Service Training

By Jim Wheeler

How To Charge Air Conditioners

In our October 1991 issue we ran the article "How NOT to Charge Systems." In reply to many requests for information on how to charge systems, we have decided to update and reprint this article that originally ran in December 1988.

Capillary/Orifice Metered Systems

In literally hundreds of visits to problem jobs, I've found most air conditioners/heat pumps to be overcharged with refrigerant. Why? Because incorrect charging techniques are too commonly used in the field.

I remember my first training on charging a residential air conditioner. The technician I worked with said: "Just add refrigerant until the high side is about 250-psig and the low side is about 60." And that's how I did it for the first six months of my career as a hvacr service technician.

Unfortunately, this is the same training many others in our industry received during the building rush of the early '70s.

It's comforting to know that few still use that method today, but some are even worse! The **"Gifted Finger" technique:** Adding refrigerant until the suction line turns cold – is one. Another is called the **Amprobe Method:** you add refrigerant until the compressor reaches rated amps.

And let's not forget the **Add 35*F approach:** this is a little more scientific. You add refrigerant until the saturated condensing temperature is 35*F above the outdoor ambient.

I know that by now some of you are sitting back and laughing, while others are wondering what's so funny. I really don't want to hurt your feelings if you use one of these methods- you certainly aren't alone or in the minority- but each of these techniques result in an overcharge, and often a ***GROSS*** overcharge.

Back when I used to work as a training manager for a Carrier distributor, I found it strange to find contractors filing claims for 10-lbs. Of refrigerant on systems that only held 6-lbs. However, after several field calls I found many actually ***WERE*** putting 10-lbs. Of refrigerant into a6-lbs. systems!

It's a common misconception among some technicians [and a few managers] that if you increase refrigerant beyond the specified charge, you *increase* system capacity. Actually, the opposite is true. Refrigerant added beyond the proper charge *reduces* capacity. This is because, on capillary or orifice metered equipment, as you add refrigerant you also raise the evaporator temperature.

The problem with some of these common charging methods, and the reason they shouldn't be used, is because they fail to address such factors as:

- Temperature relationships
- Proper superheat
- System operating conditions
- Condenser efficiency

An overcharge is far more likely to damage the compressor than an undercharge. With capillary and orifice metering devices, excess refrigerant is returned to the crankcase as a constant floodback, reducing capacity, efficiency, and compressor life.

I only know two ways to properly charge non-TXV [Thermostatic Expansion Valves] systems. Both are simple to use and generally universal in application. They include: the ***Weight Method*** and the ***Superheat Method.***

Weight Method: Weighing charge is simple, quick, and certain. The weight of the factory supplied charge is found on the model/serial number nameplate. If the system has 25-ft. of line [on split systems], the lines aren't over or undersized, and there's no field installed liquid line filter dryer, simply weigh the amount shown.

If there's a liquid line filter dryer, you probably have one of the same on the truck. Get it out and look at the instructions to find out how much extra refrigerant you must add to compensate. If the lines are longer, shorter, under or oversized, use the following chart to calculate corrections.

Weight	Line size
Oz./10 ft.	OD
2.1	¼"
3.6	5/16"
5.8	3/8"
11.5	½"
18.4	5/8"

Note: The total weight must be within one-half ounce of the recommended charge!

Since the charge is so critical, most mechanical scales aren't nearly accurate enough for use. Instead, use properly sized charging cylinder or an electronic charging scale.

When weighing refrigerant in, be careful about leakage to the atmosphere. Due to the laws on refrigerant venting, purging air from lines is no longer recommended. I suggest using self sealing refrigerant lines and keeping them as short as possible.

Four-port service gages are also a good idea. Although a manifold isn't required when charging, it's often needed when pulling a vacuum before charging. So connect the high and low sides, the refrigerant drum, and the vacuum pump, then open all the manifold ports and pull a vacuum on the lines as you evacuate the system.

To weigh the charge in, close all the manifold valves except the one to the drum/cylinder and the one to the system high side. Then turn the drum upside down. ***ALWAYS CHARGE LIQUID INTO THE SYSTEM HIGH SIDE ONLY!*** Next, open the drum/cylinder and allow the vacuum to draw liquid refrigerant in.

When no more refrigerant can be drawn in, turn the drum right side up [or connect to the top side of the cylinder], close the high side manifold valve, open the low side valve and start the system. The lower suction pressure will quickly draw in the rest of the charge.

Some electronic scales make charging easy as they shut the refrigerant off automatically when the proper weight is achieved.

Superheat Charging Method: I don't recommend adding charge to a system that's "just a little low", because I know there's probably a leak that should be ***REPAIRED!*** [Some technicians forget we're in the business of repairing leaks.] Find the leak, recover the remaining refrigerant, repair the leak, then put the refrigerant back into the system.

Now you're ready to charge by the superheat method.

