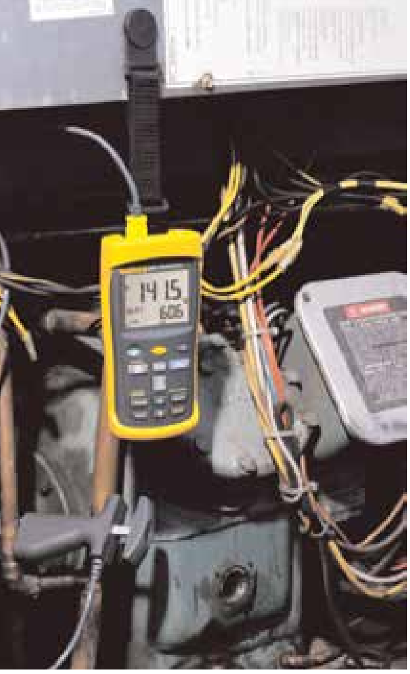

Finding problems in HVAC/R refrigeration cycle

By D Opperman, Comtest

Valuable advice on troubleshooting a compressor, associated problems that can cause a system to fail prematurely, proper methods of diagnosing and repairing system problems, rather than just their symptoms.

The core of a refrigeration system is the compressor, which is designed to pump cool refrigerant gas from the evaporator into the condenser. To accomplish this task the compressor raises the temperature and pressure of the low superheated gas, forcing it into the condenser. The compressor should never pump liquid. This will not only damage the compressor, but could create a potential safety hazard.

If the refrigeration compressor is not properly maintained, it malfunctions or stops running - at which time it gets replaced and the system is back and running - temporarily. Often the culprit is not the compressor, but a system failure or design problem with accessory equipment which kills the compressor prematurely.

Measuring compressor suction and discharge pressure

Both the suction and discharge pressures at the compressor are normally measured with a standard set of refrigeration gauges. However, this article will explain how to measure both pressures on the suction and high side of the system with the digital multimeter (DMM) and a pressure/vacuum module, with or without the standard gauges. If the gauges are left on the system and used in conjunction with this test, the module will verify the accuracy of the standard manifold gauges.

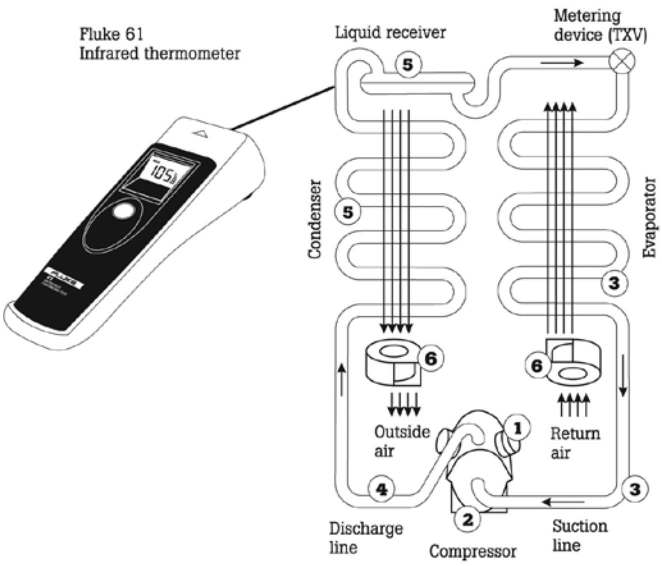

Figure 1: Infrared thermometer.

To measure the pressures on a DMM in conjunction with the standard manifold gauges, take the following steps:

- Attach the pressure/ vacuum module hose fitting to the refrigerant service hose on the manifold gauge set, usually the yellow hose
- Attach the pressure/ vacuum module to a DMM and set the module function to cm/in Hg
- Install the blue and red hoses to the suction side and high side of the system as during any normal service process

To read the suction pressure on the DMM, open the blue handle on the manifold gauges. This puts the system suction pressure into the pressure/ vacuum module. Read the pressure on the digital readout and compare it to the gauge pressures. Do not be alarmed if the pressures do not match exactly. Certain modules are typically much more accurate than a standard set of refrigeration gauges. To read the discharge pressure on the DMM, close the blue valve on the gauges and open the red handle on the manifold gauges. This puts the system discharge pressure into the module. To remove the module, simply reverse the process followed when installing the unit.

