3.8 EVALUATING REFRIGERANT CHARGE

The performance and efficiency of residential and light-commercial air conditioners and heat pumps is very dependent upon having the correct amount of refrigerant in the system. This section describes accepted procedures for measuring and adjusting refrigerant charge in residential and light-commercial air conditioners and heat pumps.

The testing procedure for different air conditioners and heat pumps depends on the type of expansion valve the unit has. Units with fixed-orifice expansion devices require superheat testing. Units with TXVs require subcooling testing. All testing and subsequent addition or removal of refrigerant should be done by qualified and EPA-licensed refrigeration technicians.

PREPARATIONS FOR CHARGE TESTING

Refrigerant-charge testing and adjustment should be done after airflow measurement and improvement and after duct testing and sealing. The logic behind this sequence is that airflow should be adequate before duct sealing is done in case you have to add or enlarge ducts. Manufacturers recommend that adequate airflow be verified before charge is checked and adjusted.

With existing condenser units, it's an excellent idea to clean the condenser coil before testing and adjusting refrigerant charge. After cleaning the coil with outdoor coil cleaner, let the coil dry thoroughly. Otherwise suction and head pressures will read abnormally low.

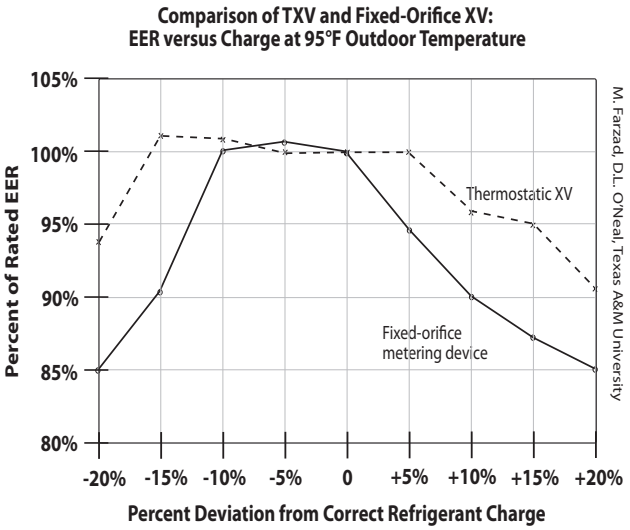
Required equipment

For withdrawing refrigerant, use a U.S. Department of Transportation (D.O.T.) recovery cylinder. You'll usually be adding refrigerant from a R-22 or R-410A cylinder, however you can put refrigerant back into the same unit from the recovery cylinder after evacuating the system.

Required equipment includes a refrigeration gauge set and a digital thermometer. The digital thermometer should have a cloth covering for the tip of one of its thermocouples, which is wetted to measure wet-bulb temperature of air entering the evaporator. A sling psychrometer can also be used to measure wet-bulb temperature of air entering the evaporator.

