

Understanding Refrigerant Blend Performance

PART ONE

Since the phaseout of CFCs more than 10 years ago, refrigerant blends have become commonplace in the refrigeration market for both retrofit and new installations. Equipment that traditionally used R-12 or R-502 is now running on one of approximately 13 commercially available blends.

When you consider the pending phaseout of R-22, another three or four blends get thrown into the mix. In addition, contractors and service technicians must know the pitfalls of refrigerant blends. Fortunately, we have learned much about blend performance during the last 15 years.

Each refrigerant blend has its own unique properties that are somewhat different from the original product they are intended to replace. By understanding how blends differ from single-component refrigerants, contractors and technicians can better identify or avoid blend-related problems when installing or servicing equipment.

Fractionation and temperature glide will affect system operation, control settings and service/troubleshooting practices. Different blends will show different amounts of fractionation or temperature-glide effects, though the impact on a system will be similar for all blends.

What are blends?

Blends are made up of two or more single-component refrigerants. Each

single-component refrigerant has its own pressure-temperature relationship and unique physical properties, such as density, heat of vaporization and heat-transfer coefficient. To match the properties of a single refrigerant with a blend, the individual components must be mixed in the right proportions.

Azeotropes are a special case in which the refrigerants combine in a unique way. There is some attraction/interaction between the different types of molecules, which causes unique properties within the blend. Since azeotropes, such as R-500, R-502, R-503, R-507 and R-508B, do not allow components to separate, they will not be

Knowing how and why blends differ from single-component refrigerants can help you better identify or avoid problems when installing or servicing equipment. Part one of a three-part series covers fractionation

By Jim Lavelle

included in this discussion.

Azeotropes have a pressure-temperature relationship that is a natural combination of the components' properties. There is no interaction between

Figure 1: New variable — composition

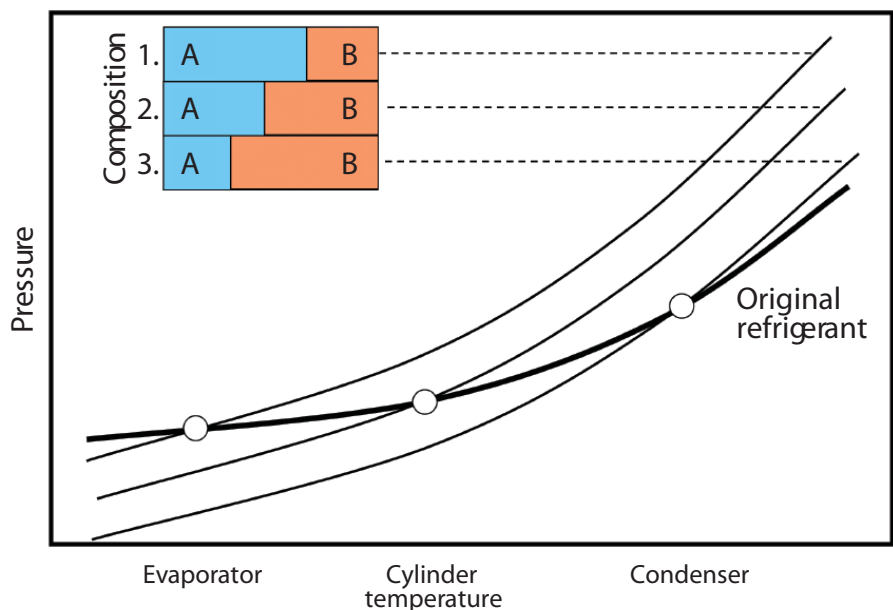
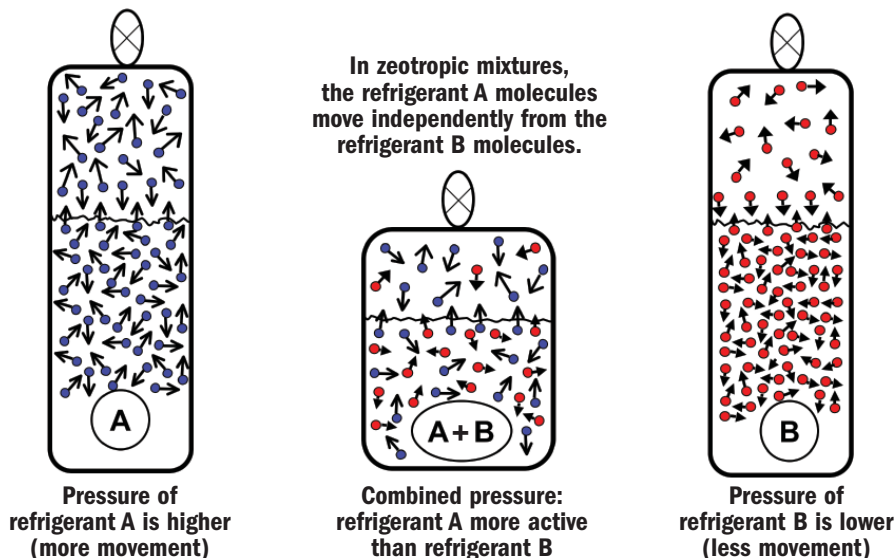


Figure 2: Behavior of individual refrigerant molecules



the different types of molecules. The pressure for the blend falls between the pressures of its components. But as we will see later, the vapor composition will become a problem.

If we mix a blend of refrigerant A and refrigerant B, we usually talk about the higher-pressure component first, in this case A. In general, if a greater amount of A is mixed with B, then the blend will have a pressure closer to A. If a greater amount of B is in the mix, then the blend will have a pressure closer to B. If you mix equal amounts, the blend will fall in between the pressures of A and B.

Zeotropic blend compositions have been adjusted so the resulting blend properties fall exactly where the manufacturers intended. The problem, however, is that not all of the properties can match the original refrigerant under all conditions.

Composition is a concern

Once a blend is mixed at a given composition, the pressure-temperature relationships follow the same general rules as for pure components. For example, the pressure goes up when the temperature goes up.

For three blends containing different amounts of refrigerants A and B, the pressure curve is similarly shaped (see Figure 1). But the resulting pressure will be higher for the blend that contains more of the A (higher pressure) component.

