HVAC&R
Skills Workshop

MODULE 109

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TESTING FOR ELECTRICAL FAULTS IN REFRIGERATION SYSTEMS

Skills summary

What?
A guide to testing for electrical faults in refrigeration systems and troubleshooting common problems.

Who?
HVAC&R apprentices, teachers, lecturers, contractors, installers, mechanics/technicians and maintainers.

The first consideration when working on electrical equipment should be for the safety of yourself and other users. The major risk is of leakage to earth through the insulation, which is compounded if the earth lead is broken, or just damaged or corroded.

As well as being dangerous, electrical faults can stop or reduce the efficiency of refrigerating systems. Using a range of standard testing instruments and following the procedures described below, it is possible to run practical tests and diagnose the problem.

Most manufacturers specify test procedures in their service manuals, and may also include a diagnosis guide and test charts, together with complete instructions as to the appropriate replacement or repair technique to be used.

This Skills Workshop covers the main service faults, dealing with refrigeration system faults as well as electrical faults where the one may be indistinguishable from the other, or is a direct cause of the other.

PREVENTATIVE TESTING

It is not generally known that a megohmmeter (or megger) can be used to indicate moisture inside sealed units, and so warn the service technician of potential seizure of the compressor or burn-out of the motor.

Because moisture is a ready conductor of electricity, while refrigerants and oils are dielectric (low conductors), a megger test between winding terminals and frame that shows a resistance of less than 1 megohm generally indicates the presence of moisture or the by-products of chemical action – mainly carbon.

An oil and refrigerant change, dehydration or the fitting of driers (preferably all three) will remove the immediate source of contamination and prevent rapid and complete breakdown of the system.

Of course, the reason for the original contamination must also be found, and corrective measures taken if necessary.

GENERAL SERVICE DIAGNOSIS

The following applies to commercial and domestic refrigeration.

1. Compressor will not run

Single-phase units:

(a) Check main supply for correct voltage; if no power, check fuses, switch and power plug for open circuit. Check refrigeration wiring for visible signs of break.

(b) Test thermostat or LP control for open circuit. If low-pressure control is open-circuited,

check for refrigerant pressure – do not short circuit unless system pressure is normal.

(c) Check for power to relay and motor overload; then check relay or overload for open circuit. Study relay circuit to ensure understanding of circuit. Do not short circuit overloads – look for reason for failure.

(d) Test compressor winding resistances against manufacturer's specification using ohmmeter (see Table 1 for examples), looking for open circuit, short to earth or shunted winding. Use megger to test for short to earth if main fuse is blown.

(e) Test capacitors for fault if motor tries to start but stalls (if capacitors are fitted).

(f) If no electrical fault can be found and compressor tries to start, compressor may be seized.

Three-phase units:

(a) Check supply on all three phases right through the circuit, using circuit diagram to assist.

(b) If unit has high-pressure or oil failure cut-out switches, check these also for open circuit, then find the reason for failure.

(c) Check contactor for open circuit; if overload circuit is open, find the reason. If coil is open-circuited, check that correct voltage is applied across coil (connection between one phase and neutral for 240V coil, and between two phases for 415V coil).

