Compressors Part 1

Tech to Tech April 07

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The compressor is often referred to as the heart of the air conditioning system. Just like the human heart moves the vital fluid blood, through our piping system (arteries, veins, etc.); the compressor moves the refrigerant (vapor, liquid or combination of both) through the A/C system.

When someone is having trouble with their heart or compressor they want a doctor/service technician well versed in the accurate detection and diagnosing of the different symptoms associated with a particular problem in order to determine the best method of repair or replacement.

Before we can do any of this we first must understand how the two most common compressors in the residential/light commercial market work and some common terminology.

How a Reciprocating Compressors works:
The reciprocating compressor is driven by a crankshaft that is common to the motor and compressor. This crankshaft powered by the motor makes one or more pistons rise and fall. When the piston is in the down position, the low pressure refrigerant vapor enters from the intake valve. When the piston rises up, it compresses the low pressure/temperature refrigerant vapor to a high pressure/high temperature superheated vapor that is pushed out through the exhaust valve into the discharge line.

How a Scroll Compressors works:
Refrigerant is compressed by the use of two spiraled scrolls that fit together. One scroll is stationary while the other makes a continuous orbit. The movement of the orbiting scroll causes the refrigerant to be compressed as it is moved toward the center of the scroll and then discharged out to the condenser.

Both have overloads that help prevent the compressor from overheating and its damaging effects, more on this when we get to troubleshooting.

Hermetic Compressors:
We will only be addressing the hermetic compressor in this article. This hermetic compressor is often referred to as a “canned, sealed or welded” compressor because all the components of this compressor are sealed within a welded casing and inaccessible to the technician.

The motor and compression chamber are in the middle of the container and create heat as the result of their movement. The area around them is open and allows the cool suction gas to fill the inside of the “can” and cool these components before being draw into the compression head. All hermetic compressors are refrigerant vapor cooled. This will be explained further later.

The compressors two functions:

- The compressor creates the pressure differential that allows the system to evaporate and condense the refrigerant. It does this by pulling the refrigerant that evaporates and forms a low pressure, low temperature vapor from the evaporator coil into the compressor, keeping the evaporator pressure low. This low pressure, low temperature gas is then compressed into a smaller volume, high temperature-high-pressure vapor that is sent to the condenser coil through the discharge line.

This process also adds what is called the *heat of compression* to the discharge vapor. When the gas is compressed it is hotter because it is in a smaller volume but all the heat generated by the compressor motor, windings and other moving parts is also added to the discharge vapor.

This vapor is now superheated--heat added that increases temperature but not pressure. In order for there to be a pressure-temperature relationship you need both vapor & liquid to be present, more on this later.

Since we need temperature differential for heat transfer to take place, the superheated discharge vapor temperature must be higher than the temperature of the ambient air entering the condenser for condensation to occur.

- It is also one of the two points that divide the air conditioning circuit. The metering device being the other.

What determines when to use a scroll or reciprocating compressors?
In studies done by Bristol for their Benchmark series of compressors, the overwhelming evidence showed that capacity (tonnage) is the determining factor on which technology to use (scroll or reciprocating). Below 3 ½ tons, reciprocating compressors offered superior performance in efficiency and reliability. This is because of the lower condensing temperatures and higher evaporating temperatures in 13 SEER systems. The reciprocating compressors efficiency gets better compared to a scroll when condensing temperatures decrease and evaporating temperatures increase.

For larger jobs the scroll is better and the entire benchmark line is a mixture of the two technologies in the proper capacity range. This certainly doesn’t mean that some equipment manufacturers don’t use only scrolls in their whole line, top to bottom.

Sound Levels:
With the new generation of 13 SEER compressors, both the reciprocating and scroll are not that far apart in the sound department and many of today’s consumers expect nothing less than silence.

Keep in mind that a scroll has the potential to put significantly more vibration energy into the condensing unit base pan and the refrigerant piping than a reciprocating compressor, therefore all the mechanical imbalance and start up torque must be absorbed by the condensing unit and piping. This happens because the scroll mechanical unit is hard mounted in the compressor shell and the reciprocating mechanical unit is mounted on springs within the compressor shell, passing less energy to the system.

Suction gas pulsations are lower in the new reciprocating compressor than they are in the already low pulsation scrolls. This is due to innovative suction gas management techniques that reduce compressor sound levels.

Proper installation and securing of piping inside walls, possible use of vibration eliminators and sound blankets all must be taken into consideration by the technician to get the lowest sound levels for customer satisfaction.

Line Sets:

Line sets are the refrigerant highways that connect the condensing unit and evaporator coil. Having a good understanding of them will aid the technician in spotting initial installation errors and better servicing of problems associated with incorrect line sets that can lead to premature compressor failure.