Refrigerant blends that are intended to match some other product (R-12, for example) will rarely match the pressure at all points in the desired temperature range. What is more common is the blend will match in one region and the pressures will differ elsewhere.

The blend with composition 1 matches the pure refrigerant at cold evaporator temperatures, but the pressures run higher at condenser conditions. The blend with composition 2 matches closer to room temperature and might show the same pressure in a cylinder being stored, for example. The operation pressures at evaporator and condenser temperatures, however, will be somewhat different.

Finally, the blend at composition 3 will generate the same pressures at hot condenser conditions, but the evaporator must run at lower pressures to get the same temperature. We will see later that the choice of where the blend matches the pressure relationship can solve (or cause) certain retrofit-related problems.

The graph also illustrates that if a blend loses some of the higher-pressure component, the remaining blend will have to achieve a lower operating pressure in order to achieve the same temperature. Turning this around, a system operating at the same pressure actually will boil refrigerant at a higher temperature.

Why blends fractionate

Figure 2 illustrates two basic behaviors of refrigerant molecules that will help explain why fractionation occurs. A pure refrigerant, A or B, exerts pressure on the cylinder (or a system) because the molecules are in motion.

At higher temperatures the molecules move faster, which increases pressure. At lower temperatures there is less movement and lower pressure. Different refrigerants have different energies at the same temperature, and, therefore, generate higher or lower pressures at the same temperature.

Molecules of refrigerant are constantly moving from liquid to vapor and vapor to liquid at the surface of the liquid. Vapor and liquid at equilibrium transfer the same number of molecules back and forth.

Boiling liquid transfers more from liquid to vapor and condensing refrigerants transfer more from vapor to liquid. Different refrigerants transfer back and forth to the vapor at different rates and ultimately have different numbers of molecules in the vapor at the same temperature.

When refrigerants A and B are mixed together and they don't form an azeotrope, the individual refrigerant molecules behave as if the other type is not there. The refrigerant A molecules bounce harder than the refrigerant B molecules, contributing more pressure to the blend. The composition can be adjusted so that the combined pressure from the two types of molecules matches the desired pressure.

More importantly, as the two refrigerants move in the cylinder, the A's transfer back and forth to vapor faster than the B's. This means there will be a higher concentration of A's building up in the vapor compared to the B's. When liquid and vapor are together at equilibrium, it is always the vapor that goes to the wrong composition.

How blends fractionate

Looking at the containers in Figure 3, you can see that when vapor is removed from a cylinder or system containing a zeotropic blend, two things will happen:

1. The vapor being removed is at the wrong composition. The vapor will have more of the higher pressure/higher capacity refrigerant component compared to the liquid composition.

2. The liquid that is left behind boils more of the higher-pressure component out of the liquid to replace the vapor. Eventually, the liquid composition changes because more of the A component leaves the container compared to the bulk liquid composition.

Fractionation is the change in composition of a blend because one (or more) of the components is lost or removed faster than the other(s). A larger difference between the pressures of the starting components will cause a greater difference in the vapor composition compared to liquid.

This will worsen the effect of fractionation on that blend. The high fractionation potential blend shown in Figure 3 will produce a vapor composition of 80 percent refrigerant A and 20 percent refrigerant B above the liquid composition of 50/50.

The closer the individual component pressures become, the more similar the transfer of molecules to vapor. The low-fractionation-potential blend in Figure 3 will not have that different a vapor composition compared to the liquid. In this case it will take a long time to noticeably change the liquid composition away from 50/50. Temperature glide, which I will discuss in part two in the February issue, will be higher for high-fractionation blends and lower for low-fractionation blends.

In order to avoid charging the wrong composition and fractionating the remaining blend, zeotropic blends must be removed from the cylinder as a liquid. You can do this by turning the cylinder over so the valve is on the bottom. You should open larger cylinders with vapor and liquid valves using the liquid valve. This will force the liquid product through a dip tube to the valve.

(All of the major manufacturers removed dip tubes from their 30-pound packages as of 1999. There

Figure 3: Fractionation of blends

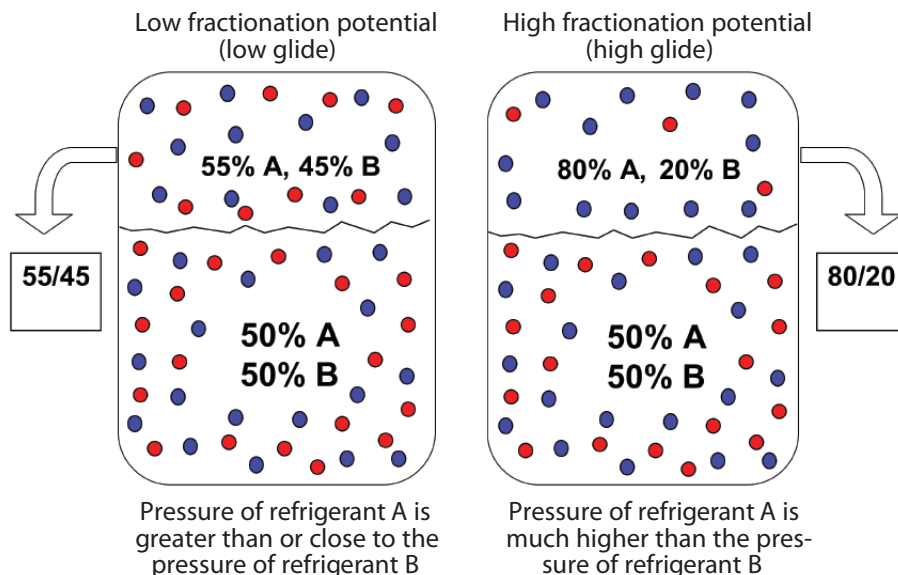
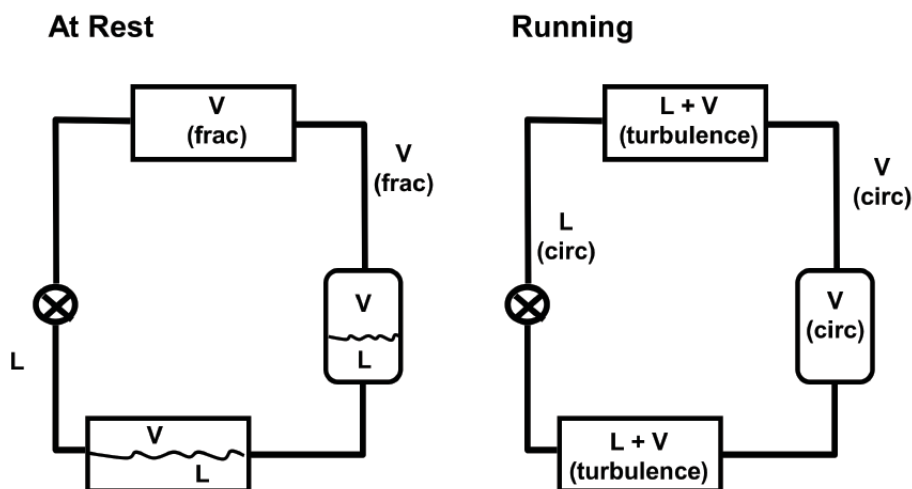