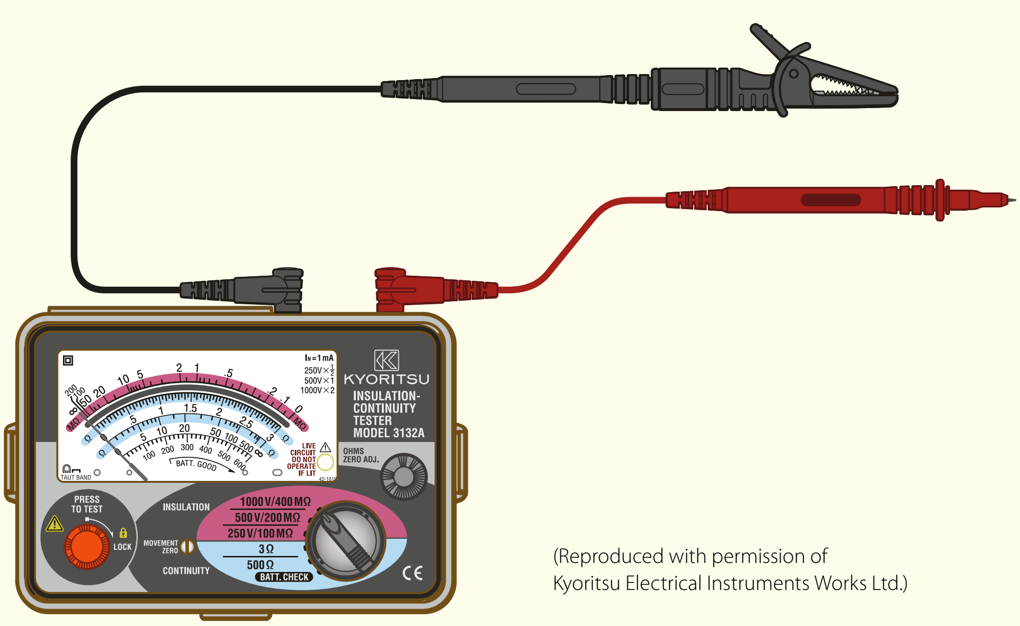

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Figure 1: Insulation continuity tester megger.

2. Compressor starts and stops quickly (short cycles)

(a) Check supply voltage for low or fluctuating voltage.

(b) Test motor control. If thermostat is the cause, replace before compressor and windings are damaged. If pressure control is the reason, check system pressures, and correct system fault, or adjust control differential to approved setting.

(c) Check amps and watts against name plate rating if compressor is cycling on overload. Look for reason for overload.

(d) Test motor windings, capacitor and relay for fault using ohmmeter, megger and capacitor testers.

(e) If unit is fitted with high-pressure cut-out or automatically resetting oil failure switch, check system pressures.

3. Compressor runs, but little or no refrigeration (automatic defrost models – where electrical fault indicated)

(a) Test defrost timer circuit to ensure that timer is not stuck on defrost.

(b) Test electric defrost heaters for short circuit to earth. Use megger.

(c) Check defrost solenoid (if hot gas defrost) – if pipes in and out are hot, then solenoid valve is leaking. Check coil for power and short.

(d) If cooling depends on evaporator fan, check fan operation.

If fault is not electrical, recheck refrigeration cycle for faults such as worn compressor, leaking compressor valves, shortage of gas or overcharge etc.

4. Evaporator(s) blocked with ice

(a) Check defrost timer operation and wiring circuit.

(b) Check door switch if it controls fan operation.

(c) Check defrost solenoid for open circuit or loose wire.

(d) Test setting on thermostat or low-pressure control. Reset correctly to manufacturer's specification. If off-cycle defrost is required with pressure controller, leave the compressor off until ice melts off and then set pressure control to cut in at the pressure ice melts.

(e) If ice has accumulated in the drain pan, test drain pan heater for open circuit.

(f) Check fan operation for intermittent electrical fault, tight bearings.

SEALED MOTOR WINDING RESISTANCES

Two problems arise when sealed-unit motors are to be tested for fault. They are:

(a) Identification of start, run and common terminals

(b) Determining the correct resistance for each winding.

To assist in determining correct resistance, Table 1 has been compiled from service manuals for models with power ratings from 1.1kW to 3.75kW. If the particular winding you require is not included, and information is not available, some estimate may be made from the figures quoted for the equivalent power.

Table 1 gives a useful checklist which can be applied to sealed as well as open motors.

