TECH TIP # 51

HEATING, AIRCONDITIONING & REFRIGERATION DISTRIBUTORS INTERNATIONAL

One of a series of dealer contractor technical advisories prepared by HARDI wholesalers as a customer service.

Refrigerants and Their Numbers

Refrigerant 12 and 22 are only two of today's 100+ recognized refrigerants. They are part of the halocarbon family of refrigerants; that is --- a chemical compound of carbon and one or more halogens. Halogens, in turn, are among the most active elements in chemistry and include fluorine, chlorine, bromine and iodine.

A "CFC" refrigerant is one with chlorine, fluorine and carbon as part of its structure. CFC means **C**hloro-**F**luoro-**C**arbon.

The halocarbon refrigerants began joining -- and then soon supplanting -- the old time inorganic refrigerants such as ammonia, carbon dioxide and sulfur dioxide in 1928. Development was spirited by Charles Kettering, perhaps more famous in the automotive world for his self-starter and the Kettering V-8 engine.

Numbers assigned to the refrigerants are really clues to their chemical compositions. It's a three digit system and it works like this:

> The **last** number indicates the exact number of fluorine atoms in the compound. **Subtract** one from the middle number and you have the number of hydrogen atoms (if any) in the refrigerant's chemical make-up.
>
> **Add** one to the first number and you have the number of carbon atoms in the refrigerant. (With only one carbon atom in a formula, the first digit is zero and therefore it is dropped.)

As examples: Refrigerant 22 has one atom of carbon (first number is really zero and code should read 022), one atom of hydrogen (subtract one from two) and two atoms of fluorine.

Refrigerant 12 has one atom of carbon, no hydrogen atoms and two atoms of fluorine. When a refrigerant has no hydrogen atoms, it is said to be a fully halogenated refrigerant.

Let's consider this in another way. To keep it simple, we'll skip over the complex chemical processes that are involved and only look at results.

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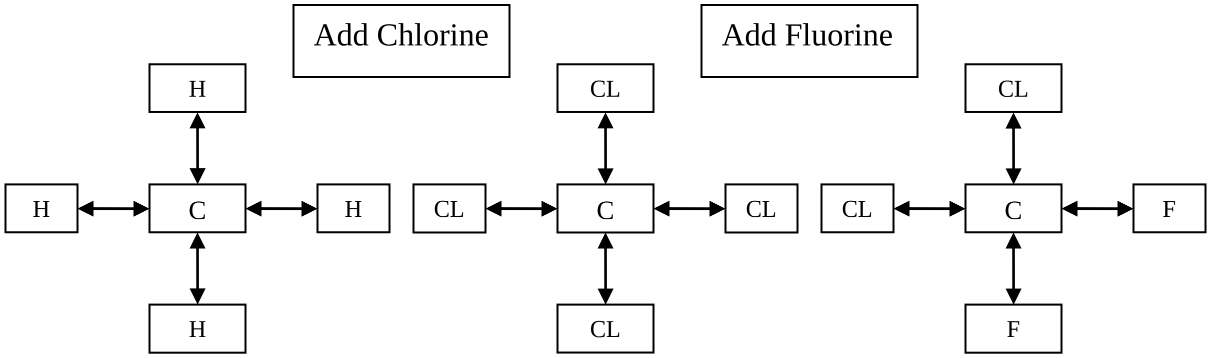
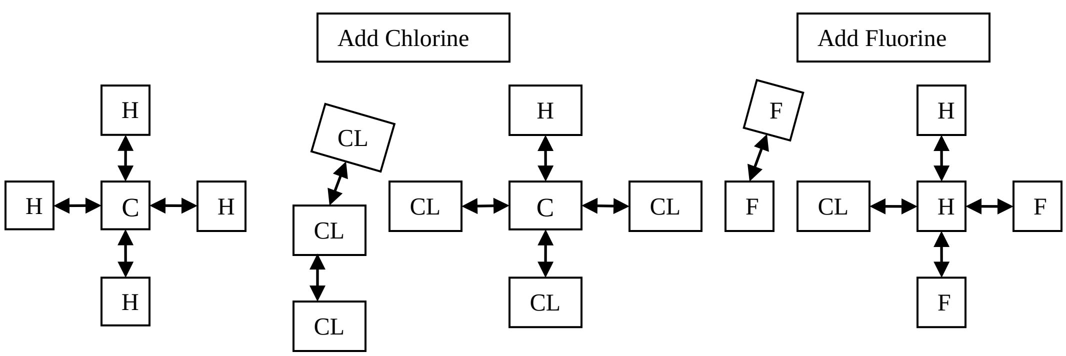


