prepared by 1) the documentation author and submitted to the mechanical contractor, or 2) a mechanical engineer, or 3) the mechanical contractor who is installing the equipment.

## 4.3.2 Prescriptive Requirements

*§151(f)7*

The prescriptive packages C, D and E, for split system equipment in climate zones 2 and 8 through 15, require refrigerant charge measurement (RCM) and the installation of temperature measurement access holes (TMAH) and saturation temperature measurement sensors (STMS). The RCM must be HERS verified. TMAH and STMS make non-intrusive methods for HERS verification of RCM possible. The alternative to the RCM, TMAH, and STMS is the installation of a refrigerant charge indicator display (§151(f)7Aii).

### *Refrigerant Charge Measurement (RCM)*

The prescriptive standards require that a HERS rater verify that split system air conditioners and heat pumps have the correct refrigerant charge. The procedures that HERS raters are required to follow are documented in the Reference Residential Appendix RA3.2. Packaged units are not required to have refrigerant charge measurement.

The measurement and regulation of correct refrigerant charge can significantly improve the performance of air conditioning equipment. Refrigerants are the working fluids in air conditioning and heat pump systems that absorb heat energy from one area (the evaporator) and transfer it to another (the condenser).

Refrigerant charge refers to the actual amount of refrigerant present in the system. Excessive refrigerant charge (overcharge) reduces system efficiency and can lead to premature compressor failure. Insufficient refrigerant charge (undercharge) also reduces system efficiency and can cause compressors to overheat.

### *Temperature Measurement Access Holes (TMAH)*

TMAH provides a non-intrusive means for refrigerant charge verification by HERS raters and other third party inspectors, since it eliminates the need for the raters/inspectors to drill holes into the installed air conditioning equipment enclosures for placement of the temperature sensors that are required by the refrigerant charge verification test procedures described in the Reference Residential Appendix RA3.2.

Installation of TMAH must be performed by the installer of the air conditioner or heat pump equipment according to the specifications given in Reference Residential Appendix RA3.2.

The TMAH feature consists of two 5/16 inch (8 mm) holes in the plenum, one upstream from the evaporator coil and one downstream from it (see diagram in section RA3.2).

### *Saturation Temperature Measurement Sensors (STMS)*

The STMS provides a non-intrusive means for refrigerant charge verification by HERS raters and other third party inspectors, since it eliminates the need for the raters/inspectors to open the system's refrigerant service access ports to install refrigerant pressure gauges on the suction and discharge lines. The test procedures that utilize these STMS are described in the Reference Residential Appendix RA3.2.

The STMS feature consists of two permanently installed temperature sensors, one mounted on the evaporator coil and one mounted on the condenser coil. The sensors are required to be factory installed, or field installed according to manufacturer's specifications, or otherwise installed in accordance with an alternative installation/instrumentation specification that must be approved by the Executive Director. These STMS must be equipped with industry standard mini plugs that allow the system installers and HERS raters to use the sensors to measure the coil saturation temperature by attaching the temperature sensor mini plugs to a digital thermometer instrument.

To adjust or check the refrigerant charge on an air conditioning system using the standard charge measurement procedures in Reference Residential Appendix RA3.2, it is necessary to determine the instantaneous "saturation temperature" in the evaporator coil and in the condenser coil. A refrigeration technician typically determines this temperature by measuring the coil pressure and using a saturation temperature chart to look up the saturation temperature at that pressure.

Another way to determine the saturation temperature in the coil is to measure the temperature of the refrigerant tubing in the saturation temperature region of one of the tubing circuits in the coil, using a thermocouple installed for this purpose by the equipment manufacturer or the air conditioning contractor.

For a coil in a typical system operating at steady state, approximately 75% of the length of any tubing circuit in the coil will be at a constant saturation temperature and pressure (the refrigerant is undergoing a phase change). To determine the location of the saturation temperature region of the circuit, trace the path of the refrigerant tubing circuit from the inlet of the tubing circuit, to the outlet of the tubing circuit.