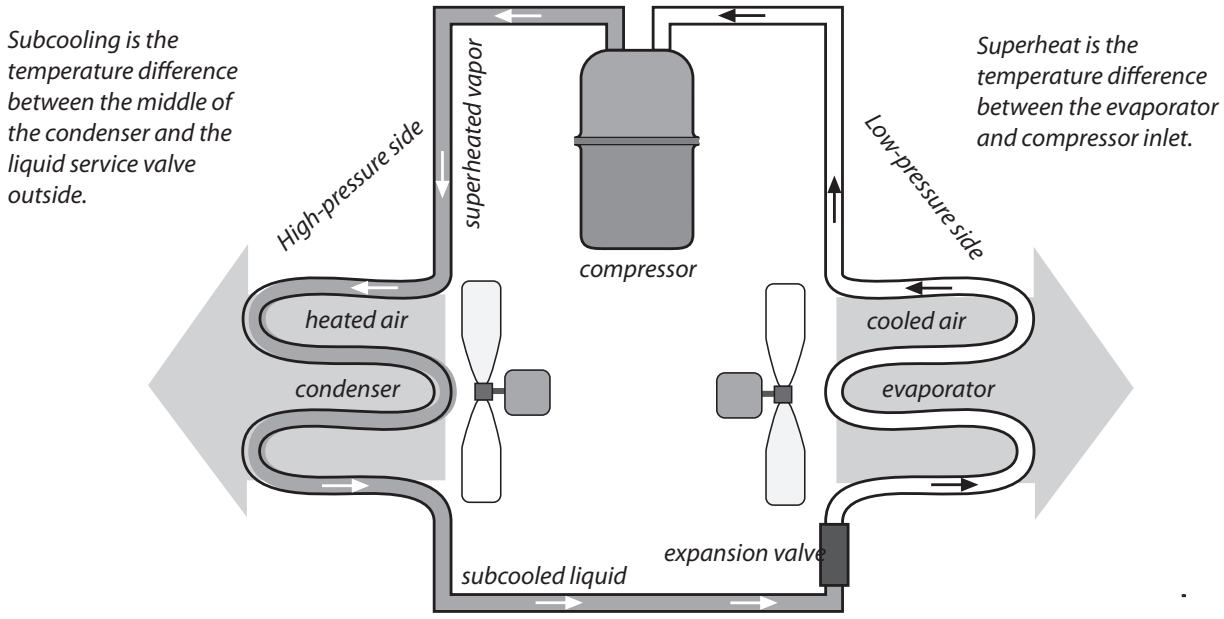
EVAPORATOR SUPERHEAT TEST

Adjusting the refrigerant charge to produce the recommended superheat temperature, based on current indoor and outdoor temperatures optimizes system performance and efficiency. Superheat is an good indicator of correct charging for air conditioners and heat pumps with capillary-tube or fixed-orifice expansion devices, operating in the cooling mode.

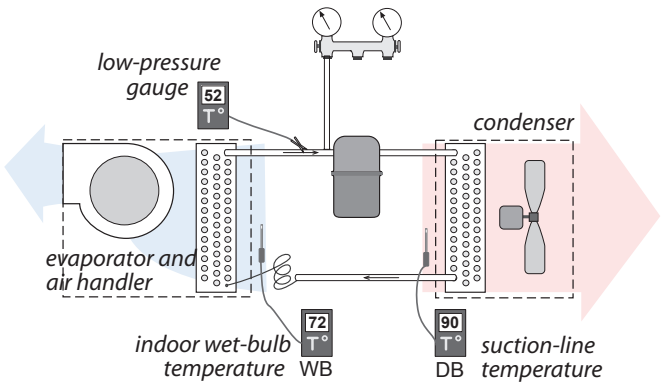


Energy Efficiency Ratio (EER) degrades with incorrect charge: Thermostatic expansion valves compensate a little for charge that is too high or low. Fixed-orifice expansion devices are more severely affected by incorrect charge.

Use this test only for fixed orifice or capillary-tube systems and not for thermostatic expansion value (TVX) systems. This test should only be done when the outdoor temperature is at least 60°F.



1. Before checking charge, test and verify adequate airflow, using procedures in *Section 3.6.*
2. Measure the dry bulb temperature of the air entering the outdoor coil.
3. Measure the wet bulb temperature of the return air at the air handler.
4. Determine the recommended superheat temperature from a superheat table.
5. Measure the compressor-suction pressure at the suction-service valve. Add 2 pounds per square inch of gauge pressure (psig) for line losses between the evaporator and compressor. Then convert this adjusted pressure to a boiling-point temperature using temperature-pressure tables.
6. Measure the suction-line temperature at the suction service valve by attaching a thermocouple there, taped and insulated to the piping.
7. Subtract the boiling-point temperature determined in (4) from the measured temperature in (5). This is the actual superheat temperature.
8. If the actual superheat is greater than the recommended superheat obtained from the table by more than 5°F, add 2-4 ounces of refrigerant, and wait at least ten minutes before repeating this superheat procedure.
9. If the actual superheat is less than the ideal by more than 5°F, remove 2-4 ounces refrigerant, and wait at least ten minutes before measuring superheat again. Refrigerant must be removed into a Department-of-Transportation-approved (DOT-approved) recovery cylinder, either empty or containing the same refrigerant as the system.