Figure 4: Fractionation effects on system charge



may be some older cylinders or products from third-party packaging companies that still contain dip tubes. Check the box or cylinder labels for instructions on which side should be up for liquid removal.)

Liquid charging does not mean that liquid refrigerant should be pushed into the suction line of the system and allowed to slug the compressor. After the initial charge into the high side of a system, you can start the compressor and complete the charging by flashing the refrigerant from liquid to vapor in the charging hose or across specially designed valves.

Any method that allows the refrigerant to become vapor before it hits the compressor should work. In gen-

eral, it's best to add refrigerant slowly at this point.

Effects of fractionation

A system at rest will allow the refrigerant to pool and the vapor to reach an equilibrium concentration above the liquid. Leaks that occur in vapor areas of the equipment will allow fractionation of the blend. The worst case will occur when about half of the refrigerant charge has leaked.

(Small amounts of refrigerant leaked from a system will not change the remaining blend by much. Large leaks will shift the composition, but the majority of the pounds after recharge will be from fresh product at the right composition.)

Recharging the system after repair will result in a blend with slightly reduced capacity and operating pressures. Looking again at Figure 1, you will see that blends that have fractionated — the composition changes from composition 1 to composition 2 — will lose some of the higher-capacity/higher-pressure component.

In general, the pressures will run lower in order to satisfy the thermostat and the system may run longer during the on-cycles. It is possible to check for a fractionated refrigerant charge. I will cover that topic in part three on system operation and troubleshooting in the March issue.

In smaller systems where charge size is critical, it is best to pull any remaining refrigerant and charge with fresh blend. In larger systems, you will need to make a decision whether the remaining charge should be pulled or not. For low-fractionation-potential blends, you will not see much shift in composition anyway. Therefore, the charge can be topped off after repair without loss of properties.

In running systems it has been found that the circulating composition is the bulk blend composition. In liquid and suction lines there is no second phase and in the heat exchangers there is much turbulence.

Leaks anywhere in a running system will lose both vapor and liquid.

Testing has shown that leaks from a running system do not cause fractionation, and a normal cycling system will not fractionate much during the off cycle. In most cases, servicing systems with blends does not require full recovery of the charge.

After repair, most systems can be topped off with the blend. Only systems that are off for long periods of time, such as air-conditioning units over the winter, will need charge replacement after leakage of a blend.

There are two system components that can be directly affected by fractionation effects: flooded evaporators and suction accumulators. Flooded evaporators are designed to keep a pool of boiling liquid refrigerant surrounding a bundle of tubes. When using blends the vapor that boils off this pool of refrigerant will be at the fractionated composition.

If the properties at this composition differ significantly from what the compressor expects, then the system could develop high head pressures, high amperage draw at the compressor and reduced cooling effectiveness (capacity) in the evaporator. Normally, it is not recommended to use blends in this type of system.

Suction accumulators are placed in the suction line before the compressor to keep liquid from flowing into the compressor. The liquid slug is trapped in the accumulator where it can boil off to vapor, combining with other suction gas. Zeotropic blends will fractionate in the accumulator, giving a short-lived spike of higher-pressure vapor back to the compressor.

Generally, this dissipates quickly as the refrigerant boils out of the accumulator. Systems with suction accumulators should not be overcharged with the expectation that the accumulator will protect the compressor. (This may lead to frequent pressure spikes.) In addition, this type of system should never be charged by dumping liquid refrigerant into the suction line and allowing it to vaporize in the accumulator.

Part two in next month's issue will focus on how temperature glide occurs with blends and the effect glide has on system operation and control settings. Part three in March will cover system operation and troubleshooting systems with blends. ♦

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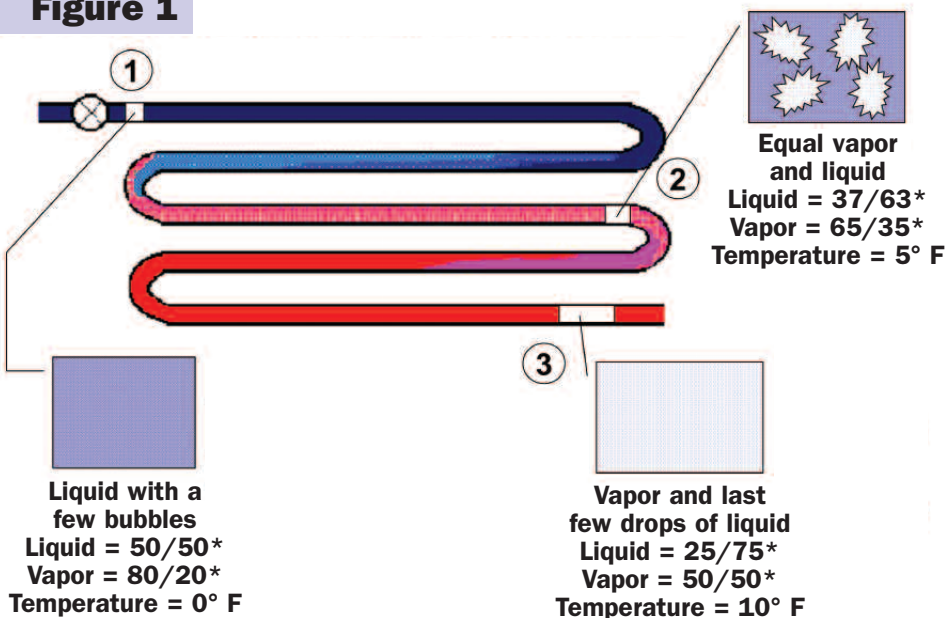
Part 2

Refrigerant Blends: The Impact of Temperature Glide

The second report in a three-part series on refrigerant blends addresses how temperature glide occurs in the evaporator and its effect on system operation and controls

BY JIM LAVELLE

Figure 1



The diagram shows the relationship between blend fractionation and temperature glide through an evaporator coil. *The number left of the slash represents the percentage of refrigerant A and the number right of the slash represents the percentage of refrigerant B.