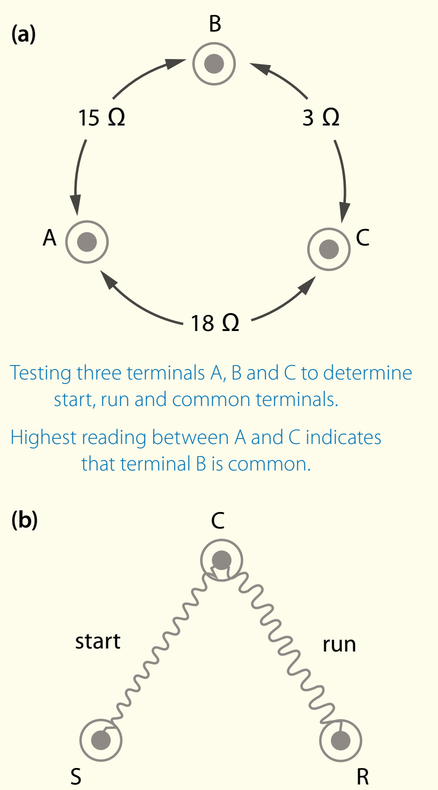
To confirm your diagnosis, it will be necessary to carry out full testing procedures as previously listed, with reference to the specified current and power consumption or winding resistances.

HOW TO IDENTIFY START, RUN AND COMMON TERMINALS

Sealed unit windings are brought to three external terminals, one of which is common to both start and run windings, while the other two terminals connect to the individual windings.

To identify terminals, an ohmmeter is essential and the procedure is as follows (refer to Figure 2).

1. Connect the ohmmeter across two of the terminals (eg A and B) and write down the resistance.
2. Connect the ohmmeter across terminals A and C and then across B and C and write down these resistances.
3. Note which two terminals show the highest resistance – the other terminal is common.
4. If terminal B is common, compare the resistance between B and A with that between B and C, the lower reading indicating the run winding terminal and the higher reading indicating the start terminal.



(a) Testing three terminals A, B and C to determine start, run and common terminals.

Highest reading between A and C indicates that terminal B is common.

(b) Result of test indicating internal connections of start and run winding.

Start winding has higher resistance than run winding.

Figure 2.

Example:

Resistance A–B = 15 ohms
Resistance A–C = 18 ohms
Resistance B–C = 3 ohms

then, highest resistance is A to C, so:

common terminal = B
run terminal = C
start terminal = A

Note: That the highest reading must be the sum of run winding resistance plus start winding resistance because the two windings are being measured in series. Figure 2 again shows the relationship of windings to terminals.

SUMMARY OF HERMETIC COMPRESSOR TROUBLESHOOTING

Handy tips to prevent wrong diagnosis

1. Thoroughly test sealed units before condemning and replacing. Remember that there are many other possible reasons for breakdown.
2. PSC motors may stall due to liquid flood-back reducing lubrication, or overload. Test by fitting a relay and start capacitor before removing.
3. A good multimeter is essential for sealed unit testing, particularly when shunted windings are suspected.
4. A megger is the only satisfactory instrument for testing for short to earth or ground.
5. Do not test compressors when they are hot. Internal overloads in motors may remain open-circuited for up to three hours before resetting. To be sure, disconnect power and leave motor to cool down.
6. If sealed units will not start, test the mains voltage. Supply faults can result in voltages too low to provide necessary starting torque. Also, beware high voltages, which will cause high current and burn-out.
7. If compressors will not start yet test electrically correct, test the system pressures – suction and head.

Handy tips to prevent repeated compressor failure

1. If a system is contaminated due to moisture or acid from previous failures, only complete and thorough cleaning and dehydration will prevent repeat failure.
2. If a compressor is found to be faulty, find the reason. Because the fault may re-occur and lead to another breakdown, test for:
   (a) Defective relay, capacitors, motor protector, heater thermostat, reversing valve or check valve; leaking refrigerant control; blocked valve or filter; or wiring errors.
   (b) Operating conditions exceeding design limits, such as excessive load (high ambient, high suction temperature).