Low-pressure gauge reads 67 psi, which corresponds to 39°F evaporating temperature. Superheat is 52° – 39° = 13°F.

Superheat test: Superheat is the heat added to the evaporating vapor to ensure that no liquid enters the compressor. For a fixed-orifice system this value varies with outdoor temperature and indoor temperature and humidity.

Limitations of the Superheat Test

First, superheat won't be accurate unless airflow is around 400 cfm per ton, so airflow should be measured and improved, if inadequate. Sometimes you can't charge by superheat because of either low or high outdoor temperature. Superheat disappears at high outdoor temperatures, and charge-checking at these temperatures is not recommended. As outdoor temperature rises, system pressures rise, and refrigerant flow rate through the fixed orifice increases until flooding may occur. Therefore, some superheat is desirable, even at high outdoor temperatures to protect the compressor from liquid refrigerant. Providing 1 to 5°F of superheat—even at high outdoor temperatures where superheat values aren't listed—would create a slight undercharge, which would protect the compressor while slightly improving hot-weather performance.

Subcooling Test to Ensure Proper Charge

Follow manufacturer's instructions for the subcooling test, if available. This test is only to be used for thermal expansion valve (TXV) systems when the outdoor temperature is at least 60°F. The air conditioner or heat pump should be running in the cooling mode for 10 minutes prior to the test.

1. Measure the liquid pressure at the liquid service valve. Convert this pressure to the condenser saturation temperature, using temperature-pressure tables for the system's refrigerant.
2. Measure the temperature of the liquid refrigerant leaving the condenser.
3. Subtract the liquid-refrigerant temperature measured in (2) from the condensing temperature determined in (1). This is the subcooling.
4. Find the correct subcooling from the permanent sticker inside the condenser unit, from manufacturer's literature, or from a manufacturer's slide rule. Add refrigerant if the measured subcooling temperature is 3°F or more below the recommendation. Withdraw refrigerant if the subcooling temperature is 3°F or more greater than recommended. Refrigerant must be removed into an empty DOT-approved recovery cylinder or one containing the same refrigerant as the system.

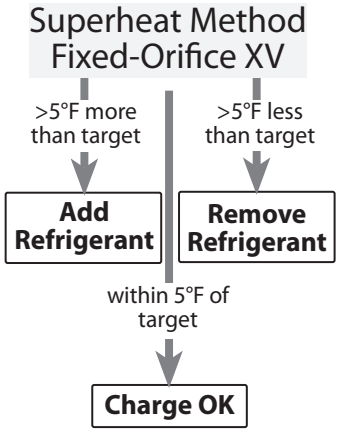
Allow the system to run for 10 minutes to adjust to the new operating conditions. Repeat the subcooling procedure, until the measured subcooling temperature matches manufacturer's recommendations or is between 10° and 15°F.

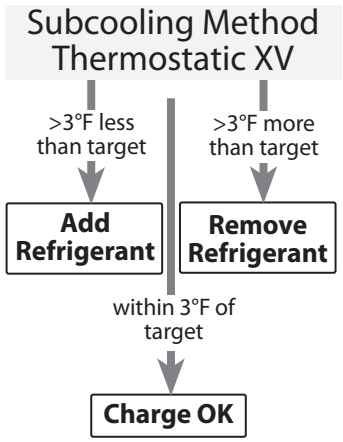
Table 3.8.1: Ideal Superheat Values for Different Indoor and Outdoor Conditions