To correctly charge a capillary or metering piston system, you must put in enough refrigerant to cool the compressor, but never so much that it allows floodback under any operating conditions. So to charge using the superheat method, you must consider:

- Outdoor temperature
- Evaporator temperature: which reflects airflow, system conditions, indoor humidity and temperature.
- Suction line temperature: which reflects superheat.
- Condenser efficiency

The first of these parameters can be plotted on a chart or graph. Condenser efficiencies can be divided into two basic categories:

- High efficiency
- Standard efficiency

The dividing line is probably around 10 SEER. So two charts, one for each, are necessary.

OD Temp	Standard Efficiency Charging Chart									
	Evaporator Pressures									
	44	48	52	56	60	64	68	72	76	80
	Suction Line Temperature [Degrees F]									
55	36	45	57							
60	31	40	51	66						
65	27	36	46	58	73					
70		32	41	52	63	76				
75		29	37	47	57	67	80			
80		26	33	42	51	61	71	83		
85			30	38	47	55	64	74	86	
90			27	34	42	51	59	68	77	90
95				31	38	46	54	62	71	81
100					34	42	50	57	65	75
105						38	45	52	60	69
110							41	47	54	63

OD Temp	High Efficiency Charging Chart											
	Evaporator Pressures											
	57	60	63	66	68	71	75	77	81	84	87	91
	Suction Line Temperature [Degrees F]											
60	60											
65	49	58	65									
70	41	48	58	68	70							
75	35	41	48	58	68	75						
80	31	36	42	50	59	69	80					
85			38	44	52	60	71	82				
90				40	47	53	61	69	78			
95					42	48	53	59	67	79		
100						43	47	52	58	68	88	
105							44	48	53	60	75	104
110									49	54	65	80

FIGURE 1

Note: On the two charts in Figure 1, only three readings are needed to determine the proper charge:

- Outdoor temperature
- Suction pressure-an indication of evaporator temperature
- Suction line temperature

As a result, only two tools are necessary, an accurate thermometer [preferably a digital thermometer reading 1/10ths of a degree] and your service gauges.

After taking an initial outdoor reading, attach the thermometer sensor securely to read the suction line temperature. With the system running, add the refrigerant as a vapor into the suction service port, while carefully monitoring the suction line temperature for a sign of a drop. I usually allow the vacuum to draw as much liquid into the liquid line as possible, then turn the drum upright and fine tune with vapor fed into the suction service valve. When some small temperature drop is noted [a few tenths of a degree], turn off the refrigerant and allow the system to run for a few minutes until it is stabilized. When a suction line temperature drop, no matter how slight is noted, you are within a few ounces of the correct charge.

Now check the temperatures and pressure against the appropriate charging chart. If the suction line is too warm and the pressure too low, too much superheat, add a little more refrigerant to raise the pressure and lower the suction line temperature. If you add too much, the pressure will rise too high and the line will become too cold, too little superheat. It takes very little charge to change these readings drastically. Always operate the system for at least five minutes after adding or removing some charge to assure it is stabilized, before taking further readings.

Advantages and conflicts

The charging charts demonstrate how incorrect and potentially damaging other, non-authorized charging methods really are. Notice that a unit will be properly charged when the suction line temperature is anywhere between 26 and 104*F, depending on the type of unit and conditions. What will charging until a cold return is felt by the hand yield?

Have you ever charged a unit one-day and returned a week later to find it grossly over or undercharged? Using this method, you can charge a system on a 55* day and it will still be correctly charged when the weather is 105*F, if the condenser airflow is correct and there are no noncondensibles [air or other refrigerant] in the system. *Even when the evaporator airflow is low, you can* *use this method to check for a correct charge, before diagnosis.*

Some manufacturers of residential units prefer their own charts and may object to this method. Certainly use the manufacturers recommended methods when they are available. These charts are for use only when you don't have the proper charging information. However, all manufacturers suggest methods to achieve the same results, top efficiency and compressor protection.

Suction line temperature curve

Typical temperatures of a suction line as it is being charged are graphed in figure 2. The line to point [a] is considerably shortened. It represents the temperature of the suction line before some cool refrigerant is returned. Suction line temperatures at this point reflects the temperature of the indoor air flowing across the evaporator coil.

When the system is within an ounce or two of the proper charge, suction line temperatures usually start to drop at this point [b]. If you read this drop using a sensitive thermometer and immediately close off the refrigerant feed, after stabilization the line temperature may reach point [c], the correct charge.

Point [d] represents floodback, 0* superheat. Notice, either adding or removing refrigerant will raise the suction line temperature. Try to prevent the refrigerant charge from ever reaching this point, because compressor damage begins here. It frequently takes just one fluid ounce more that the proper charge to reach zero superheat/floodback, at design conditions. Point [e] represents a worsening floodback condition. As refrigerant is added, the suction line temperature starts to rise, because a rise in suction pressure causes the saturated evaporator temperatures to rise. An overcharge reduces system capacity because the greater the overcharge, the warmer the evaporator and the lower the capacity. The cooling isn't lost, it is simply being wasted in a compressor that is beginning to sweat. *A sweating compressor is an indication of an overcharge!*

Temp
Deg.F.