Because temperature glide results from the effects of fractionation inside the evaporator, it is useful to review a few key points from last month's article on fractionation.

► When two (or more) refrigerants are mixed and they don't form an azeotrope, the vapor and liquid compositions tend to differ. This occurs because the higher-pressure refrigerant tends to jump into the vapor faster than the other(s) and take up more space.

► When individual components have extremely different pressures, the vapor composition will be much different than the liquid composition. When the pressures are similar the vapor composition will be close to that of the liquid.

► When vapor is taken away from the liquid, more liquid will boil to replace the vapor and more of the high-pressure component boils out of the liquid. This causes the liquid composition to change, becoming more concentrated in the lower boiling component(s).

► Changing the liquid composition causes the boiling point temperature to rise.

Fractionation and temperature glide

The key point with fractionation is that the vapor above a large pool of liquid turns into the wrong composition. When considering temperature glide in the evaporator, however, there is no longer a large pool of liquid.

Instead, there will be a small amount of liquid that we will follow as it travels down the length of the evaporator coil and eventually becomes vapor. Figure 1 shows a blend of 50 percent refrigerant A and 50 percent refrigerant B, with A being the higher-pressure refrigerant.

The refrigerant flows into the evaporator as liquid then it leaves as vapor. It is the local fractionation effect on each portion of the refrigerant that causes the shift in liquid composition along the way, which then causes a rise in the boiling temperature. In the example given in

Figure 1 the blend begins boiling at 0° F and ends boiling at 10° F. That means there is a 10° F temperature glide across the coil.

At the beginning of the coil, the blend is mostly liquid with a few bubbles in it. The liquid is composed of half refrigerant A and half refrigerant B (the correct composition) and the vapor in each bubble consists of 80 percent refrigerant A and 20 percent refrigerant B.

For this example, the 50/50 liquid is boiling at 0° F. As the blend moves down the coil, more of the refrigerant A molecules will shift to the vapor and the liquid composition will begin to change (see sidebar below for an analogy).

Somewhere in the middle of the coil, the blend will become part liquid and part vapor. Both of these phases are at the wrong composition because of the uneven shift of refrigerant A molecules to the vapor. The liquid composition has changed to 37 percent refrigerant A and 63 percent refrigerant B. The corresponding boiling point has gone up to about 5° F.

At the end of the coil, most of the refrigerant is now vapor at the correct composition of half of each of the two refrigerants. The last few

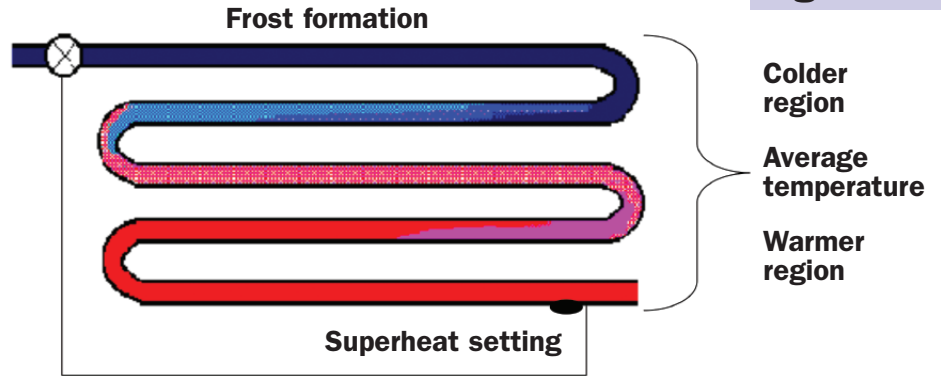


Figure 2

Effects of temperature glide

- Thermostat placement in air stream.
- Ice machine: ice formation and harvest control setting.

drops of liquid are now at 25 percent refrigerant A and 75 percent refrigerant B, and boiling at 10° F.

Impact on system operation

Figure 2 shows the effects of temperature glide on system operation. Extending the previous example, the average evaporator temperature will be 5° F. The first part of the coil is colder and the last part of the coil is warmer.

But if you blow a fan over the entire coil, the air coming off the other side will look like it went over

a 5° F coil. There are several system operation issues that will be different with blends than they would be with single refrigerants:

► **Frost formation.** Coils operating below 32° F probably will show frost formation, and the colder a system runs the more likely there will be a defrost timer and some sort of defrost mechanism (electric coil, hot-gas bypass). Systems with a single refrigerant, like R-12 or R-22, will show an even frost pattern over the entire surface of the coil.

High-glide blends, however, will

Refrigerant can behave like stopped traffic

If traffic is stopped, then allowed to move suddenly, the cars will take off quickly and the trucks will take some time to rumble up to speed. Refrigerant acts quite similarly.

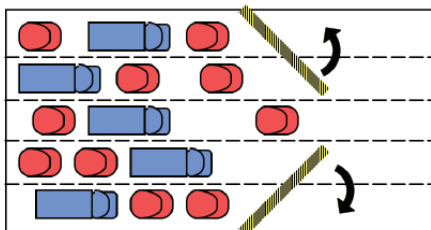
This is like the molecules in refrigerant A jumping quickly into the bubbles, while the molecules in refrigerant

B stay in the liquid. The average speed is low, just as the boiling point is lower at this point.