			Resistance in ohms at stated temperatures		
kW	**Model**	**Winding**	**15°C**	**25°C**	**35°C**
1.1	Single-phase	Start Run	5.8 1.5	6.2 1.6	6.6 1.7
1.1	3-phase – Model A	Across two terminals	11.8	12.6	13.4
1.1	3-phase – Model B	Across two terminals	7.7	8.2	8.8
1.3	Single-phase – Model C	Start Run	6.0 2.0	6.0 2.0	7.0 2.0
1.3	Single-phase – Model D	Start Run	5.0 1.75	6.0 2.0	7.0 2.0
1.3	3-phase	Across two terminals	5.4	5.8	6.15
1.5	Single-phase	Start Run	3.9 1.4	4.2 1.5	4.45 1.6
1.5	3-phase	Across two terminals	6.8	7.2	7.7
2.25	3-phase	Across two terminals	3.0	3.2	3.4
3.0	3-phase	Across two terminals	3.2	3.4	3.6
3.75	3-phase	Across two terminals	2.7	2.8	2.9

Note: Different resistances for similar power result from the different design characteristics of particular models – which require specific relays, start and/or run capacitors for correct operation.

Table 1: Resistance in ohms at stated temperatures.

PULLOUT

(c) Poor maintenance resulting in blocked air-cooled condenser or faulty fan, scaled water-cooled condenser, faulty water pump, incorrect direction of rotation of evaporator or condenser fans, blocked air filters or cooling of motor-compressor.

3. Correctly charge the system according to the manufacturer's specification. Capillary systems must have the exact charge as set down by the manufacturer. If the exact charge cannot be weighed into the system, or measured from a dial-a-charge cylinder at the correct temperature, the system should be charged to approximately 3K subcooling at the condenser at design operating conditions.

4. Particularly on air conditioners, return air filters must be fitted and maintained. Blocked filters result in low suction pressures and flood-back of refrigerant to the compressor. Without filters, the evaporator coils will block up with similar results. Check centrifugal fans for build-up of dirt inside blades.

5. Prevent short-cycling of compressor on and off by ensuring correct airflow and correct location and setting of thermostat or pressure control, with correct refrigerant charge and supply. Motor life is greatly affected by the number of starts. Large motors may be permitted only three starts per hour.

6. Ensure fuses are correctly sized for the load. Over-fusing greatly increases the damage resulting from electric faults, and is the major cause of fires resulting from electrical breakdown.

7. Ensure cleanliness of the highest order during installation and service. Keep dirt and copper filings out of the pipework and equipment, use oil from sealed containers, purge through with dry nitrogen when welding, evacuate with high-vacuum pump drawing on both sides of the system through large lines, replace old oil and fit appropriate filter-driers.

OPEN-TYPE MOTOR SERVICE

Open or serviceable electrical motors suffer from the same electrical problems as the motors of sealed units, but there are additional mechanical problems to do with lubrication, bearing wear and the mechanical switch gear used instead of the electrical relay to open-circuit the start winding.

MOTOR FAILURE AND PROBLEMS

Refrigeration motors fail for a number of reasons, some of which are:

- Low voltage or high voltage – check name plate rating against supply.
- Phase unbalance for three-phase – unbalance should not exceed two per cent at any time.
- Breakdown of unit's electrical winding insulation. On sealed units, a major reason is system contamination.
- Insufficient ventilation or cooling suction vapour. Many sealed motors will burn out if operated on a vacuum. With some refrigerants, cool suction vapour at normal pressures is essential to prevent overheating.
- Compressor overload or tightness – refrigeration system faults.
- Faulty winding. Factory errors or damage are rare but possible, particularly with rewinds.
- Faults in relays, capacitors or wiring connections.
- Insufficient lubrication or bearing tightness. For sealed units, correct system oil levels must be maintained without dilution by liquid refrigerants or contamination.

CONCLUSION

The understanding of component operation, the ability to use test meters and the skill of interpreting circuit diagrams are all vital to the service technician when fault finding on refrigeration and air conditioning systems. However, there is a fourth important ability that enables the others to function efficiently: that is, *the use of logical thought.*

When you start on any job, take the time to analyse the data that you already have at hand (e.g., visual and audible information). Find the logical starting point for your testing procedure, and work from that point step by step. When you find and repair a fault, make sure that you have also repaired the cause of the fault and not just the symptom. Also, make sure that the fault you have repaired is the only fault or potential fault in the system. ■

MORE INFORMATION

This month's Skills Workshop has been taken from Australian Refrigeration and Air-Conditioning Volume 1, by Graham Boyle, F.AIRAH.

Next month: Flammable refrigerants