

# RIGOROUS INVESTIGATION INTO THE IDENTIFICATION OF MALFUNCTIONS IN THE AIR CONDITIONING AND REFRIGERATION SYSTEMS OF URBAN RAIL VEHICLES

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**Abstract:** The air-conditioning and refrigeration system is an important part of urban rail vehicles. The comfort of the train environment is mainly guaranteed by the air-conditioning and refrigeration system. If the unit's cooling capacity decreases or fails to cool down frequently, it will seriously affect the service quality and quality of the vehicle. Safety. This paper studies the fault diagnosis of air conditioning and refrigeration systems of urban rail vehicles, discusses the characteristics of fault diagnosis of air conditioning and refrigeration systems of urban rail vehicles, summarizes several common fault phenomena and causes of air conditioning and refrigeration systems of urban rail vehicles, and uses refrigerant leakage Taking a fault as an example, a diagnostic simulation scheme is proposed.

**Keywords:** Urban rail vehicles; Air conditioning and refrigeration systems; Cause analysis; Fault diagnosis

## 1 INTRODUCTION

At present, most urban rail vehicles in our country have been air-conditioned. As an important equipment to improve the indoor environment, air-conditioning equipment will suffer from various failures during its operation, such as refrigerant leakage, compressor wear, and condensation fan overload protection, condenser and evaporator are clogged, etc., if not dealt with in time, the air conditioning operating parameters will deviate from the normal values for a long time, the cooling capacity of the entire unit will decrease or no cooling will be caused, which will have a certain impact on vehicle operation and maintenance, and affect the passenger comfort[1]. In view of this, this article will analyze the causes of air conditioning and refrigeration system failures and propose corresponding maintenance measures, aiming to reduce the occurrence rate of failures and reduce maintenance costs during the operation of the air conditioning and refrigeration system.

## 2 OVERVIEW OF AIR CONDITIONING AND REFRIGERATION SYSTEMS FOR URBAN RAIL VEHICLES

The air-conditioning and refrigeration unit of urban rail vehicles includes components such as a compressor, axial flow condensing fan, dryer, evaporator, condenser, expansion valve and high-pressure protection device, forming a closed refrigeration cycle system that works together to exert the refrigeration effect. It is an important system to ensure the comfort of the internal environment of urban rail vehicles[2-3]. In addition, the evaporator element in the refrigeration system can also reduce the humidity of the air in the environment. Under normal circumstances, in order to avoid large changes in the environment of the entire carriage due to the failure of the air conditioner in one carriage, urban rail vehicles usually install an air conditioning unit at the front and rear of each train. The air-conditioning units of urban rail vehicles use evaporative compression refrigeration, which is liquid vapor refrigeration.

## 3 CHARACTERISTICS OF FAULT DIAGNOSIS OF AIR CONDITIONING AND REFRIGERATION SYSTEMS

The air conditioning and refrigeration system of urban rail vehicles is a complex whole composed of multiple subsystems. It is composed of main components such as evaporators, compressors, condensers, and some ancillary devices. The components are organically combined and operate in coordination with each other[4]. Any refrigeration system If the subsystem in the air conditioner fails, the air conditioner will not be able to perform its cooling function normally. The complexity of the refrigeration system determines that the causes of failures are also complex.

### 3.1 Complexity

There are many reasons for the failure of air conditioning and refrigeration systems, such as refrigeration cycle blockage, insufficient air volume, refrigerant leakage, excessive refrigerant charging, etc., which lead to many types of failures, such as the unit cannot cool or the cooling effect is poor, and the condenser condenses. Scale, evaporator failure, compressor failure, etc., the causes and phenomena are complicated[5].

### 3.2 Intersectionality

One fault cause of the air conditioning and refrigeration system of urban rail vehicles may produce multiple fault phenomena, or one fault phenomenon may have multiple causes. The causes and phenomena of faults generally show overlap.

### **3.3 Mutual Influence**

In the entire air conditioning and refrigeration system fault diagnosis process, characteristic parameters are an important reference basis, but a single characteristic parameter cannot be used to characterize the occurrence of the corresponding fault, because the occurrence of a fault usually causes changes in several parameters, and at the same time, a Changes in parameters will also affect changes in other parameters[6].

## **4 TYPICAL FAULTS OF AIR CONDITIONING AND REFRIGERATION SYSTEMS OF URBAN RAIL VEHICLES**

There are various faults in the air-conditioning and refrigeration system of urban rail vehicles during the entire operation process. Several common fault types are analyzed below.

### **4.1 The Air Conditioning Unit Makes Loud Vibration and Noise**

When urban rail vehicles are running, the air-conditioning unit vibrates and makes loud noises. After diagnosis, it is found that it is usually caused by the looseness of the return air inlet cover or the air-conditioning cover support rod and the noise generated by the vibration of the ventilator in the air-conditioning unit. An inspection and analysis of the replaced ventilator revealed that the main cause of the fan noise was minor damage to some ventilator motor bearings. For the problem of high vibration and noise of the air conditioner, the author believes that the following measures can be taken to solve it: first, strengthen the control of the fan quality; second, strengthen the maintenance procedures, regularly check the ventilator and air conditioner return air cover; finally, adjust the installation of the air conditioner cover support rod method and the locking method of the return air vent cover.