In the condenser coil, generally the first 10% to 20% of each tubing circuit contains superheated vapor, the center 60% to 80% of the tubing circuit contains refrigerant undergoing a phase change (condensing the vapor into a liquid at a constant temperature) and the last 10% to 20% of the tubing circuit contains sub-cooled liquid. Figure 4-3 shows a condenser coil with multiple tubing circuits, with a Type K thermocouple attached to the saturation temperature region of one of the tubing circuits.

In the evaporator coil, the first 60% or more of the circuit contains refrigerant changing from liquid to vapor at the saturation temperature, and the last portion of the circuit contains superheated vapor. Figure 4-4 shows an evaporator coil with a simple tubing circuit.

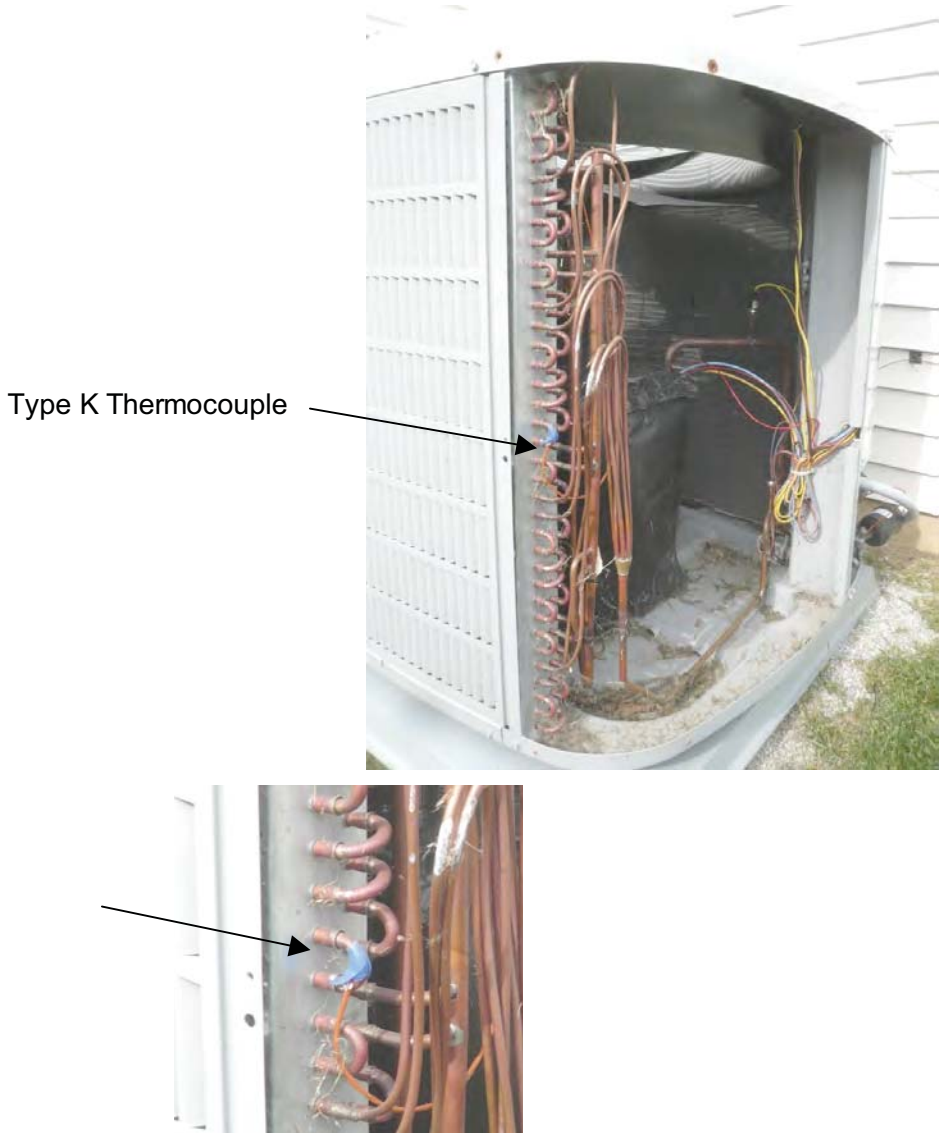


*Figure 4-3 – Condenser Coil with STMS attached*

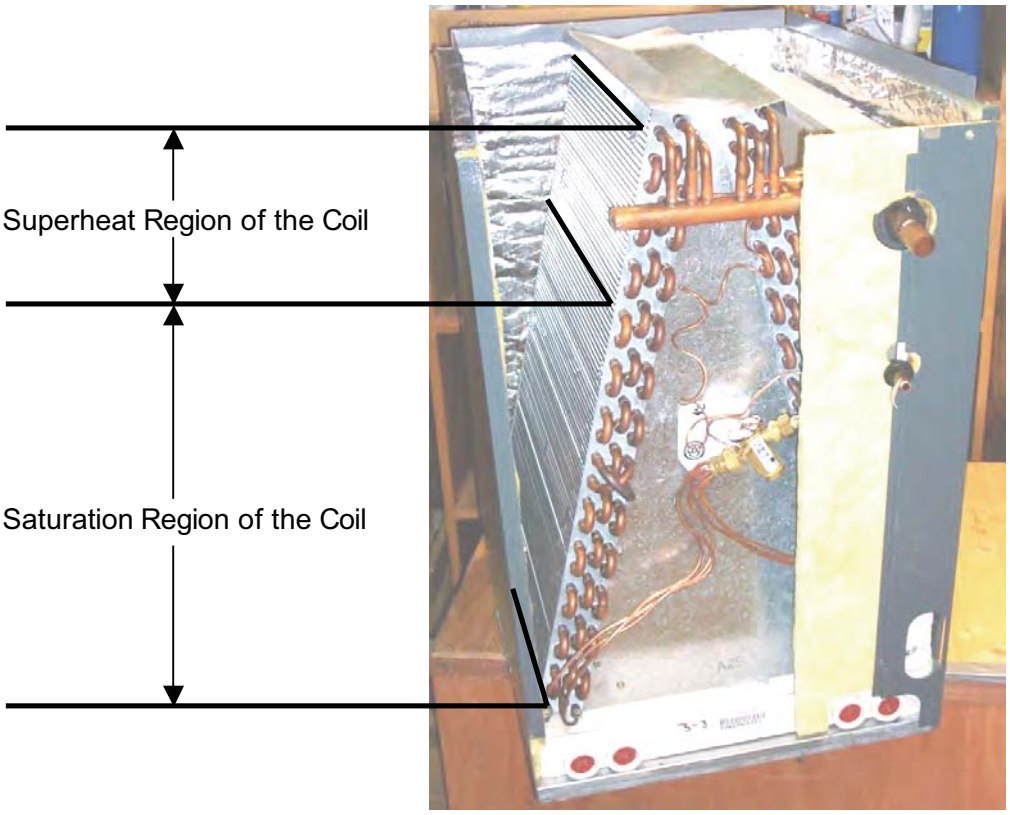


*Figure 4-4 – Evaporator Coil*

Thermocouples shall be type K with the sensing tip permanently attached to the refrigerant piping and insulated with cork tape at the location specified by the equipment manufacturer. An industry standard plug shall be lead to the outside of the equipment where it will be accessible to technicians or HERS raters without any disassembly of the equipment.

If the manufacturer's thermocouple installation instructions are not available, the system designer shall include specifications on the system's design drawings for the installed location of the thermocouples. The air conditioning contractor shall install the thermocouple in good contact with the tube bend at the specified location and insulate it from the surrounding air to provide a direct measurement of the coil "saturation temperature".

### *Charge Indicator Display*

The installation of a charge indicator display (CID), if verified by a HERS rater, may be used as an alternative to the prescriptive requirement for HERS diagnostic testing of the refrigerant charge in split system air conditioners and heat pumps. The purpose of the CID is to provide real-time information about the status of the system refrigerant charge, metering device, and airflow to the building occupant. The CID will monitor and determine the operating performance of split system air conditioners and heat pumps and provide visual indication to the system owner or operator if the system's refrigerant charge, airflow, or metering device performance does not conform to approved target

parameters for minimally efficient operation. Thus, if the charge indicator-display signals the owner/occupant that the system requires service or repair, the occupant can immediately call for a service technician to make the necessary adjustments or repairs. A CID can provide significant benefit to the owner/occupant by alerting the owner/occupant to the presence of inefficient operation that could result in excessive energy use/costs over extended periods of time. A CID can also indicate system performance faults that could result in system component damage or failure if not corrected, thus helping the owner/occupant to avoid unnecessary repair costs.