Take a hydrocarbon --- a compound made up of only hydrogen and carbon atoms. Methane gas is a good example --- four atoms of hydrogen (H) joined to one atom of carbon (C). Now “mix in” some chlorine (CL) and the result is carbontetrachloride. Four chlorine atoms (CL) have “kicked out” the four hydrogen atoms (H) and attached themselves to the one carbon (C) atom.

Next, “toss in” some fluorine (F). Two of the four chlorine (CL) atoms are replaced by two fluorine (F) -- the result is two fluorine atoms and two chlorine atoms attached to one carbon atom and we call it refrigerant (CFC) -12.

Note there are <u>no</u> hydrogen (H) atoms remaining in the finished product. Again, this is termed a <u>fully</u> halogenated CFC.



Suppose we find a different way of combining our elements. We start with a hydro-carbon again. We add chlorine again, but this time only three of the four hydrogen (H) atoms are kicked out --- one (H) stays. We have now produced chloroform. If we add fluorine (F) to this compound two chlorine (CL) atoms are replaced by two fluorine atoms as before, and the hydrogen atom (H) is undisturbed. The final product now is refrigerant (HCFC) -22 --- a hydro-chloro-fluoro-carbon, and not fully halogenated.

Why is this Distinction Important?

There is evidence that CFC type refrigerants released into the atmosphere help deplete the ozone layer that surrounds the earth and protects us from harmful ultraviolet radiation from the sun.

However, HCFC's --- those refrigerants that are not fully halogenated -- tend to break down before reaching the ozone layer and therefore are much less harmful to the ozone layer.

How much less? Scientists have established an Ozone Depletion Potential ((ODP) factor for each refrigerant.

To begin, CFC-11 is given an ODP of 1.0; then, all refrigerants are related to CFC-11 in terms of harmful effect. For example: CFC-12 has an ODP of 0.86 and HCFC-22 has an ODP of 0.05. Stated another way, it would take 20 pounds of HCFC-22 released in the atmosphere to cause the same effect on the ozone layer as one pound of CFC-11. For CFC-12, it would only take 1.16 pounds to cause the same effect as CFC-11.

Because hydro-chlorofluorocarbons are significantly less harmful to our atmosphere, the Air Conditioning and Refrigeration Institute (ARI) in the mid-1980's, dropped the "R" designation and started to identify halocarbons as either CFC or HCFC in their literature.

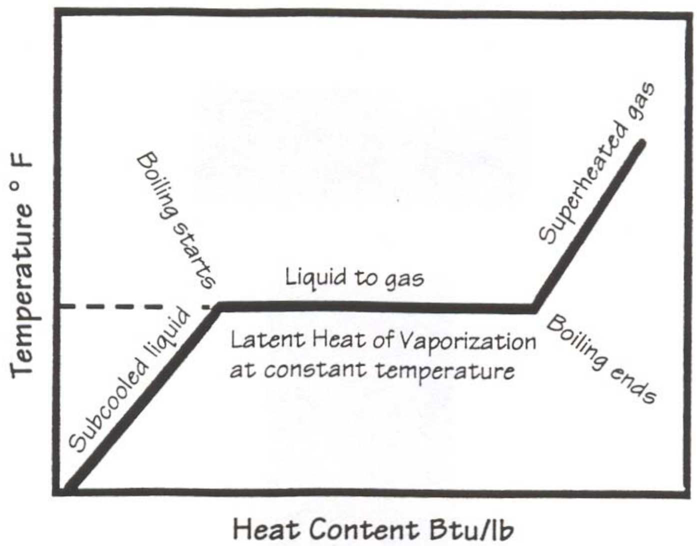
CFC-12 and HCFC-22 are examples of *methane* based compounds. They are part of the 000-series of refrigerants. The 100-series is *ethane* based. One example is R-134a or HFC-134a. This relatively new refrigerant contains no chlorine atom and is called a hydro-fluoro-carbon. Incidentally, the lower case "a" indicates a specific arrangement of the basic atoms. R-134 has the same "ingredients" as R-134a, but the atoms are linked differently and each refrigerant has different properties.