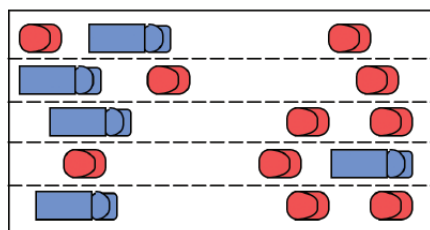
If you stand about one mile down the road, you will see a bunch of cars go by with a truck or two, then you will see a bunch of trucks with a car or two. This is like the liquid and

vapor being at different compositions. The average speed is higher, as the boiling point is getting higher.

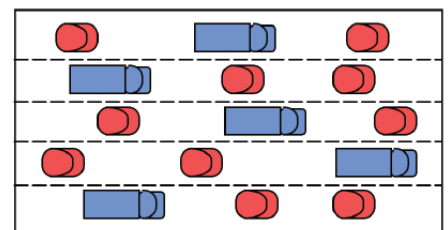
Go 10 miles down the road and the trucks have caught up to the cars. Similarly, the refrigerant A and B molecules come together as vapor. The speed is higher still, like the boiling point.◆



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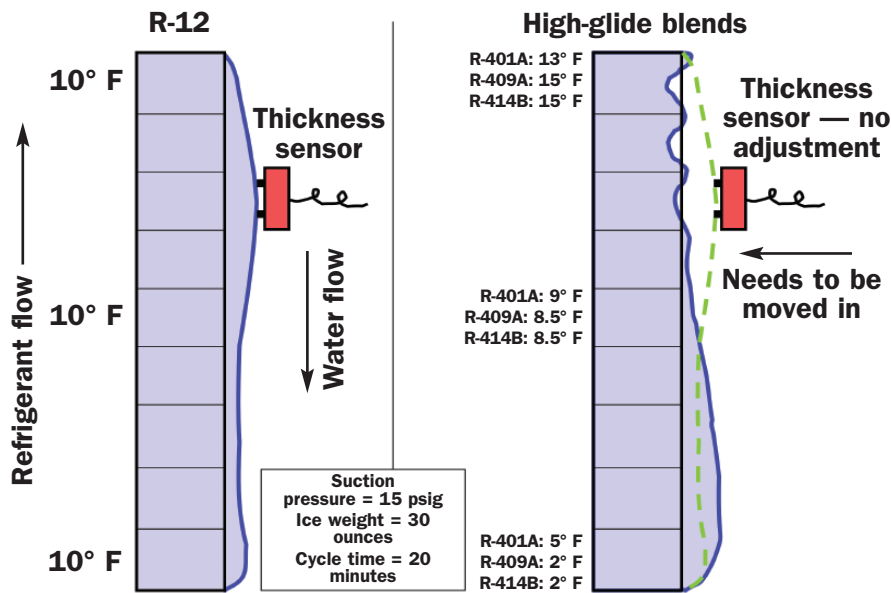


2



3

Figure 3



Side view of an ice machine grid/ice profile near harvest — R-12 and high-glide blends.

show thicker frost formation toward the valve, where the actual boiling temperatures are lower than at the end of the coil. After a retrofit to a high-glide blend, it is possible that the first part of the coil could be blocked by frost before the original timer setting calls for defrost. You may need to adjust the defrost timer to avoid this condition.

► **Temperature controls or indicators.** It is possible that thermostat bulbs or case temperature indicators could be placed close enough to the coil to be affected by temperature glide. If the bulb is located nearer the colder part of the coil, then the system may shut off early (or show a colder temperature). If the bulb is closer to a warmer part of the coil, then the system may run longer (or show a warmer temperature).

In general, temperature sensors should be located far enough from the coil that they will read the bulk air temperature in the case or box, not the air temperature coming directly off a part of the coil.

► **Thermostatic expansion valve (TXV) sensor bulbs.** These are located on the suction tubing after the outlet of the evaporator. The spring

setting on a TXV is adjusted to make sure that superheated vapor is moving up the suction line, not liquid.

Because the boiling temperature of the refrigerant gets warmer toward the end of the evaporator, and there is still liquid present, you need to check the superheat setting of the TXV and possibly adjust it higher after a retrofit to a high-glide blend. I will address superheat adjustment in part three of this series, in the March issue.

► **Ice machines.** Many ice machines have an evaporator coil running vertically behind a cube-making plate. A single refrigerant will produce a constant temperature across the entire face of the plate, whereas a high-glide blend will be colder at the bottom than at the top. Figure 3 summarizes a retrofit study for high-glide blends used in an R-12 ice machine.

Generally speaking, a high-temperature glide does not necessarily affect a system's ability to remove heat from the air or from a product. More likely, the glide will affect the response of various controls on the system and retrofitting with high-glide blends will require adjustment

of those controls.

Frost formation and hot or cold spots will need to be addressed outside of the refrigeration loop by adjusting the defrost timer and product placement, for example. Changing the thermostat setting to avoid frost or a cold spot would make the box run too warm.

Ice machine retrofit study

A retrofit study was performed on a Manitowoc 200 ice machine using the popular R-12 retrofit blends R-401A, R-409A and R-414B.

Original baseline R-12 operation:

- **Suction pressure:** dropped to just below 15 psig before harvest.

- **Suction temperature:** around 10° F across entire coil before harvest.

- **Cycle time:** about 20 minutes per block.

- **Ice weight:** entire block weighed about 30 ounces after harvest.

After retrofit, each blend performed similarly:

- **Suction pressure:** dropped to just below 15 psig before harvest.

- **Suction temperature:** R-401A averaged 9° F. R-409A and R-414B averaged 8.5° F.

- **Cycle time:** about 20 minutes (after adjustment of thickness sensor).

- **Ice weight:** about 30 ounces after harvest.

The key difference from R-12 to the blends was in the profile of ice thickness from the top of the block to the bottom. Figure 3 shows a side view of the ice plate showing how the thickness of the ice grew away from the coil.

For R-12, with a constant temperature profile, the ice sheet grew steadily and uniformly until harvest. The third row from the top showed the most weight of ice compared to the other rows. This also happened to be where the thickness sensor was located.

With each of the high-glide blends the general result was the same: there were dimples in the first few rows of ice, and the majority of the weight of ice was in the lower five rows. The first cycle after retrofitting took over 30 minutes to harvest because the thickness sensor was not

contacting the ice after 20 minutes.