Be sure to close the high side port of the gauges first, and remember to remove the refrigerant from the high side gauge by allowing the compressor to run and pull excess refrigerant into the low side of the system.

To measure the pressures on the DMM and pressure/ vacuum module without installing the manifold gauges, take the following steps:

- Attach the module hose fitting to any standard refrigerant service hose
- Connect the refrigeration hose to the service port on the compressor
- Open up the service port and read the refrigerant pressure directly on the pressure/ vacuum module.

Read one pressure at a time using a single pressure vacuum module, and record the suction or discharge pressure one at a time. If using a DMM meter with a minimum/ maximum (min /max) feature, record the suction pressure as the minimum value and then the discharge pressure as the maximum value.

To remove the pressure/ vacuum module, simply reverse the process followed when installing the unit. Take care when removing the high side port of the gauges as it can be under very high pres-

Abbreviations

DMM –	Digital Multi-Meter
HVAC/R –	Heating, Ventilating, and Air Conditioning/ Refrigeration
PT –	Pressure Test

sure. To minimise refrigerant loss, learn to practise safe refrigerant handling habits when removing the module from the high side of the system. This includes shutting off the compressor prior to gauge removal and allowing the pressure to equalise. When removing the gauge from the low side of the system it is not necessary to first shut down the compressor.

Troubleshooting the compressor discharge line temperatures

Pressure and temperature are fundamental tests that must be performed to determine what is happening inside the compressor. It is important to know the correct methods for checking the refrigerant superheat and sub-cooling at the compressor [1]. To measure the temperature of the compressor, take the following steps:

- Use a pipe clamp accessory with a DMM to measure the discharge line temperature at the discharge of the compressor. High temperatures above 275 - 300°F (135 - 148°C) will slowly destroy the lubricant qualities as well as the performance of the compressor. These high temperature conditions can be caused by high condensing temperatures/ pressures, insufficient refrigerant charge, non-condensables within the system, high superheat from the evaporator, restricted suction line filters, or low suction pressure. These conditions cause the compressor to have a higher than normal compression ratio, work harder, generate hotter internal hermetic motor windings, and as a result, cause compressor wear, fatigue and failure.

A temperature survey is a critical part of the service technician's job. A quick check of a system's components not only helps to diagnose troubles but also allows failures to bed anticipated by regular monitoring of critical temperatures. Use an infrared thermometer to do a quick survey of:

- Compressor head temperatures
- Compressor oil sump temperatures
- Evaporator coil and suction line temperatures
- Discharge line temperatures
- Condenser coil and liquid line temperatures
- Fan motor temperatures.

With an infrared thermometer a refrigeration system can be surveyed quickly by scanning the temperatures of various components. While touching each of the components often does this, a non-contact infrared tool is faster. By keeping careful records it is possible to detect trends that indicate impending failure. This allows for keeping the system in top condition - avoiding costly failures.

IR instruments read best when measuring an object with a dull (not shiny) surface. If the surface is shiny, dull it with black markers, non-gloss paint, masking tape or electrical tape.

Recording a temperature overnight

To check refrigeration system performance, it is often useful to record temperatures in the refrigerated space. This makes it possible to detect problems that may go unnoticed with a single system check.

For instance, in a refrigerated space it is important to ensure that temperature variations are minimised. Temperature variations may result from changes in load or ambient conditions that occur over periods of time, so constant monitoring is called for. By recording min/ max temperatures in key locations over a period of time, air circulation and refrigeration capacity will meet the application requirements.

