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

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.

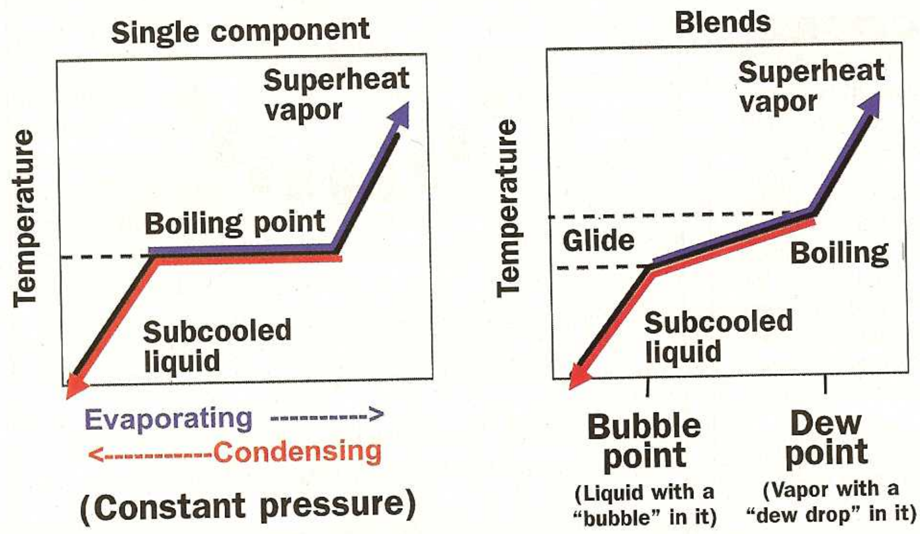
Therefore, a quick review of temperature glide from last month's article is necessary:

- 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.

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.

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 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.

Three types of PT charts — **Figure 2**

Type A

P	R-12 T° F	R-409A T(v)* Dew	R-409A T(l)** Bub
0	-22	-15	-30
5	-9	-2	-18
10	2	7	-8
15	11	16	0
20	18	23	8
25	25	30	15
30	32	36	21
35	38	41	26
40	43	47	32
45	48	51	37
50	53	55	41
55	57	59	45
60	62	63	50
70	70	70	57
80	77	77	64
90	84	83	70
100	90	89	76
110	96	94	82
120	102	99	87
130	107	104	92
140	112	109	96
150	117	113	101
160	121	117	105
170	126	121	109
180	130	125	113
190	134	129	117

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**

Type B

P	R-12 T° F	R-409A T(v)	R-409A T(l)
0	-22	-15	← Bubble point (↓)
5	-9	-2	
10	2	8	
15	11	16	
20	18	23	
25	25	30	
30	32	36	
35	38	41	
40	43	47	
45	48	51	37
50	53	(↑) Dew point →	41
55	57		45
60	62		50
70	70		57
80	77		64
90	84		70
100	90		76
110	96		82
120	102		87
130	107		92
140	112		96
150	117		101
160	121		105
170	126		109
180	130		113
190	134		117

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).

Type C

T° F	R-12 P	R-409A P(v) Dew	R-409A P(l) Bub
-10	4.5	1.7	8.7
-5	6.7	3.8	11.4
0	9.2	6.1	14.4
5	11.8	8.6	17.6
10	14.6	11.4	21.1
15	17.7	14.4	24.9
20	21.0	17.6	29.0
25	24.6	21.2	33.4
30	28.5	25.0	38.1
35	32.6	29.2	43.2
40	37.0	33.6	48.6
45	41.7	38.5	54.4
50	46.7	43.6	60.6
55	52.0	49.2	67.2
60	57.7	55.2	74.2
65	63.8	61.5	81.7
70	70.2	68.4	89.6
75	77.0	75.6	98
80	84.2	83.4	107
85	91.8	91.6	116
90	99.8	100	126
95	108.	109	136
100	110	119	147
105	118	130	159
110	122	141	171
115	126	152	184

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.

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 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.