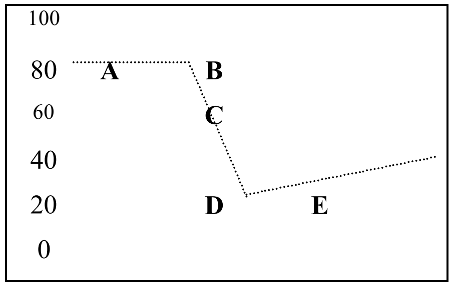

Figure 2
Typical suction line temperature curve as charge is being added.

A good test of principle is to check the suction line temperature on a system that has been running for a while and then let out a little refrigerant. If the temperature remains constant, or if it starts to drop, the system is overcharged. You will be surprised at how many times you will encounter an overcharge.

Without even considering capacity loss, damage to the compressor is occurring. The main cause of residential compressor valve or lubrication failures is an overcharge. Most residential air conditioners are overcharged some time during their operational life. Remember, on small air conditioning systems where capillary tubes or metering pistons are used, the charge is critical! Charge accuracy on such systems should be within 1/100th of the total charge weight.

Part 2- Commercial

Large, commercial air conditioning equipment using thermostatic expansion valves also require the correct system charge, although charge tolerances are not as critical as with capillary tubes. Just as most small systems are overcharged, most large systems are undercharged! The problem here is a lack of understanding of subcooling and how it is achieved.

The common method for charging TXV [Thermal expansion valve] equipment is simply to add refrigerant until the sight glass clears. Everyone knows that, right? That's right, but sometimes they're wrong, sometimes.

Charging until the sight glass clears is the correct for equipment in which receivers are used. Since both refrigerant liquid and vapor are present in a receiver, the refrigerant is in a saturated condition, which does not allow for the energy saving effects of subcooling [cooling below saturation]. With such systems, the sight glass is located just outside the receiver, and charging until it is clear is the correct procedure.

But today, due to greater emphasis on high efficiency operation and concern over compressor problems associated with too much refrigerant volume, receivers are becoming obsolete, along with this charging method.

Subcooling considerations

Subcooling occurs when the temperature of the refrigerant in the liquid line is lowered below its saturation point. When refrigerant is subcooled, there is less heat content as it enters the metering devise and thus, more cooling is possible. Most modern equipment is designed to provide 10 or more degrees of subcooling, by using larger condensers or by addition of subcooling coils.

So after adding refrigerant to clear the liquid line sight glass at normal temperatures, you must add more refrigerant to provide the necessary subcooling. If you fail to do this, the equipment will not work to capacity and further losses due to liquid line "flashing" will occur.

Subcooling charging method

The amount of subcooling can be determined by checking the liquid line temperature and then comparing it to the saturated condenser temperature as read on a high side gauge. As an example: A head pressure of 250 psig yields a saturated temperature of 117*F [using a refrigerant pressure-temperature chart or from the gauge R-22 scale].

Charging until the liquid line temperature leaving the condenser is 107*F [in our example] assures at least 10* subcooling [117-107=10]. This [10*] is the amount of subcooling specified for many systems, and it will seldom get you in trouble.

However, to achieve even greater efficiencies on some systems [where subcooling circuits are large enough], charge until the liquid line temperature at the metering device equals the outdoor temperature. Since condenser coils are less than 100% efficient, the refrigerant temperature leaving the condenser will never equal the outdoor ambient, but a liquid line that is sufficiently long and which runs through a cooler outdoor ambient may be used to provide additional subcooling. You can then achieve maximum efficiency by adding refrigerant to cool this line, until you note some significant rise in head pressure or until the line temperature reaches outdoor ambient, whichever comes first.

Rapid charging method

Many service mechanics still try to charge large systems by cracking the suction line service valve and adding refrigerant in the vapor state with the system operating. This procedure takes forever! As a result, these service mechanics take a chance on damaging a new compressor by turning the refrigerant drum upside down and flooding liquid into the suction side. There are safer and faster methods.

When you are weighing in a charge, refrigerant can be added as a vapor more quickly on small systems by::

- bypassing the low pressure switch and…
- connecting the refrigerant drum with a short hose to the compressor suction service port, then…
- close the compressor suction service valve and open the refrigerant valve, making the drum the sole source of refrigerant for the compressor. It will be quickly emptied.

High side charging

On larger systems, where there is a king valve in the liquid line, the refrigerant can be more quickly charged into this valve in the liquid state. Once again:

- Use a short hose
- Connect the drum to the king valve
- With the system running, front seat the king valve
- Turn the refrigerant drum upside down and open the refrigerant valve.

Liquid refrigerant will be quickly drawn into the liquid line by the compressor, metered and evaporated. Compressed liquid is then stored in the condenser or receiver until the complete charge is weighed in.

Be careful not to use this method where there are long or oversized liquid lines and no receiver, as the condenser may not be sufficiently large to hold the entire system charge.