Line sets are sized based on three things:

- Velocity
- Pressure drop
- Refrigerant charge

Suction lines must be sized large enough to keep *pressure drop* to a minimum which has a direct effect on capacity loss, and small enough to allow proper velocity pressure to return oil to the compressor.

There is always a small amount of refrigerant oil entrained in the refrigerant circulating through the system and must be returned to the compressor without causing refrigerant system blockages or compressor damage due to a lack of lubrication.

To keep this oil from falling out of the circulating refrigerant at any point in the system, the suction line must be sized small enough to keep the refrigerant velocity at about 1200 FPM; while at the same time keeping in mind if the suction line is sized to small we will increase the resistance to flow better know as *pressure drop*.

Pressure drop will reduce the efficiency and capacity of the equipment. The lower the suction pressure of the gases returning to the compressor, the less dense they are. When suction gases have a lower density upon entering the compressor cylinder, the less refrigerant volume can be pumped per stroke.

Liquid lines must be large enough to minimize *pressure drop* and small enough to keep the extra refrigerant in them from damaging the compressor.

When liquid lines are sized to small they will create excessive pressure drop causing the liquid refrigerant to boil in the line. This is basically a restriction and makes it so the metering device and evaporator are not getting the proper amount of refrigerant creating a low capacity and high super heat that can eventually overheat the compressor. Remember, in most hermetic compressors the motor windings and other moving parts are cooled by the suctions gases before they enter the compression chambers.

Oversized liquid lines cause one of two problems: overcharge or undercharge.

The liquid line robs refrigerant from the system and any refrigerant in the liquid line is doing nothing for the A/C process and is only in the transportation mode. When you oversized the liquid line you are just keeping the refrigerant from the place it is most needed “the coils”. We need to keep as much of the refrigerant in the coils absorbing or giving off heat as possible.

I will not go into sizing because you can look in the Manufacturers Installation Instructions for the recommended line set sizing.

Goodman brand units have line set lengths up to 74’ in the Installation & Operation manuals. Extended line set charts for both R-22 & R-410A applications that go longer than 74’ are also available. The Installation & Operation manual has all the information needed to get that particular unit up and running.

Goodman also recommends crankcase heaters and pump down solenoids on all extended line sets of 80’ or more. See Migration for more details on why.

Oil Traps and Risers:
Since refrigerant oil and refrigerant are miscible (they mix together easily), the system will have small amounts of oil leaving the crankcase and settling in low points in the system. The velocity of the circulating refrigerant is usually enough to push the oil to the next low spot and eventually gets it back to the compressor.

Because large slugs of refrigerant returning to the compressor can damage valve plates and internal running gear when hydraulic pressure becomes too great in the compressor cylinders; oil traps can prevent large slugs from forming by trapping a small amount of oil in the trap and returning it to the compressor at a gradual rate. Oil traps are constantly being filled and emptied at a gradual rate, protecting the compressor. All vapor carrying lines should have oil traps installed to maintain proper oil return.

It does this by oil collecting in the trap and increasing velocity when the refrigerant gas travels by this slight restriction of the pipe, kind of like reducing a trunk duct to keep airflow velocity up. The increase in velocity then picks up a small amount of minute surface droplets of oil from the trap and takes them to either the next trap in line or the compressor.

When the condenser (with compressor) is higher than the evaporator, the run of piping that causes upward flow of refrigerant suction vapor is called a *Riser*. When there is oil and refrigerant mixed together in this upward run, the oil tends to drop out and go back to the bottom of the run because of the distance to the top of the riser.

There should be an oil trap at the bottom of the run for this reason because of the need to lift the oil to the higher compressor. There also should be an oil "lifting" trap (what I have always called them) every 15' to 20' of vertical height to off set the reduction in velocity of the oil and refrigerant vapor as it climbs up the riser.

Because everyone does things a little differently for example some manufacturers recommend a trap on a riser more than three feet, technicians should **always follow manufacturer Installation Instructions.**

The following three important terms apply to air conditioning and refrigeration compressor that many technicians either misuse and/or misunderstand. Every start up or service technician should have a solid understanding of these three terms.

Flooding:
Flooding occurs when liquid refrigerant enters the compressor crankcase while the compressor is running. Flooding of a compressor occurs only during the **on** cycle.

Hermetic compressors are more prone to flooding because the suction line of the hermetic compressor stops at the outside casing wall. Any liquid that makes it back to the compressor immediately drops down into the oil sump or hits the hot motor windings and flashes off.

