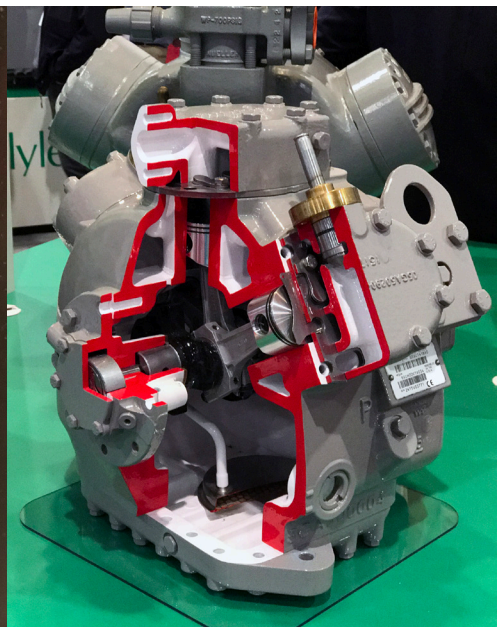
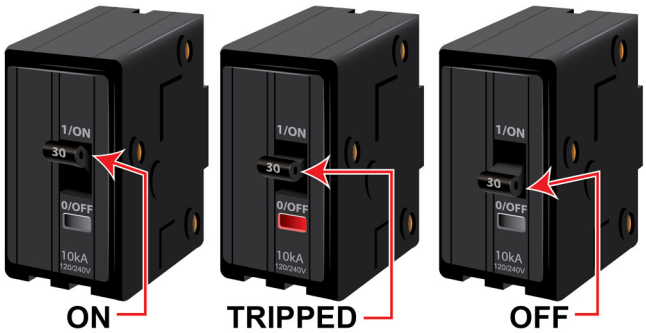
HVACR & PLUMBING
Video Showcase
March 22-June 25, 2021
Partners:
Contracting Business
CONTRACTOR
HPAC Engineering











Compressor Diagnostics

Seven prerequisite diagnostic steps ensure we are giving the compressor what it needs to survive.

By Bryan Orr

The compressor is like the family dog, often getting blamed for messes just because it can't speak up and defend itself.

Before we begin diagnosing compressor failures, it's critical to understand what a compressor is, and the conditions under which it is supposed to operate. This understanding will allow us to diagnose the fault and also fix the underlying cause of the issue.

The compressor is the heart of the compression refrigeration circuit, and just like our heart, it is the center of the circulatory system which generates the pressure differential required to move the "blood" (in this case refrigerant) through the system.

The compressor moves refrigerant vapor from the larger volume suction line on the inlet to the smaller volume discharge line on the compressor outlet. Because the compressor forces the refrigerant molecules together, the temperature and pressure of the refrigerant greatly increase after it is compressed.

For a compressor to work properly and to run a full, long life, some basic requirements must be met:

- Correct, balanced incoming voltage based on the data tag requirements
- Properly functioning capacitors sized per equipment manufacturer (single-phase compressors)

- Vapor only entering the compressor through the suction line
- Refrigerant and oil free of solid contaminants, oxygen and water
- Proper lubrication
- Temperature control to keep from overheating
- Long, steady cycles (as opposed to short cycling)
- Proper compression ratio for the application
- Correct mounting and vibration isolation

When we come across a compressor issue or failure, it makes sense not only to find and fix the failure at hand, but to also walk through these seven prerequisites to ensure we are giving the compressor what it needs to survive.

The Visual Assessment

When you do encounter a problem with a compressor, it's best to start with visual inspections of the compressor itself, the terminals, connecting wires, contractors, and the start gear, such as run and start capacitors and potential relays.

Take stock of the equipment and look for any signs that previous work may have been done, such as new line driers, field brazed connections, new capacitors, modifications to the original wiring or terminals, etc. Pay especially close attention to the compressor itself for signs that it may have already been replaced. If it has, ensure that the compressor installed is the correct model. If a capacitor appears to have been replaced, further scrutiny of it is in order. You may find that a previous tech used a capacitor they had on hand, and not necessarily one with a rating that's similar to the original one. Most equipment manufacturers have apps available for you to easily check the parts list for the model you're servicing to verify that the correct capacitors are installed.

Compressor Failures

When a compressor does fail, one or more of these basic observations can often be made:

1. Tripped breaker or blown fuse
2. Doesn't run at all
3. Runs but has poor compression (not pumping well)
4. Locked / Seized
5. Noisy Operation

Tripped Breaker / Blown Fuse

When the compressor or a unit containing a compressor has a tripped breaker or blown fuse, resist the temptation to just reset it and see what happens. A fuse or breaker usually opens due to a short circuit, although an overload condition also may have been the cause.