The bridge between cubes had not grown out as far on the upper part of the plate. After adjusting the sensor closer to the ice, harvest times came back closer to 20 minutes. The total ice block was about the same size (30 ounces). However, more of the ice was on the lower part of the plate where the temperature was colder.

Overall, the ice machine still produced the same amount of ice and the bin was full each morning regardless of the refrigerant used. Each sheet of ice, however, looked different than it did with R-12 because of the temperature glide. All that was needed to make this a successful retrofit was an adjustment of the control.

Temperature glide in the condenser

The discussion for evaporator coils can be reversed for condenser coils. As the blend condenses, initially

forming a few drops and later becoming all liquid, the condensing temperature will drop by an amount similar to the glide seen in the evaporator.

Air-cooled condensers will operate similarly to how they did with a single

Each sheet of ice, however, looked different than it did with R-12 because of the temperature glide. All that was needed to make this a successful retrofit was an adjustment of the control

refrigerant. Water-cooled condensers may gain or lose efficiency depending on which way the water and refrigerant flow relative to each other, but generally they will behave as they did with the original refrigerant.

Localized fractionation as refrigerant moves through the heat exchanger will create temperature glide. The glide may cause the system to behave differently than it did with a single refrigerant.

The changes, however, usually will involve adjustment of a control. Affected controls typically include the defrost timer, thermostat bulbs, ice machine thickness sensors, and superheat and pressure control settings, which I will address in part three in next month's issue of *RSES Journal*.

Part three also will cover how temperature glide affects the information given on a pressure-temperature (PT) chart. Pressure gauges and PT charts are used to check for correct or abnormal system operation, set superheat and subcool temperatures and set pressure controls. High-glide blends require special attention for these operations.◆

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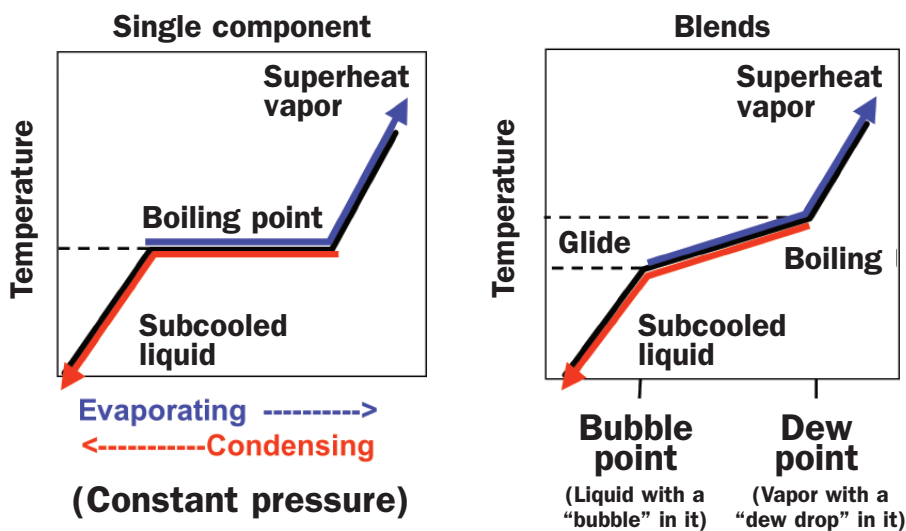
Part 3

Refrigerant Blends: P-T Charts and System Troubleshooting

The final article in this series focuses on the use of pressure-temperature (PT) charts and how they differ for blends compared to single-component refrigerants

BY JIM LAVELLE

Figure 1 Bubble point and dew point for blends



Single-component refrigerants boil at one temperature, and superheat or subcool measurements are compared to that boiling point. Blends change temperature while boiling or condensing, so the end points of the glide must be known in order to calculate superheat or subcool temperature.

Pressure-temperature (PT) charts can be used to troubleshoot system operation, specifically to check proper low- and high-side pressures, set superheat and subcooling temperatures, and to set pressure controls. The temperature glide of a blend will determine how the PT chart will look.

Therefore, a quick review of temperature glide from last month's article is necessary:

- As a portion of a refrigerant blend works its way down the length of an evaporator tube, local fractionation of the liquid, as it boils, will cause the boiling temperature to increase.

The average evaporator temperature is the average between the temperature where the blend begins boiling at the expansion device and where it stops boiling at the end of the evaporator.

- The average of the temperature glide is used to compare to a single refrigerant's boiling point for purposes of having the same "coil temperature."

- Temperature glide in the condenser occurs in the same way as in the evaporator, but the process is reversed as the components condense at different rates from the inlet to the outlet.

Bubble point and dew point

As shown in Figure 1, a single-component refrigerant will either evaporate or condense at a single temperature called the boiling point. During evaporation, the liquid reaches a point where bubbles start to form and the liquid boils to vapor at the boiling point.

When the last drop of liquid disappears, any additional heat input causes the vapor to superheat (rise in temperature above the boiling point). During condensation, the vapor forms liquid drops and continues to condense to liquid at the boiling point. When the last of the vapor disappears, any additional removal of heat causes the liquid to subcool (lower in temperature below the

Three types of PT charts

boiling point).

For blends, the process is exactly the same: liquid evaporates to saturated vapor and then superheats from that point, or vapor condenses to saturated liquid and then subcools from that point. The difference with a blend is that while it is boiling it is also warming up from the effects of the temperature glide (and cooling during condensation).

The glide is not considered a sensible heat change in the same way that superheat and subcool are defined. Rather, glide is a function of the local fractionation effect on the blend as it travels along the heat exchanger.

For a given pressure, the temperature where a blend is saturated vapor will be different from the temperature where a blend is saturated liquid. A traditional PT chart would list the pressure next to the boiling point temperature.