The 500-series such as R-502 identifies *Azeotrope* compounds. These are refrigerant blends that behave essentially like a single component -- boil and condense at constant temperature.

The 400-series of refrigerants are *Zeotropes*. One popular example is R-410A. These compounds do not behave exactly like a single refrigerant. (The capital "A" in this case relates to the percentage of each refrigerant in the blend. Thus, R-410B has the same "ingredients" but in different proportions. (R-410A is a 50/50 blend of R-32 and R-125; R-410B is a 45/55 blend.)

Zeotropes experience *glide* during boiling. Evaporation from a liquid to a vapor does not occur at a constant temperature. Glide is the difference between temperatures at the start of evaporation and at the start of condensation. *Bubble point* temperature is the start of boiling and the *dew point* temperature is when vapor first turns to liquid. Glide can range from a low of just 1^o to 14^o or more depending on the refrigerant blend.

Chart 1.



Let's consider this in some detail. Chart 1 plots temperature versus heat content for a pure substance or an azeotrope blend. Consider water at atmospheric pressure. The subcooled liquid water is heated until at 212° F it begins to boil and change into vapor (steam). When all the liquid has changed to vapor and heat is still added, it becomes superheated vapor. The liquid to vapor conversion (latent heat of vaporization) takes place at constant temperature. Thus, boiling start temperature and boiling end temperature are the same.

Chart 2.

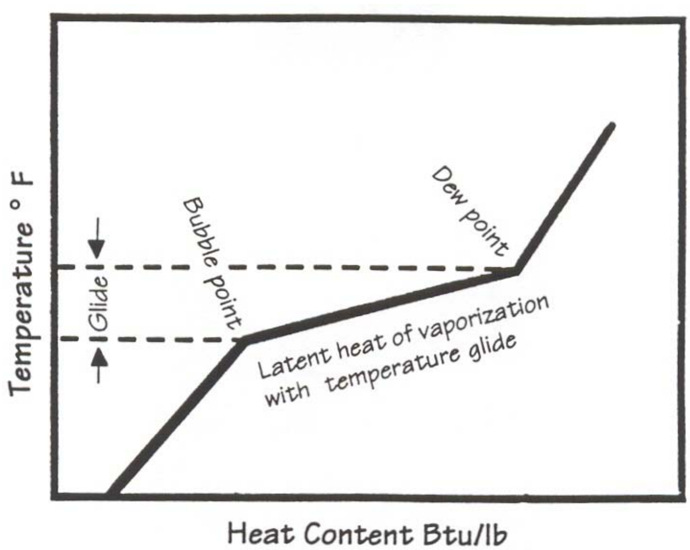


Chart 2 illustrates the same thing for a zeotrope mixture. The subcooled liquid mixture is heated until one of the refrigerants in the blend starts to vaporize. This is the bubble point. As more heat is added, the other refrigerants begin to vaporize at a higher and higher temperature (because of their individual characteristics) until finally all the refrigerants are vaporized. This is the dew point. The difference in the bubble point temperature and the dew point temperature is the glide.

Unlike standard refrigerant pressure/temperature tables, 400-series blends with large glides (2.5 or higher) will show two pressure columns versus temperature -- one for the liquid (bubble point) and one for the vapor (dew point).