### **4.2 Refrigerant Leakage**

Refrigerant leakage failures are common in urban rail vehicle air conditioning and refrigeration systems. The air conditioning and refrigeration system components of urban rail vehicles are usually made of copper. Due to long-term operation, blisters and cracks may appear on the pipelines, which will eventually evolve into cracks. However, refrigerant leakage is mostly caused by system valve failure or poor welding of the evaporator and condenser pipelines of the refrigeration system. The refrigeration system pipelines need to be repaired in time and recharged with refrigerant in accordance with specifications.

### **4.3 Evaporator and Heat Exchange Coil are Clogged**

On urban rail vehicles, after the evaporator of the air conditioning and refrigeration system has been operated for a long time, the heat exchange coil will be blocked due to excessive dust or other pollution, which will affect the circulation of the refrigerant and the heat exchange effect, resulting in a reduction in cooling air volume and long-term Down, it will affect the function and life of the entire air conditioning system.

### **4.4 The Condenser is Scaled and has Poor Heat Dissipation.**

The compressor pressure failure of the air conditioning unit is not only related to the inlet air temperature, but also related to the cooling air inlet volume of the condenser. If the heat dissipation and exhaust air of the air conditioner condenser is blocked and the exhaust air volume is reduced, it will also cause poor heat dissipation of the air conditioner condenser, resulting in a high-pressure failure and shutdown of the air conditioner compressor during operation.

## **5 URBAN RAIL VEHICLE AIR CONDITIONING AND REFRIGERATION SYSTEM FAULT DIAGNOSIS SIMULATION SCHEME**

The various components of the air conditioning and refrigeration system of urban rail vehicles are closely related, work together and influence each other. During the diagnosis and simulation process, in order to ensure the singleness and pertinence of fault characteristics, if you want to find one of the fault characteristics, you must keep other components operating normally. The refrigerant leakage fault simulation method is as follows: Use FLOWMASTER to simulate the fault, mainly by changing the simulated refrigerant charge. When the air conditioning and refrigeration system fails, select the parameter with the most obvious change, that is, the parameter with the highest sensitivity to the fault. Find out the change rules between refrigeration system faults and characteristic parameters, analyze the characteristic

parameters of the refrigeration system, and finally determine the cause of the failure of the air conditioning and refrigeration system.

In the refrigerant leakage fault, the condensing wind speed is kept at 5 m/s, the evaporator air volume is 500 m<sup>3</sup>/h, and the compressor speed is 1 700 r/min. In order to simulate refrigerant leakage, the original refrigerant 15 kg is gradually reduced. Each single fault includes 6 different fault degrees, the leakage degrees are 10%, 20%, 30%, 40%, 50% and 60% respectively. As the refrigerant charge gradually decreases, the corresponding refrigerant leakage degree It also gradually becomes serious. The suction pressure and discharge pressure parameters of the compressor both decrease and change significantly. This solution shows that both the suction pressure and discharge pressure are sensitive to refrigerant leakage; contrary to the pressure parameters of the compressor, in Under the influence of refrigerant leakage, the suction temperature and discharge temperature of the compressor both show an upward trend. It can be seen that the temperature parameters are also sensitive to refrigerator leakage. The leakage of refrigerant leads to insufficient liquid supply to the evaporator and a decrease in cooling capacity. At the same time, the system's heating energy efficiency ratio COP also decreases significantly, indicating that the cooling capacity is weakened when refrigerant leaks.

## 6 CONCLUSION

Of course, there are many faults that occur during the operation of the air conditioning system, and it is impossible to analyze and summarize all types of faults. This article mainly discusses the characteristics of fault diagnosis of the air conditioning and refrigeration system of urban rail vehicles based on the working principle of the air conditioning and refrigeration system of urban rail vehicles, and Several common fault phenomena and causes of air conditioning and refrigeration systems of urban rail vehicles are summarized, and a simulation scheme for refrigerant leakage fault diagnosis of air conditioning and refrigeration systems is particularly listed.

At present, my country does not have relatively mature and complete system diagnostic software in the field of HVAC and refrigeration. There is also little research on fault diagnosis of the air conditioning and refrigeration system in the carriage. There are still many problems in fault diagnosis of the air conditioning and refrigeration system of urban rail vehicles. Some studies use VC++6.0 language to edit the human-machine interface of air conditioning and refrigeration systems. They have a rich, expert-level knowledge system, and can also reason about some uncertain fuzzy information, and can intuitively query common fault information. Improve work efficiency. In future research, more analysis and research on this diagnostic system can be carried out.

## COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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