Measured Return-Air Wet Bulb	Measured Outdoor Condenser Entering Dry-Bulb Temperature												
	55	60	65	70	75	80	85	90	95	100	105	110	115
76	45	43	41	39	37	35	33	31	29	27	26	25	23
74	42	40	38	36	34	31	30	27	25	23	22	20	18
72	40	38	36	33	30	28	26	24	22	20	17	15	14
70	37	35	33	30	28	25	22	20	18	15	13	11	8
68	35	33	30	27	24	21	19	16	14	12	9	6	-
66	32	30	27	24	21	18	15	13	10	8	5	-	-
64	29	27	24	21	18	15	11	9	6	-	-	-	-
62	26	24	21	19	15	12	8	5	-	-	-	-	-
60	23	21	19	16	12	8	-	-	-	-	-	-	-
58	20	18	16	13	9	5	-	-	-	-	-	-	-
56	17	15	13	10	6	-	-	-	-	-	-	-	-
54	14	12	10	7	-	-	-	-	-	-	-	-	-
52	12	10	6	-	-	-	-	-	-	-	-	-	-
50	9	7	-	-	-	-	-	-	-	-	-	-	-

Interpreting Subcooling

The thermostatic expansion valve is the best available metering device because it varies the orifice size to meet changing indoor and outdoor conditions. It compensates for low airflow and incorrect charge better than fixed orifice expansion valves. With luck, the technician will find a recommendation for subcooling in the manufacturer's literature or on the nameplate or sticker somewhere in the outdoor unit. A subcooling temperature between 10° and 15°F is common for a properly functioning residential air conditioner, but it is better to use manufacturer's specifications for subcooling if they are available.

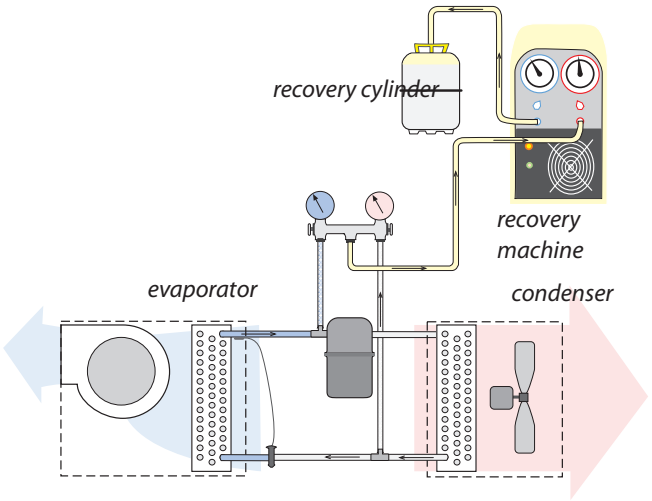




WEIGH-IN TEST FOR PROPER REFRIGERANT CHARGE

This is the preferred method of achieving the correct charge. Weigh in refrigerant whenever you are charging:

- New installations,
- Systems where the refrigerant has leaked out,
- To correct refrigerant charge if found to be incorrect after checking superheat or subcooling, or
- To remove existing refrigerant in an EPA-approved manner and recharge the system by weighing in the correct amount of refrigerant whenever superheat or subcooling tests can't be employed.



Refrigerant recovery. Most of the refrigerant will flow from the system to a recovery cylinder as a liquid, while being filtered by the recovery machine. The recovery machine can recover the most of the remaining refrigerant as a vapor by pulling a vacuum of 10 inches of mercury.

Follow these procedures to evacuate the existing charge and weigh in the correct one.

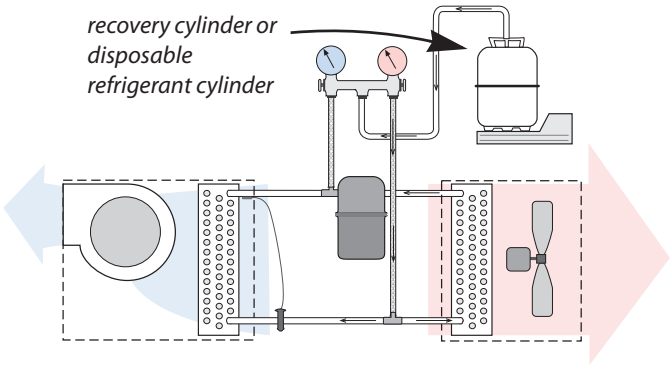
1. Follow the recovery machine's operating instructions for connecting hoses.
2. Remove the refrigerant with the recovery machine. The recovery machine should pull a vacuum of at least 10 inches of mercury. Recover the refrigerant into a DOT-approved cylinder, noting the weight of refrigerant recovered and recycled.
3. Evacuate the system to 500 microns to remove moisture and impurities, using a vacuum pump.
4. Determine the correct charge by reading it from the nameplate. From manufacturer's literature or by contacting a manufacturer's representative, determine the length of lineset that the nameplate charge assumes.
5. Accurately measure the unit's installed lineset length. Depending on whether the existing lineset is longer or shorter than the manufacturer's assumed lineset length, add or subtract ounces of refrigerant, based on the manufacturer's specifications of refrigerant ounces per foot of suction and liquid line.

