

Increasing the Reliability of Ship Refrigeration Units Through Permanent Control of Refrigerant Leakage

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Abstract: Refrigerating plants on board are used in refrigerating holds, gas carriers, and refrigerating chambers for receiving and maintaining low temperature, for conditioning air at all seasons, and other purposes. Separate elements of the refrigerating machines are cooled by fresh or seawater. That's why the metal should be corrosion-proof. The installation should be lightweight, stand out with simple maintenance, be cheap, and economical.

It is necessary to keep not only the main operating parameters, but also to control the operation of its separate elements. It is important that the refrigerant does not have leakage of freon, which will cause the poisoning of the service personnel and ecological damage. Various kinds of sensors are used, which react to the leakage of freon. Practically, their acting is expressed by activating of alarm.

The purpose of this article is not only the discussion of activation of the signaling system of the refrigerating installation, but depending on the situation freon supply valve shut-off system and after a certain delay (if there was a delay in involving the personnel to eliminate the faculties), to discuss the action of shut off system of installation.

Keywords: refrigerating plant, freon, signaling system.

1. Introduction

For improving the reliability of the operation of the refrigerating machines, it is provided the duplicating of the machinery is provided without shutting off the operation for carrying out the repair work. The ship's refrigeration equipment may include one or more/duplicated refrigerating machines, installations for various duties and systems, devices for controlling, protecting, signaling, automated controlling systems, and adjusting devices, which provide the normal operation of the refrigerating machines (Hafner Ing. A., Gabriell C.N. & Widell K, 2019).

According to the temperature mode, refrigerating ships are divided into low temperature, which are designed for frozen products, universal, any kind of cargo, and fruit carriers, with induced ventilated compartments.

It's important not to allow a leakage in the refrigerating plant – leakage of freon (British Refrigeration Association Action Group, 2018). The leakage of freon has effects, such as reducing cold

productivity, which is followed by damage to perishable goods and cargo (Running parts will make an uncharacteristic sound; Oily stains and damages on refrigerator components; generation of harmful emissions that are harmful to the environment and human health).

To avoid these problems, it's necessary to check regularly all refrigerating plants for detecting mechanical damage and corrosion spots. Also, regularly must be checked the freon pressure, according to the manufacturer's instructions must be carried out its filling and adding (European Commission, 2006 & European Commission, 2014).

To avoid the freon leakage signaling system must be used, which will fix the pressure drop in the refrigerating system (НПО «РУСХИМПРОМ», 2026).

Locating the leak and responding to it promptly remains a problem.

Prolonging the time of freon leakage may result in serious environmental damage and a reduction in the cooling capacity of the unit.

Under the influence of ultraviolet radiation, the chlorine atom begins to separate the freon molecules, remains in particles, and starts rusting.

It results in new radical chlorine particles being formed, which interact with the ozone layer in the air and enter a chemical reaction. This impact is a prerequisite for the depletion of the ozone layer in the atmosphere. If damage occurs frequently, it can cause ozone holes, global warming, and greenhouse gas emissions.

Based on the above, all measures aimed at reducing the leakage are essential.

2. Main part

The research discussed in the article aims to reduce losses caused by malfunctions during the operation of refrigeration equipment, developing an additional signaling system for reducing emissions. Based on the signal recorded during the usage of pressure relays, not only should the alarm system operate, but also the supply chain of freon should be affected by the lockdown. If the leakage from the damaged outlet continues, the control system must ensure that the unit is stopped.

To achieve the research goals, an alarm and refrigeration unit freon supply valve control system should be created.

The operation of the compressor is evaluated by controlling measuring instruments, by its physical condition, with the sound of working nodes, temperature of various parts, oil, refrigerant pressure, temperature, and level.

Operation of the piston compressor is accompanied by the rhythmical knock of suction and discharge valves. A malfunction of the suction and discharge valves is indicated by a rapid increase in pressure on the stopped compressor. Also, looseness of the suction and discharge valves indicates an increase in temperature of the compressor (when there is no cause). Running parts in operating machinery emit a characteristic sound that changes with the working conditions of the nodes.

With the change of pressure, meaning it's possible to detect the freon leakage, and with the alarm signaling and control system, provide timely detection and stopping of the leakage.

For detecting the freon leakage, the transferring sensor FROI -24/220 (MRS Elektronik, 2026) is used. Its operating principle is based on a change in the electrical conductivity of a lead oxide semiconductor layer, as a result of the adsorption of a controlling gas on its surface.

The selective property of the sensor is ensured by the presence of regulating additives in the semi-permeable membrane. The micro heater is used to increase the speed of reaction. The gas sensor used in the transmitter provides high sensitivity to the concentration of freon in the air at the level of the tenth part of ppm level. The transmitter gives a sound or light signal. The research team suggests that the technical personnel's response to the alarm delay adds to the engine of the freon propulsion system a blocking signal, which will activate after a short delay of time by disconnecting the switching off normally closed contact of the **KM** contractor.

FR01-24/220 sensors' correct operation during technical work is checked in three ways:

1. Using the ethanol steam
2. Using the freon leakage simulator
3. Using the complex of calibration based on R134A-air mixture freon (1000 ppm concentration).

Under the basis on the developed principal scheme (Fig. 1) is possible to provide correct operation of the sensor. Considering that the aim of the researchers is the improvement of the existing controlling system, which is connected with the total change of the system, it will be easy to implement in existing operating systems.

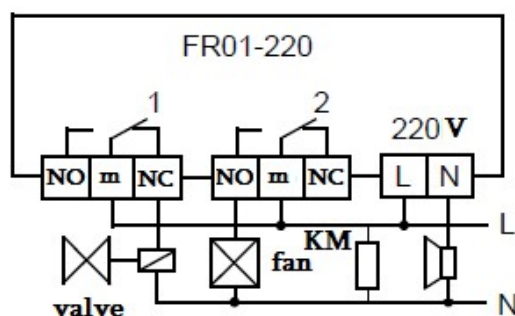


Fig 1. Freon propulsion system engine Blocking signal circuit diagram.

As we have already mentioned, the problem is urgent and concerns not only the ship's refrigeration units, but also all refrigeration units on land. The number of the latter is very large, and the result obtained by controlling the leakage of freon in each of them, even if the volume is small for one device, will contribute to solving a very large ecological problem in total.

3. Conclusion

In addition to the alarm and control system, the corresponding relay-contactor in the drive control circuit for locking the coolant supply valve and shutting down the refrigeration unit will be activated to stop emissions on time.

The development appropriate alarm scheme ensures the timely elimination of the freon leakage, which is one of the most important tasks among the malfunctions of the refrigeration units.

Timely detection and elimination will help to reduce emissions, which will have a positive impact on the ecosystem.

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