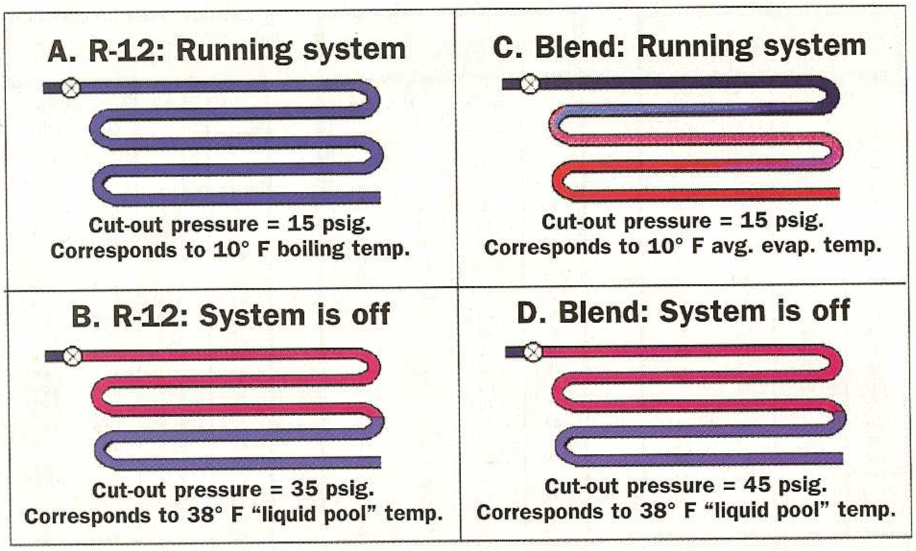
For the condenser, only the bubble point (liquid) is given at higher temperatures. Since the bubble point is the temperature of saturated liquid at the end of the condenser, you must add one half of the glide to the bubble point to find the average coil temperature.

- **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

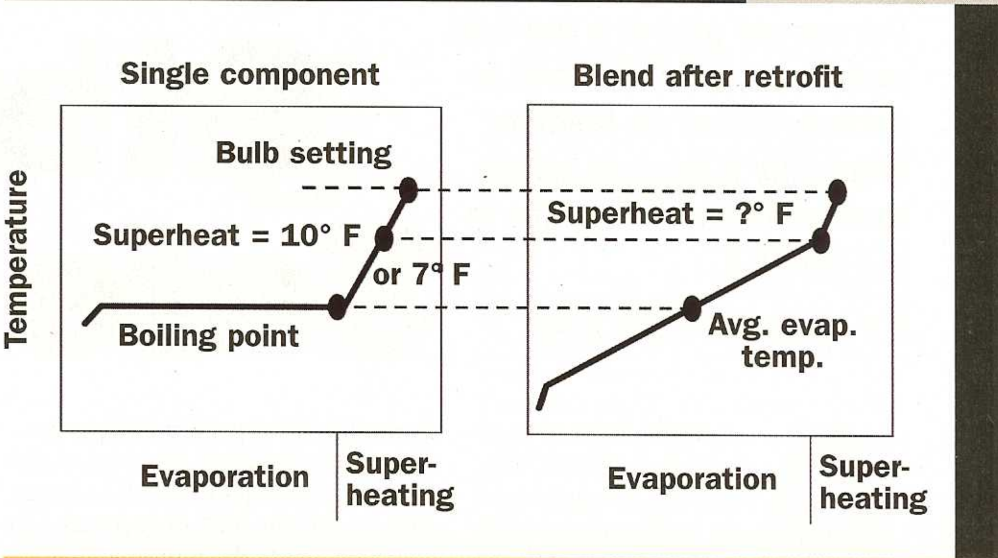
Refrigerant blends are able to duplicate many of the essential properties of the refrigerants that they are intended to replace. Blends, however, are also subject to fractionation and temperature glide, which can cause specific changes in system operation compared to the original refrigerant.

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

Jim Lavelle is technical sales manager at National Refrigerants Inc.

Average evaporator temperature and superheat **Figure 4**



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.