6. Connect the EPA-approved recovery cylinder or disposable cylinder to the gauge manifold. Place the cylinder on an electronic scale and zero the scale. During charging, be very careful not to bump or otherwise disturb the scale or cylinder. The scale could reset itself, forcing you to evacuate and start all over.
7. To prepare for liquid charging, connect the common port of the gauge manifold to the liquid valve of the recovery cylinder. If using a disposable cylinder, turn the cylinder upside down after connecting the common port to the cylinder valve.
8. With the compressor off, open the cylinder's valve and suction service valve, and let the liquid refrigerant flow in.

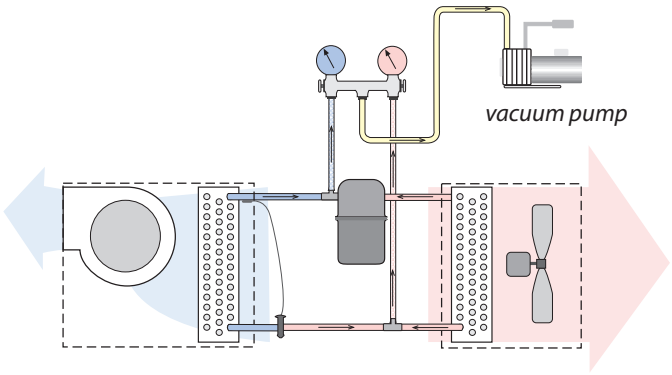
Purging refrigerant for a gauge hose

When you connect your high-pressure gauge to the high-pressure liquid service valve, the hose fills with liquid refrigerant. Rather than releasing this refrigerant into the atmosphere or carrying it around to contaminate another system, run it back into the low-pressure suction service valve. Modern hoses hold refrigerant under pressure when they are disconnected, so disconnect the high-pressure hose. Open the common chamber of the gauge set to the suction service valve. Then open the common chamber to the high-pressure hose, slowly letting the liquid refrigerant hiss through the chamber, vaporizing before reaching the low-pressure service valve or nearby compressor.

9. If liquid stops flowing before the correct charge has entered, reconfigure the gauge manifold and cylinder to charge with vapor through the suction service valve.
10. With the compressor running, add the remaining refrigerant as a vapor. Before opening path between the cylinder and the system, check the low-pressure gauge to make sure the cylinder pressure is higher than the system's suction pressure.
11. Weigh in the remainder of the charge.
12. Check performance after 10 minutes of operation using superheat test or subcooling test.



Liquid charging: Most of the captured refrigerant should flow into the evacuated system as a liquid through the liquid service valve.



Vacuum-pump evacuation: The last remains of the system's refrigerant are vented into the atmosphere along with air and moisture, leaving the system clean and ready for charging.

Limitations of the Weigh-In Method

Ideally, the service technician will have the manufacturer's literature, which specifies the lineset length, assumed by the manufacturer, and the amount of refrigerant required for each foot of suction and liquid line. You may also need to know the weight of refrigerant contained in the indoor coil. The weigh-in method can't be performed accurately without this information. Without accurately measuring the lineset length, the weigh-in method can't be performed accurately either. Sometimes, the difficulty of obtaining the manufacturer's specifications makes the weigh-in method a poor choice because just the difference between the manufacturer's choices of linesets (15, 20, and 25 feet) can result in a charge no more accurate than ±5-to-15 ounces, which is unacceptable.