Digital recording thermometers record min/ max temperatures over extended periods of time. Temperature values can be viewed at anytime by pressing the view button (recording still continues). If the 'hold' button is pushed, the recorded min/ max values are saved and recording stops. The data is saved until the user selects a different input or turns off the instrument. Some DMM scan also measure min/ max of a single temperature, plus they offer the benefit of a 100-hour relative time stamp to record when the min/ max occurred. When selecting a digital recording thermometer look for a model that can record hundreds of temperature samples for precise measurement. Additional features that are helpful include a time stamp feature, operator interval settings and dual channels to record two temperatures at the same time. With this type of device temperature difference across a coil can be recorded for extended periods of time. This feature is especially handy for troubleshooting erratic problem areas of the HVAC equipment where time limitations do not allow the technician to wait until the problem occurs.

Compressor valve performance test

To test small hermetic and semi-hermetic compressors used for medium and low temperature applications, the following method can be used to test for internal valve leakage *(see Figure 2)*:

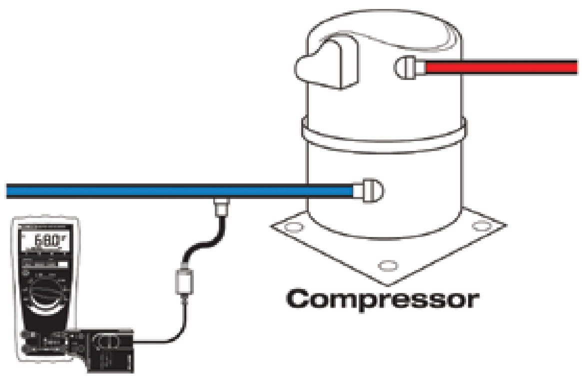

Figure 2: Use a multimeter and a pressure module to quickly and accurately determine suction pressure.

- Attach a pressure/ vacuum module to a DMM and set the module to cm/in Hg
- Connect the module at the suction line service port

- Close the compressor off from the low side of the system by front seating the suction service valve
- Run the compressor for two minutes
- Turn off the compressor and observe the reading

The compressor should have pulled down to at least 16″ (410 mm) of Hg. If the vacuum reading starts weakening toward 10″ (254 mm) of Hg vacuum, the discharge valves of the compressor may be leaking and will probably need to be replaced. If the compressor does not pull a vacuum below 16″ Hg, the suction valves are weakening and may need to be replaced. If the compressor is welded or hermetically sealed and these conditions exist, a new compressor is the only possible remedy.

Whenever replacing a compressor with faulty valves, be sure to diagnose the complete refrigeration system before and after a new compressor is installed to avoid repeated compressor failures.

Troubleshooting compressor electrical motor faults

A clamp meter is a great tool for troubleshooting electrical motor faults, especially meters designed to accurately measure both ac voltage and ac current. These meters allow current to be measured without breaking into the electrical circuit. A compressor failure is often caused by an electrical fault. To check the compressor for electrical problems, remove the electrical terminal cover and check the following external connections.

- Check line voltage at the load centre with the compressor off. Low line voltage causes the motor to draw more current than normal and may result in overheating and premature failure. Line voltage that is too high will cause excessive inrush current at motor start, again leading to premature failure
- Check line voltage at the motor terminals with the compressor running. The voltage should be within 10% of the motor rating
- Check running current. The readings should not exceed manufacturers full load rated amps during heavy load periods. Low amps are normal during low load conditions. Excessive high current maybe due to shorted or grounded windings, a bad capacitor, a faulty start relay, or an indication of excessive bearing fatigue

When performing electrical measurements on compressors with internal thermal motor protection devices that have been running extremely hot, be sure to give the compressor time to cool down prior to the electrical test. This will allow the device to reset to its normal position.

Troubleshooting compressor electrical motor failures caused by refrigeration system problems

Occasionally defective compressors with electrical winding failures are diagnosed by a service technician as caused by an electrical system problem. However, mechanical system failure or inferior installation and service practices often cause compressor electrical problems. These problems include:

- Poor piping practices resulting in oil not adequately returning to the compressor during the run cycle
- High discharge temperatures creating acids in the oil
- Insufficient air flows across the evaporator and condenser coils.
- Extremely low suction pressures
- Liquid refrigerant flooding back into the compressor

Diagnosing these refrigeration system problems and avoiding compressor failure can be done effectively using DMMs, clamp meters, digital thermometers, pipe clamps, infrared thermometer and pressure/ vacuum modules.