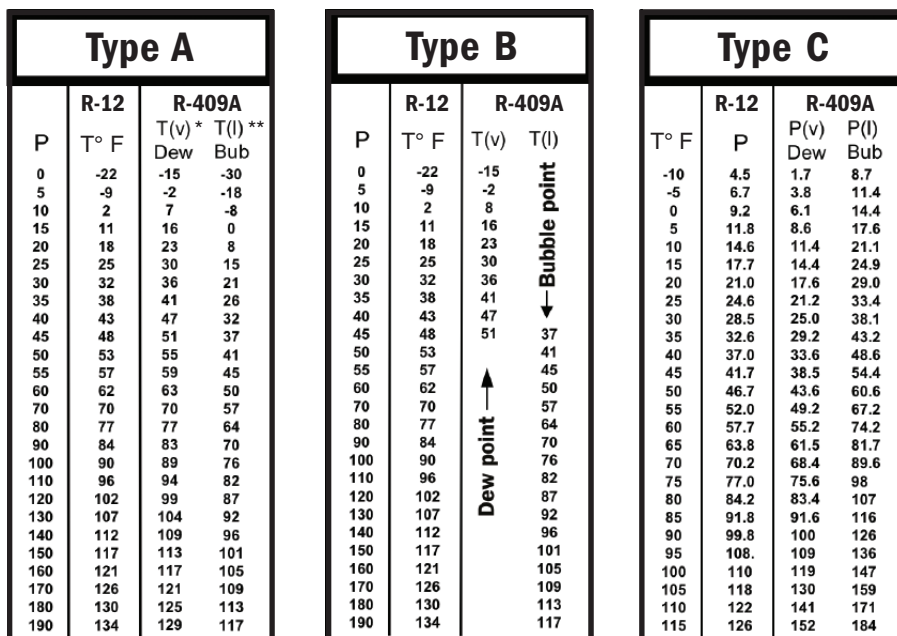
For blends, there are two values for the pressure/temperature relationship — one for the vapor and one for the liquid. Since saturated liquid will start to form bubbles when heated, this is called the bubble point. Similarly, when saturated vapor starts to cool it will form dewdrops, so it is called the dew point.

Troubleshooting with a PT chart

There are several key troubleshooting activities that require the use of a PT chart. It is important for the contractor or service tech to use the correct data when performing these activities, such as determining the operating coil temperature (or average coil temperature).

Service personnel will often want to know at what temperature the refrigerant is boiling or condensing inside the coil. Popular refrigerants, such as R-22 and R-404A, will have the temperature scale printed on the gauges and the coil temperature can be read directly.

The operating coil temperature for other single-component refrigerants, or low-glide blends, can be found on the PT chart by finding the gauge's pressure reading and looking



Pressure is on the left, and the columns are temperatures. For blends, there are two columns for dew-point temperature and bubble-point temperature at each pressure.

* Vapor
** Liquid

Pressure (or temperature) is on the left, and the columns contain temperatures (or pressures). For blends, lower temperatures list only dew-point data (for superheat measurements) and higher temperatures list only bubble-point data (for subcooling measurements).

Temperature is on the left, columns contain pressures. For blends, there are two columns for dew-point pressure and bubble-point pressure at each temperature.

It is important to recognize which kind of PT chart you have before using it to troubleshoot a system. The figure shows the three basic types of blend PT charts that are available.

at the corresponding temperature (there will be only one column to read). For higher-glide blends, however, the task is a little more difficult (refer to Figure 2 above):

- **Type A chart:** The pressure is found on the left, and the average of the bubble point (liquid) and dew point (vapor) temperatures will give the average coil temperature.

- **Type B chart:** In this case, you also must know the temperature glide for the blend you are using. For the evaporator, only the dew point (vapor) is given at colder temperatures. Since the dew point is the temperature of saturated vapor at the end of the evaporator, you will subtract one half of the temperature glide to find the average temperature at the middle of the coil.

For the condenser, only the bub-

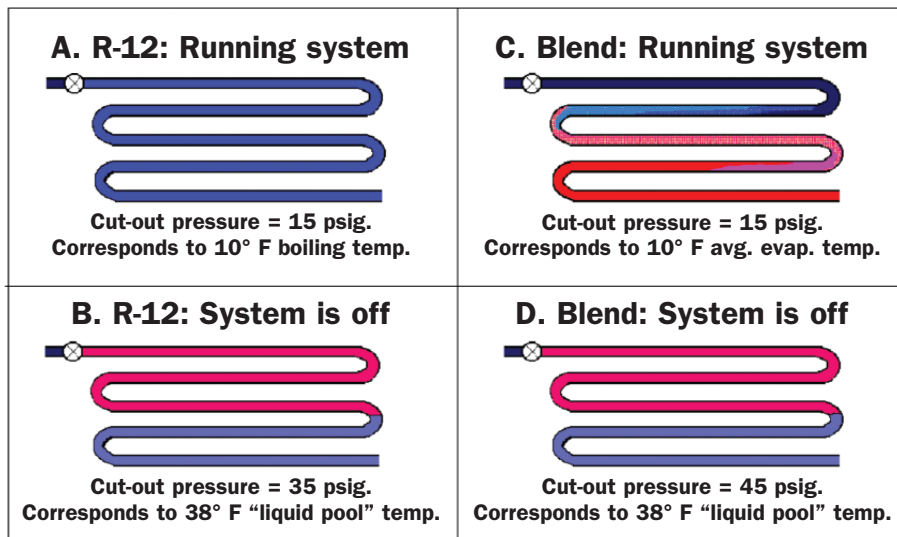
ble point (liquid) is given at higher temperatures. Since the bubble point is the temperature of saturated liquid at the end of the condenser, you must add one half of the glide to the bubble point to find the average coil temperature.

- **Type C chart:** Pressures are listed in the columns and temperature is on the left. The gauge pressure must be found in each of the bubble point (liquid) and dew point (vapor) columns, then the corresponding temperatures must be found for each. The average of these two temperatures will be the average coil temperature.

Determining superheat and subcooling

The process for determining superheat or subcooling is exactly the

Figure 3 Cut-in/cut-out pressure control using blends



An R-12 system will run until the coil reaches 10° F (the box is cold enough) and the pressure control senses 15 psig and turns off. When the system is off R-12 liquid pools in the coil. As the box warms, the refrigerant also warms until it is at 38° F and generating 35 psig. The control turns the system back on. After a retrofit, the blend is running an average evaporator temperature of 10° F at the same 15 psig. Leave the low pressure setting alone in this case. When the system is off the liquid blend is generating a higher pressure than R-12 would. Look at the liquid (bubble point) column on the PT chart to find the pressure that the blend will generate at 38° F, the new cut-in pressure setting (45 psig). Not making this adjustment will allow the system to come back on at 28° F, which is the temperature at 35 psig for this blend. The system will short-cycle and the coil eventually will ice over under these conditions.

same for blends as it is for single-component refrigerants:

A. Use gauges to determine the saturated refrigerant pressure.

B. Use a PT chart to determine the corresponding saturated refrigerant temperature.

C. Use a thermometer to measure the line temperature

D. Superheat: Subtract the saturated vapor temperature from the line temperature.

E. Subcooling: Subtract the line temperature from the saturated liquid temperature.

For single-component refrigerants or low-glide blends, there is only one temperature value on the PT chart that corresponds to the given pressure, and the vapor or liquid will boil or condense at that temperature.