1. Perform a visual inspection of all wires, terminals and plugs and look for signs of carbon or arcing.
2. Disconnect the compressor terminals and measure resistance from each terminal to ground. The easiest method is often to test from the terminals to a clean spot on the copper lines. A resistance path of less than 0.5 megohms or 500,000 ohms to ground indicates a short to ground or "grounded" condition. Resistance measurements of between 0.5 and 20 megohms are usually an indication of a contamination issue, but acceptable values may vary based on the exact compressor design and the temperature of the compressor.
3. Checking from terminal to terminal is generally not required to locate a short. Many winding to winding short circuits will also result in a winding to ground short. It is normal for the resistance between terminals to be quite low. For three-phase compressors, the terminals should read the same resistance to one another. For single-phase compressors, the highest ohm value will exist between start and run, and the lowest between run and common.
4. After all shorted and grounded possibilities are eliminated and all wires and connections checked, only then is it recommended to reset the breaker or replace the fuse and test for an over amperage/overload condition.

If a shorted/grounded compressor is diagnosed it is a best practice to disconnect and safely isolate the compressor leads, reassemble the system and reset the breaker. If the compressor is the only short / ground fault, then the breaker should no longer trip and everything else should operate normally.

Many technicians assume that an electrical fault is due to an electrical cause such as a surge, but this is often not the case. A mechanical failure inside the sealed compressor will often cause winding damage and therefore an electrical fault, so even when the compressor is shorted, issues like flooding or overheating can't be ruled out.

Compressor Doesn't Run

You'll often first notice the compressor isn't running because the condenser fans are running, but not the compressor. You can confirm it isn't running by testing with an ammeter on any leg on a three-phase compressor or on the common leg on a single phase.

1. Visually check all of the connections and start gear and confirm proper high voltage is present.

2. Leave the ammeter on to see if the compressor may be seized and cycling on overload.
3. Disconnect power
4. Discharge and test the run capacitor if the compressor is single phase
5. Feel the top of the compressor to see if it is hot to touch. If it is hot, allow it to cool before proceeding.
6. Ohm the compressor terminals to one another and ensure that none of them measure open. For a single-phase compressor, the symptoms of an open internal thermal overload are run and start each being open to common, while run and start should have low resistance between them. Any two of the three terminals on a three-phase compressor that's "out on thermal" will read open. If the compressor shows symptoms consistent with an open thermal overload, the compressor may need to cool down longer. Water can be sprayed or flowed over the compressor casing to accelerate the process. A truly "open winding" will require compressor replacement, but many compressors are replaced because the technician wasn't patient enough for the thermal overload to reset.

Poor Compression

When a compressor works properly, it moves the correct amount of refrigerant mass to provide the designed BTUs of cooling capacity. When the compressor has an issue that results in poor compression, such as leaking valves, the system suction pressure will be higher than usual, the discharge pressure will be lower, and the compressor amp draw will be low on a semi-hermetic compressor, compression issues may be rectified without replacing the compressor by inspecting and replacing valves.

Poor compression can also be confused with an oversized metering device or a bypassing reversing valve, so further diagnosis will need to be done to distinguish. There are also some cases where a scroll compressor will run backwards. This can occur due to short-cycling, or in the case of a 3-phase compressor, improper phasing.

Seized Compressor

When a compressor is mechanically locked, it will cycle on and off on overload and you will see the current jump up to locked rotor each time the overload closes and energizes the windings. Under these circumstances, the windings in the motor essentially become heaters, and the internal overload will trip very quickly when voltage is applied to the compressor.

When a single-phase compressor is seized, you may use a hard start kit (start capacitor and potential relay) to try and get it free. This is just to get the compressor started so you can do a more thorough diagnosis of the system, which hopefully will uncover another underlying issue. A seized compressor is very likely to lock up again, because SOMETHING caused it to seize.

Find the Cause

Once we repair or replace the compressor and get it started, we need to fully evaluate the whole system to ensure that any underlying causes are dealt with.

When you start up and test a compressor, the first step is to put your ammeter on the compressor and listen carefully as you start it up for any abnormal noise. This is especially important with 3-phase scroll compressors to ensure they are not running backwards.

Check the voltage entering the compressor while it is running to ensure it is still within the listed range.

Once the compressor amperage, voltage and noise are normal, a full review of the performance of the system is needed with a close eye on how it could impact the compressor.

