

INSULATION TESTING APPARATUS OF
A REFRIGERATING MACHINE

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The present invention relates to an insulation testing apparatus of a refrigerating machine such as a refrigerating container for marine transportation which is required to be subjected to an electric insulation test repeatedly in a short time.

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For example, in a refrigerating machine (hereinafter referred to as a refrigerating unit) for a marine container which is one of apparatuses utilizing refrigeration, inspection is conducted for a refrigerating system thereof prior to loading of cargoes. This inspection is implemented for diagnosis of important elements of the refrigerating system in advance in order to transport the expensive loaded cargoes to a destination thereof without hindrance under severe environment and this operation is named PTI, that is, Pre-Trip Inspection.

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In the PTI for the refrigerating container, a controller composed of a microcomputer performs the diagnosis of control functions, sensors, actuators, refrigerant systems, hydraulic systems and the like.

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As other important PTI, there is an insulation

test for electric devices. This insulation test is performed for each refrigerating unit by an operator. The PTI is performed for many (several hundreds) refrigerating units at a time prior to loading cargoes onto on a container ship at a wharf for the container and accordingly automatization of the PTI using automatic diagnosis function is required.

Fig. 3 shows an example of a control circuit of a conventional refrigerating unit. In the insulation resistance test of the conventional refrigerating machine shown in Fig. 3, a no-fuse breaker 21 constituting a main switch is turned off to stop the operation of a controller 22 so that contacts 23a to 26a of electromagnetic switches 23 to 26 are opened. An insulation resistance of a compressor 28 is measured by bringing a positive pole 27a and a negative pole 27b of a contact maker of an insulation-resistance tester 27 into contact with a load connecting terminal of the electromagnetic switch 23 and an external casing (at the same potential as the grounded potential) of a motor 28 of the compressor, respectively. Insulation resistances of other electric devices mainly constituting the refrigerating machine such as, for example, blower 29, a motor 30 and a heater 31 are also measured in the same manner.

As described above, since the conventional insulation resistance test of the refrigerating machine is

made using the insulation-resistance tester for each electric device by operator, it is troublesome and requires much time. Further, when many refrigerating units must be inspected, the insulation resistance test impedes reduction
5 of operation time greatly.

The present invention has been made in view of the above problem and an object of the present invention is to
10 provide an insulation testing apparatus of a refrigerating machine which can solve the problem in the prior art.

In order to achieve the above object, the present invention is configured as follows.

The insulation testing apparatus of the
15 refrigerating machine including electric devices mainly consisting of a compressor, a blower and an electric heater is characterized by the provision of means for generating a high dc voltage to which a series resistor is coupled, switching means for disconnecting each of said electric
20 devices from a drive power supply thereof and applying said high voltage between a power connection terminal of each of said electric devices and ground through internal power lines in the refrigerating machine successively and separately and testing means for testing an insulation
25 resistance of each of said electric devices in accordance

with a current flowing between said power connection terminal and ground.

According to the present invention, a controller of the refrigerating machine has a function for separating external power lines and internal power lines within the apparatus and includes the high voltage generator identical with that of a conventional insulation-resistance tester. The controller functions to apply an output of the high voltage generator between the internal power lines and ground and further successively opens and closes electromagnetic control switches to apply the high voltage to each of electric devices separately. The controller serves to detect a current flowing through the circuit applied with the high voltage and compare the detected current with a reference value so that insulation failure of each of the electric devices can be decided.

According to the present invention, the insulation resistance test in PTI which has heretofore required much time can be easily automatized and can be combined with self-diagnosis function of the controller to greatly reduce labor for the PTI.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a circuit diagram of a controller of a refrigerating unit having automatic insulation testing

function;

Fig. 2 is a circuit diagram of a closed loop for insulation test in Fig. 1; and

Fig. 3 is a circuit diagram of a controller of a conventional refrigerating unit.

Fig. 1 shows a configuration of an embodiment of the present invention and Fig. 2 shows a closed loop circuit for insulation test.

In Fig. 1, the present invention is applied to a refrigerating machine for a marine container. A no-fuse breaker 21 is closed to operate a controller 22, which controls control relays 23, 24, 25 and 26 for a compressor motor, a condenser fan, an evaporator fan and a heater, respectively, to thereby perform refrigerating operation. In Fig. 1, numeral 1 denotes a start switch for self-diagnosis. When the start switch 1 is depressed to be turned on, the controller 22 starts a self-diagnosis mode in which refrigerating operation is immediately stopped and a relay 3 for disconnecting an ac power source is operated so that its contacts 3a and 3b are opened and closed, respectively, and all other relays are turned off.

