent sub-unit test control function is set, as shown in Figure 3.

3.2.4 Test state control unit

It is divided into three sub-units. The first is the operator information and test conclusion unit; The second is the test bench working status indication and overall control unit; The third is the high-voltage isolation switch status and automatic storage and output unit, as shown in Figure 4.

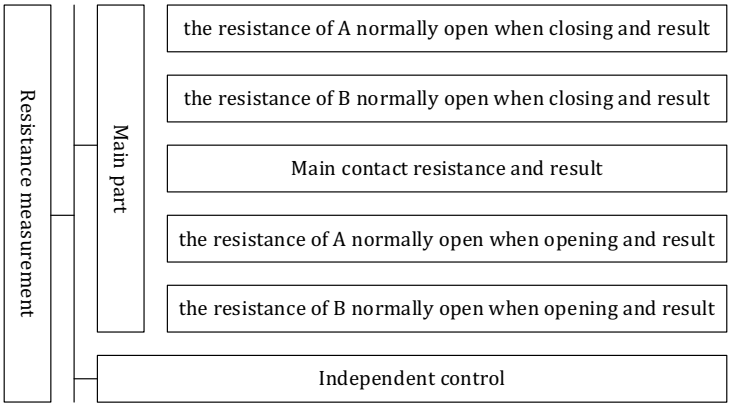

Fig. 3. Resistance measurement unit.

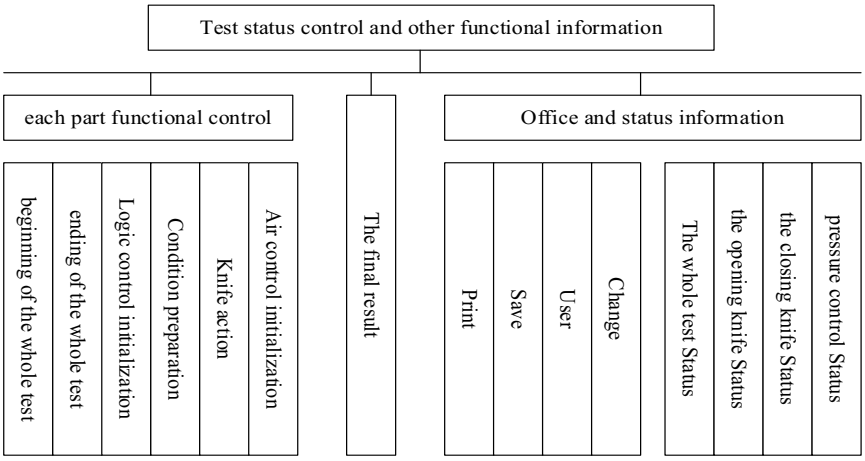

Fig. 4. Test state control unit.

4 Logic control function

The host computer control event is mainly based on the Kingview host computer software. A data dictionary is established to realize the communication between the host computer function and the workstation PLC. According to the actual function test, 92 variables are defined in five categories: I/O real type, I/O discrete type, memory discrete type, memory real type, and memory string, involving 40 memory variables and 52 I/O variables. Each variable is assigned an ID in the dictionary. Each I/O variable needs to define its own register and communicate with the two PLCs respectively. Among them, 36 parameters communicate with the PLC of station 0, and 16 parameters communicate with the PLC of station 1. The definitions of some main variables are shown in Table 1.

The host computer judges the I/O discrete variables, and the PLC executes the corresponding conversion event program. Each event program includes the measurement of the contact resistance of the auxiliary contact finger, the judgment of the result, the judgment of the opening and closing action, and the pressure leakage, etc. The events and commands for the judgment of the contact resistance measurement result of the auxiliary contact finger are as follows:

Table 1. Parts of main variable definition in communication control.

Term	Variable	Type	ID	Connector	Register
1	access rights	Memory real	10		
2	Resistance measurement control	I/O discrete	21	0 station	Y4
3	Air Pressure	I/O real	25	0 station	D6
4	reset	Memory discrete	34		
5	High-voltage time-sharing effective times	I/O real	49	0 station	D11
6	Closed count measurement	I/O discrete	54	1 station	M31
7	Leak on Close	Memory real	72		
8	Main Contact Resistance Measurement Conclusion	Memory string	82		
9	Holding pressure test flashing	I/O discrete	86	0 station	M64
10	A Normally Closed Memory When Separated	Memory real	90		

```
\\ this site\Measure contact resistance button==1
\\ this site\resistance measurement control OY=0;
\\ this site\measure=0;
\\ this site\stop=1;
\\ this site\stop=0;
if (\\this site\A normally closed resistance measurement <200 when it is separated)
{\\this site\A normally closed conclusion = "qualified" when separated;}
else {\\this site\A normally closed when separated conclusion="unqualified";}
```

The execution control unit is mainly two PLC joint control relay groups of No. 0 station and No. 1 station. The set I/O real and I/O discrete variables are mapped to the registers respectively, and the execution program is set inside the workstation. By receiving the communication instructions of the upper computer, the two workstations execute the actions specified in the design scheme to realize the corresponding functions.

5 Equipment fabrication and testing

5.1 Equipment manufacturing

According to the equipment structure design, the components of the air circuit structure, the components of the electric control structure and the peripheral components are assembled to form the entire equipment. The interior of the equipment is shown in Figure 5.

5.2 Equipment test

After the overall assembly of the high-voltage isolating switch test equipment of the harmonious high-power locomotive completed, the overall test is carried out. From the completion of the equipment production and the field test, the cumulative operation is nearly 1500h, and all functions can be completed according to the target. Through the test, it is confirmed that the performance and reliability of the whole machine have reached the design goals.

6 Conclusion

Combined with the actual work requirements for the maintenance of the high-voltage disconnector of the harmonious high-power locomotive, the test equipment scheme is expected to be designed. By manufacture and test verification, this equipment can meet various functional goals. While ensuring reliability and accuracy, it can improve the labor productivity of workers, reduce labor costs, and achieve certain social benefits.

Fig. 5. The interior of the equipment.

References

1. Shuguang ZHANG M 2009 HXD3B type electric locomotive (BeiJing: China Railway Publishing House)
2. China Railway Corporation M 2019 HXD3B electric locomotive maintenance technical regulations (C1-C4 repair, C5 repair), (BeiJin: China Railway Railway Press Co., Ltd.)
3. China Railway Corporation M 2019 HXD3C electric locomotive maintenance technical regulations (C1-C4 repair, C5 repair), (BeiJin: China Railway Railway Press Co., Ltd.)
4. China Railway Corporation M 2019 HXD3D electric locomotive maintenance technical regulations (C1-C4 repair, C5 repair), (BeiJin: China Railway Railway Press Co., Ltd.)
5. China Railway Corporation M 2019 HXD3C electric locomotive maintenance technical regulations (C6repair), (BeiJin: China Railway Railway Press Co., Ltd.)
6. Yang ZHANG and Liming GUAN J 2019 HXD3B electric locomotive high-voltage disconnector detective process analysis and design China Science and Technology Expo. vol 1 p11-12.