Charge Indicator Display technologies shall be factory installed, or field installed according to manufacturer's specifications. Joint Appendix JA6 contains more information about CID technologies.

The presence of a CID on a system must be field verified by a HERS rater. See Reference Residential Appendix RA3.4.2 for the HERS verification procedure, which consists of a visual verification of the presence of the installed CID technology. The rater must inspect to see that the CID is mounted adjacent to the system thermostat. The rater must also observe that the system reports no system faults when the system is operated continuously for at least 15 minutes when the indoor air temperature returning to the air conditioner is above 65 degrees F.

### *Cooling Coil Air Flow and Fan Watt Draw and Hole for the Placement of a Static Pressure Probe (HSPP) or a Permanently Installed Static Pressure Probe (PSPP)*

Prescriptively in climate zones 10 through 15 the central forced air system fans must maintain airflow greater than 350 CFM per nominal ton of cooling capacity across the cooling coil and have a fan watt draw less than 0.58 Watts/CFM. This measure is applicable under prescriptive packages C, D, and E. This measure requires builders to improve air handler fans and air conditioner efficiency by improving their duct systems and possibly by installing higher efficient air handlers.

Reducing the watt draw of central forced air systems provides significant peak demand savings because they are generally running continuously on the hottest days when the electricity system peaks occur. Adequate airflow also provides peak demand savings because it increases the sensible Energy Efficiency Ratio (EER) of air conditioning systems, particularly at the high outdoor dry bulb temperatures on peak demand days. Adequate airflow and low watt draw save electricity throughout the cooling season and low fan watt draw saves electricity in the heating season as well.

In addition, in the supply plenum, there must be a hole, provided by the installing contractor for the placement of a static pressure probe (HSPP) or a permanently installed static pressure probe (PSPP), downstream of the evaporative coil, that meets the specifications detailed in Reference Residential Appendix RA3.3. These are required in order to facilitate cooling coil airflow measurement using devices/procedures that depend on supply plenum pressure measurements. The installer is required to provide the HSPP or PSPP so that HERS raters can perform the required diagnostic airflow testing in a non-intrusive manner, without the necessity to drill holes in the supply plenum for placement of pressure measurement probes.

Available methods for cooling coil airflow measurement include use of the flow grid measurement tool, and the plenum pressure matching procedures described in Residential Appendix section RA3.3. These methods require use of static pressure measurements utilizing the HSPP or PSPP described above. Flow hood devices are allowed for measuring cooling coil airflow only if the measurements are taken at the return grill(s) with flow hood instruments that are large enough to completely cover the return grill(s).

The airflow measurement procedures described in Residential Appendix section RA3.3 are also allowed to be used for determining compliance with the minimum airflow requirement for the refrigerant charge verification protocol as an alternative to using the temperature split method that is described in the Residential Appendix section RA3.2 refrigerant charge verification procedures. However, the temperature split method is not allowed to determine compliance with the cooling coil airflow requirements.

### 4.3.3 Compliance Options

There are several options for receiving compliance credit related to the cooling system. These credits are available through the performance compliance method.

#### *High Efficiency Air Conditioner*

Air conditioner efficiencies are determined according to federal test procedures. The efficiencies are reported in terms of Seasonal Energy Efficiency Rating (SEER) and Energy Efficiency Rating (EER).. Savings can be achieved by choosing an air conditioner that exceeds the minimum efficiency requirements.

The EER is the full load efficiency at specific operating conditions. It is possible that two units with the same SEER can have different EERs. In cooling climate zones of California, for two units with a given SEER, the unit with the higher EER is more effective in saving energy. Using the performance compliance method, credit is available for specifying an air conditioner with an EER greater than 10 (see the compliance program vendor's compliance supplement). When credit is taken for a high EER, field verification by a HERS rater is required (see Reference Residential Appendix RA3.4).