> *Like the human heart, the refrigeration compressor needs to be properly maintained and requires periodic inspection and testing. Unfortunately, the compressor is often ignored until it malfunctions or simply stops running.*

These are simple procedures to diagnose refrigeration problems:

- Compressor bearings can fail or lock up due to poor piping practices, which causes oil clogging in the system and results in insufficient oil return to the compressor. If the bearings don't lock-up and continue to wear during these conditions, the rotor will lower into the stator housing, shorting out the windings. To diagnose this problem, measure the compressor amps. They should not exceed the manufacturer's full load ratings. Worn bearings will cause higher than normal amps. Inspect the oil level via the compressor sight glass. If there is no sight glass, use the infrared thermometer to measure the sump of the compressor housing. The oil level can be detected with the temperature probe. The sump temperature will be different on the compressor housing at the oil level.

Whenever an oil problem exists due to poor piping practices, the correct remedy is to fix the piping, not to continue to add more oil to the system.

- High discharge temperatures are caused by high head pressures or high superheat. The compressor discharge line can be measured quickly using the infrared thermometer on a dull section of pipe. Measure the discharge pressure using a pressure/vacuum module. Convert the refrigerant pressure to temperature and compare it to the ambient air temperature. If there is a temperature difference greater than 20 - 30°F (11-17°C), there are either non-condensable gases in the system or restricted airflow across the condenser.

Temperature differences will vary due to original manufacturer's design and efficiencies.

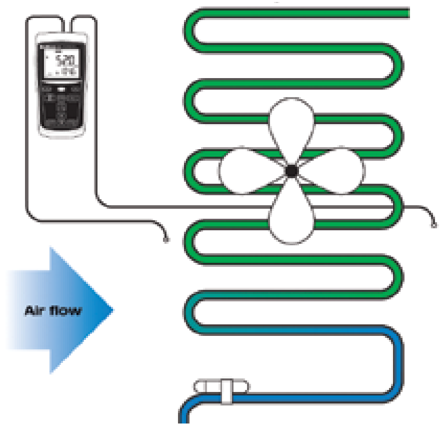

Figure 3: Record evaporator temperature differences as well as min/ max temperatures with a digital thermometer.

- Check for insufficient airflows across the evaporator using a digital thermometer (*see Figure 2*). Place a bead thermocouple on the discharge side of the coil and on the return side of the coil. Record the temperature difference on the air conditioning unit - expect about 18 - 22°F (10 - 12°C) temperature difference; on refrigeration units expect about 10 -15°F (5 – 8,5°C) temperature difference.

Temperature differences may vary depending upon initial design and humidity requirements.

- Extremely low suction pressures can be checked using the pressure/ vacuum module and the DMM. Install it at the compressor and record the suction pressure. Convert the refrigerant pressure to temperature using a pressure temperature (PT) chart. Measure the return air temperature before the evaporator. Compare the refrigerant temperature to the desired evaporator return air temperature. On air conditioning units, expect about 35 - 40°F (19 - 22°C) temperature difference and refrigeration units expect about 10 - 20°F (5 - 11°C)
- Check for liquid refrigerant flooding back to the compressor by determining the superheat using the pressure/ vacuum module and pipe clamp, along with the DMM. Check suction pressure and convert the refrigerant pressure to temperature, using the PT chart. Measure the suction line pipe temperature. Compare the difference of the two temperatures. If there is no temperature difference, then the back liquid is being brought back into the compressor. If there is a temperature difference between 10 - 20°F (5 -11°C), the superheat is normal and the compressor is not being slugged with unwanted liquid.

Conclusion

Troubleshooting and servicing refrigeration air conditioning and heat pump systems are challenges for any technician, entry level or experienced. Regardless of the size or location of the system, it is imperative that the service technician understands the principles and the tools needed to perform proper troubleshooting efficiently.

Reference

[1] Troubleshooting HVAC/R systems using refrigerant superheat and sub-cooling. Fluke Application Note.

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