- **Type A and C chart:** If you are

measuring superheat, the refrigerant will be saturated vapor at the end of the evaporator and you will use the dewpoint (vapor) column only. If you are measuring subcooling, the refrigerant will be saturated liquid at the end of the condenser and you will use the bubble point (liquid) column only.

- **Type B chart:** Superheat is usually only measured at colder temperatures. The data listed in the chart at cold temperatures will be the dew point (vapor) values.

Subcooling is usually measured at warmer temperatures. The data listed in the warmer part of the chart will be the bubble point (liquid) values.

Pressure controls

Sometimes a pressure control must be set according to the pressure that is generated by the refrigerant at a desired temperature. This is straight

forward for single-component refrigerants and low-glide blends because there is only one pressure listed for a given temperature. For blends, however, you must consider whether or not the system is running at the time.

When a system is running use the average evaporator or condenser temperature to determine the correct pressure setting for the appropriate control.

For example, a cooling water-flow control on a water-cooled condenser may be set to maintain a certain condensing temperature. The corresponding pressure setting must be determined by averaging the vapor and liquid data on the PT chart or adding half the glide for a type B chart.

When a system is off the refrigerant will sit somewhere in the system as a liquid. From the fractionation discussion in part one of this series, you should remember that the vapor above this liquid will adjust to a different composition.

Therefore, whenever a system is off you must use the bubble point (liquid) side of the PT chart to set any pressure controls. See Figure 3 for an example of setting a cut-in/cut-out pressure control.

Special note for type B charts: Data given at colder temperatures represent dew point (vapor) values and will not be correct for setting pressure controls when the system is off. Liquid pressures are needed and a Type B chart may not be useful for this operation.

How temperature glide affects superheat

One last consideration for troubleshooting a system after a retrofit: The temperature glide of a blend can affect the superheat setting of a TXV, potentially allowing the valve to flood through a hunt. Figure 4 shows how the temperature glide might reduce the effective superheat of a valve.

Given the system represented by the single-component diagram, the refrigerant is boiling at its boiling point and when the liquid is gone it will superheat. The TXV bulb is set around 10° F, as one example, or

around 7° F, as another example. This system is retrofit to a high-glide blend that has 14° F of temperature glide, as shown in the second diagram.

In this case, the average evaporator temperature would be the same as the original boiling point. However, the blend would enter the evaporator about 7° F lower than the original temperature and the saturated vapor at the end of the evaporator would be about 7° F warmer than the original temperature.

If no changes were made to the TXV bulb setting, then, given our first example, the superheat setting would be reduced from 10° F to 3° F. This would be an unacceptably low value for superheat and the valve would probably hunt or have trouble maintaining proper operation.

In the second example of a tighter superheat setting of 7° F, the blend would overcome the entire superheat safety factor. The valve would allow liquid refrigerant to flood through it.

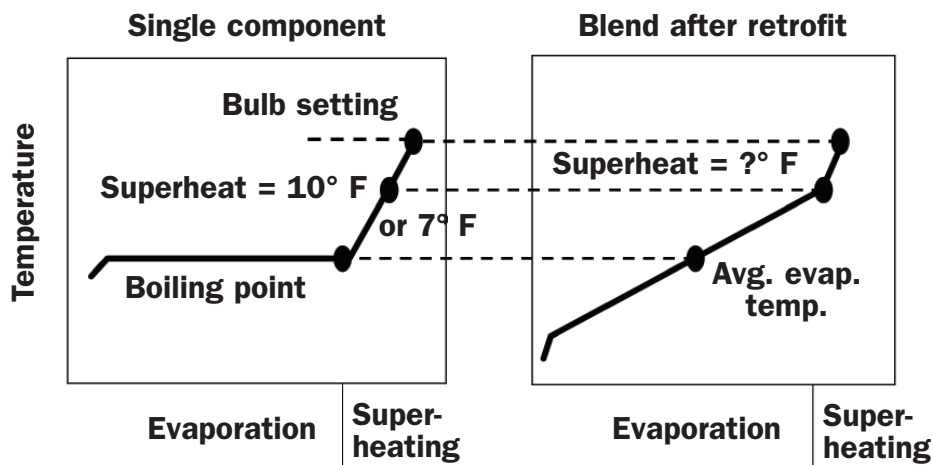
Tight superheat settings are often found on lower temperature R-12 systems; most of the higher-glide blends are R-12 alternatives. When retrofitting TXV systems with a high-glide blend you must take care to check the superheat of the valve after the retrofit using the vapor data for the blend.

Adjusting the spring setting on the bottom of the valve (turning clockwise) can increase the superheat setting. This allows the valve to regain control of the evaporator and prevent flooding.

Series wrapup

Refrigerant blends are able to duplicate many of the essential properties of the refrigerants that they are intended to replace. Blends, however, are also subject to fractionation and temperature glide, which can cause specific changes in system operation compared to the original refrigerant.

The best way to successfully apply retrofit blends is to become familiar with the properties of the products that you intend to use. Familiarize yourself with the temperature glide, average



TXV superheat settings can be affected by temperature glide. This example shows an original superheat setting of 10° F before and after a retrofit to a high-glide blend. The glide allows saturated vapor to move closer to the TXV bulb. This example also considers an original setting of 7° F and a retrofit blend with 14° F of glide, which will eliminate any measurable superheat and allow the valve to flood liquid through.

pressures that match the original temperatures of the product it replaces, charging recommendations (percentage of original) and the PT chart.

This information is usually available from the manufacturers or dis-

tributors of the blends. Much of it can be found online at companies' websites.◆

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