Liquid refrigerants are heavier than oil and will sink below the oil in the compressor crankcase. When this refrigerant boils off due to the low pressure in the crankcase, it entrains small particles of oil with the vapor and can also raise the pressure in the crankcase. This allows the oil particles to escape the crankcase into the compressor cylinders causing high compressor amperage draw due to the higher density oil/refrigerant mixture being pumped through the compressor cylinders, where they are then sent into the discharge line. This could lead to overheating of the compressor or tripping of the breaker. The oil levels in the compressor then drop and keep the mechanical parts from getting the lubrication they need to operate properly, leading to premature mechanical failure.

Oil will also coat the insides of the coils and lines decreasing their ability to absorb or reject heat, causing an undesired lowering of system efficiencies.

Signs of flooding are: a cold, frosted or sweating crankcase and higher than normal current draws. The reasons flooding may occur include:

- Lack of airflow across the evaporator: fan not running, dirty or plugged filter or evaporator coil
- Overcharge
- Low load on evaporator or end of cycle (lowest load)
- Wrong TXV setting (no compressor superheat), expansion bulb loose on evaporator outlet, oversized expansion valve

Additional things to look for when working on a heat pump:

- Defrost clock or heater out (iced outdoor coil)
- Flooding after hot gas termination
- Heat pump changeover
- Suction line accumulators in heat pumps can help with flooding, unless it is extremely severe.

Migration:
Only occurs when refrigerant liquid or vapor returns to the compressor crankcase or suction line during the off cycle when the system allows equalization during the off cycle (fixed orifice or bleed type metering devices).

Because refrigeration oil has a much lower vapor pressure than the liquid or vapor refrigerant, they both tend to migrate to the compressor crankcase where the vapor condenses to a liquid and settles under the oil, if the compressor remains off long enough. This occurs because the compressor crankcase is where the lowest pressure exists. Oil and refrigerant are like gin and tonic, they mix together well.

In residential/light commercial applications the compressor is located outside. Migration can happen faster when the outside ambient is cold causing an even lower vapor pressure in the crankcase. Migration can even take place between an accumulator (heat pumps) and compressor, and the refrigerant vapor can even flow uphill, because of the difference in vapor pressure. When the compressor turns on the instant pressure drop causes the oil/refrigerant mixture to flash (boil of rapidly) causing the same oil loss conditions as flooding.

Most technicians install a crankcase heater on the compressor to keep the crankcase area warm to prevent migration but when the condensed refrigerant is driven out of the compressor it can accumulate in the cooler suction line and cause possible liquid slugging on the next start up. A properly sized suction line accumulator should be added to make this method complete.

The only sure fire way to prevent migration is with a pump down system that removes all liquid and vapor from the evaporator, locking it in the high side of the system.

The air conditioning technician will not need to worry about this on systems only run on high ambient temperature days and nights but should keep it in mind on hot days/cool nights and when the system will be run in low ambient conditions.

Slugging:
Slugging is when liquid refrigerant and/or refrigerant oil enter the compressor cylinder during the on cycle. Air cooled semi-hermetic compressor are more prone to slugging because of their design.

The suction line of the hermetic compressor stops at the outside casing wall. Any liquid that makes it back to the compressor immediately drops down into the oil sump or hits the hot motor windings and flashes off.

If it goes into the oil sump it will eventually flash/boil off rapidly, which is actually referred to as flooding and can cause oil foaming and generate high crankcase pressures. When this occurs, a mixture of small oil droplets and refrigerant can enter the compressor cylinder(s) and cause slugging. Migration also can cause slugging in hermetic compressors.

Some causes for slugging:

- No compressor superheat
- Migration (off cycle)
- Bad TXV (Thermal expansion valve
- TXV hunting
- Low load or end of cycle (lowest load)
- Evaporator fan out and/or iced evaporator coil
- Dirty evaporator coil
- Capillary tube overfeeding
- Overcharge
- Defrost timer or heater out (heat pump)

I will stop here and continue with part 2 around the middle of April and quite possibly will need a part three. I had no idea this would go so long when I first thought about it but as I got into it I realized I couldn't talk about Z with talking about Y. I will try to keep this to a minimum in the future.

We will go into ERV/HRV's in May, depending on when the compressor series end. I will keep this topic to one article, **I promise**.

If you like the Tech to Tech column and other stuff, please tell everyone you know in the business about how to get on the mailing list and if you don't, I hope you keep quiet!!! ☺

Just kidding, please feel free to send comments (good or bad), corrections, suggestions, jokes in wav format, and especially pictures of cut-aways of valves, compressors, systems or any thing I can use for future training power points to either of my email addresses or on disc to: Randal Ripley, Total Air Supply, 171 East Hollis St., Nashua, NH 03060 Anything I use, I will give you a by line as the source.

Until next time, *"Make daily deposits to your box of knowledge, soon it will have many reference cards".*

Randal

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