Overheating

Oil begins to breakdown when the compression chamber gets over 315F with mineral oil and 400F with POE oil. This equates to a maximum discharge line temperature of 225F to 250F at 6-inches away from the compressor.

Once the compressor is up and running, we should measure discharge line temperature to ensure that it stays well below 225F unless it is a unique application where a higher discharge line temperature is acceptable.

If the compressor discharge temperature is too high, there are a few things that need to be checked that can cause overheating:

- High Head Pressures / Condensing Temperatures
- Low Suction Pressure / Evaporator Temperatures
- High Suction Temperature / Suction Superheat
- Liquid to Suction Heat Exchangers.

It's also imperative to check the suction line temperature entering the compressor. Most compressors specify a suction line vapor temperature of 65F or lower for proper compressor cooling.

Hermetic and semi-hermetic compressors are cooled by the flow of vapor refrigerant through them, so to keep them running cool, an adequate mass flow rate of sufficiently cool

vapor must be maintained. Low compression ratios indicate sufficient flow rate. The system should be operated with the highest effective suction pressure and the lowest effective head pressure, while keeping the suction temperature reasonably low without any floodback.

Flooding

Flooding occurs when liquid refrigerant makes it into the compressor crankcase. It can happen while running or at startup, and causes oil dilution and loss, which will shorten the life of the compressor. Slugging is a more extreme version of flooding where liquid enters the compression chamber, and it usually results in catastrophic failure.

Floodback while running is prevented by carefully controlling superheat to ensure that it does not reach zero. Copeland generally requires a 20 degree total superheat at the compressor suction line to ensure there is no floodback, and they recommend maintaining a suction line temperature of 65° or less. These conditions can be achieved by properly setting the evaporator TXV/EEV to maintain an evaporator superheat (measured at the outlet of the evaporator) of between 4F and 14F, depending on the application. In some cases a manufacturer may use a suction accumulator to prevent floodback, especially when a fixed metering device is utilized.

Off cycle floodback and flooded starts occur when refrigerant migrates to the compressor crankcase and condenses, or when liquid refrigerant quickly dumps down the suction line from the evaporator coil on startup.

Depending on the application, field conditions, and severity of the issue, there are several strategies that are often employed by manufacturers or in the field to prevent flooded starts.

- Crankcase heaters
- Pump down or shut off liquid line solenoids
- Suction stop valves
- Inverted suction traps
- Accumulators.

Oil Management

Most of the system's oil charge should be contained in the compressor, while a small quantity continuously circulates through the system. In built-up systems like parallel grocery racks, the amount of oil circulating or trapped in the system can be significant if not carefully managed and kept in the compressors and oil system.

These larger, built-up systems generally use oil separators and reservoirs to continuously extract the oil from the refrigerant and return it back to the compressors. These systems need to be monitored to make sure that each compressor maintains proper oil level and pressure.

You need to be 100% sure you're using the right type and viscosity of oil for the application, just like in a car.

On smaller systems that are factory-charged with the correct amount of oil, our job is to keep most of it in the compressor by preventing flooding and maintaining proper refrigerant velocity to return the oil through correct piping design and maintaining appropriate evaporator coil load.

Not all oil is created equal, so before you do anything with the oil charge, you need to be 100% sure you're using the right type and viscosity of oil for the application, just like in a car.

Contaminants

The only things that should be in the compressor are refrigerant and the correct oil. This starts with proper commissioning practices to keep solid contaminants out of the field fabricated copper by careful deburring and flowing nitrogen while brazing. Water vapor and oxygen are compressor killers, which is why pulling a complete, deep vacuum to below 500 microns (in most applications) is a must, as well as using the manufacturer-specified filter/drier strategy.

When a compressor fails, it's important to take precautions against acids and solid contaminants caused by the failure. This process generally involves removing old filter driers and installing new, appropriately sized filter driers in the suction and liquid lines. It's a good practice to return and test for pressure drop across the driers as well as test for contaminants in the oil periodically afterwards. Pressure drop across a suction filter/drier should be kept to a minimum because it can lead to a high compression ratio and compressor overheating.

References

- opi.emersonclimate.com/CPID/GRAPHICS/Types/AEB/ae1294.pdf
- rses.org/assets/journal/0110_MSAC.pdf
- climate.emerson.com/CPID/GRAPHICS/Types/AEB/ae1260.pdf
- sporlanonline.com/literature/misc/10-207.pdf

Bryan Orr is host of the HVAC Podcast and HVACschool.com.