A relay 4 for short-circuiting an internal power supply circuit in the refrigerating unit is then operated to

close contacts 4a thereof so that three lines for three phases which are internal power lines in the unit are short-circuited with each other.

5 The relay 4 can not be operated when the relay 3 is off. When an impedance of each of the three lines is enough low, the short circuit by the contacts 4a of the relay 4 is not required. Subsequently, a relay 5 for applying a high voltage is operated to close contacts 5a and 5b thereof at an input side and an output side,
10 respectively, of a high dc voltage generator 6 to apply a high positive output voltage to an internal ac 200 voltage power line. A high negative output voltage is previously coupled to a housing (ground) of a container.

The compressor control relay 23 is now operated to
15 close contacts 23a thereof. Consequently, a current I_0 flowing through the high voltage generator 6 flows through a current detection resistor (R) 7 and a voltage E_0 generated across the resistor 7 is amplified by an isolation amplifier 8 to be applied to the controller 22. When an electric
20 circuit between the container housing and the power connection terminal of the compressor motor 23 is normal, a resistance therebetween, that is, an insulation resistance is sufficiently high and the voltage E_0 is sufficiently low. On the other hand, the insulation of the internal ac power
25 line in the refrigerating unit is estimated on the basis of

the voltage E_0 before operation of the compressor motor control relay 23.

The output voltage of the high voltage generator 6 is normally dc 500 volts identical with that of the conventional insulation resister tester.

The voltage αE_0 (where α is an amplification degree of the isolation amplifier 8) applied to the controller 22 is compared with a reference value E_m determined by the insulation resistance allowed by the compressor motor 23 and when the voltage αE_0 is larger than the reference E_m , it is decided that there is an insulation failure in the compressor motor 23 and an alarm indication lamp 9 is turned on.

When the controller has character indication function, a failed portion and an insulation resistance value are indicated.

Thus, the controller 22 can measure an insulation resistance of each of other electric devices successively in the same manner. For example, an insulation resistance of each of the condenser motor 29, the evaporator fan motor 30 and the heater 31 can be measured by operating the control relays 24, 25 and 26 separately.

A normal insulation resistance is 300 K Ω to 1M Ω and thus the high voltage current I_0 is 1.6 mA to 0.5 mA.

Accordingly, the high voltage generator 6 may have

a capacity of about 10 mA output at dc 500 volts. In a load including a semiconductor switch such as an inverter, it must be ensured that a withstand voltage of the switch is more than dc 500 volts.

5 A diode 10 is connected across the resistor 7 to prevent the isolation amplifier 8 from an excessive current when the insulation resistance is extremely low.

 While the contacts 3a of the ac power disconnection relay (MG1) 3 are normally closed in the
10 embodiment described above, normally opened contacts may be used to effect the same operation.



CLAIMS:

(1) An insulation testing apparatus of a refrigerating machine including electric devices mainly consisting of a compressor, a blower and an electric heater, comprising means for generating a high dc voltage to which a series resistor is coupled, switching means for disconnecting each of said electric devices from a drive power supply thereof and applying said high voltage between a power connection terminal of each of said electric devices and ground successively and separately and testing means for testing an insulation resistance of each of said electric devices in accordance with a current flowing between said power connection terminal and ground.

(2) An insulation testing apparatus of a refrigerating machine according to Claim 1, wherein said switching means comprises a self-diagnosis switch, a relay and contacts thereof for separating each of said electric devices from the drive power supply in response to operation of said switch.

(3) An insulation testing apparatus of a refrigerating machine according to Claim 1, wherein said switching means applies said high voltage to each of said electric devices by means of control relays and contacts of said control relays and can effect the switching by opening and closing of said contacts.



(4) An insulation testing apparatus of a refrigerating machine according to Claims 1, 2 or 3 wherein a voltage value across said series resistor generated by said current is compared with a reference value in said testing means for testing the insulation resistance, and further comprising means for indicating insulation failure when the insulation failure is decided in said testing means.

(5) Insulation testing apparatus of a refrigerating machine, substantially as herein described with reference to Figures 1 and 2 of the accompanying drawings.
