AIR CONDITIONER AIR FLOW, REFRIGERANT CHARGE AND TXVS – OVERVIEW

Description	This change would eliminate the visual verification of a Thermostatic Expansion Valve (TXV) as sufficient to meet the prescriptive standard for refrigerant charge. It would replace the visual verification with a diagnostic test that confirms refrigerant charge and the proper functioning of the TXV. There would be no change to the diagnostic test for a non-TXV to confirm refrigerant charge. This change would provide an optional compliance method of a Charge Indicator Display (CID) that provides a clear indication to the homeowner that the refrigerant charge on the air conditioner is incorrect. This change also includes the following "house keeping" items: o Provide a wider range of passing values for field verification by inspectors to accommodate the accuracy of the measuring equipment. o Change the minimum level of evaporator airflow for charge testing to 300 cfm per ton and the level of evaporator airflow for adequate airflow credit to 350 cfm per ton. These numbers can be verified with either a wet or dry coil. o Remove the portion of the Temperature Split Table that displays target temperature splits for conditions where the return wet bulb temperature is near or is greater than the dry bulb temperature. This would apply to Residential New Construction and Air Conditioner Replacements (Alterations) of split system air conditioners. The new diagnostic test would determine whether the TXV controls the superheat to within acceptable range and whether the refrigerant charge is correct.
Type of Change	The proposed change is within a prescriptive requirement. It would not change the way trade-off calculations are made. The proposed change does not modify or expand the scope of the Standards. The Standards documents affected are the Standards Chapter 8; Residential ACM Chapters 7, 5, 4, and 2; Residential ACM Appendices RA, RD, RE, RI, and RJ (new); the Residential Manual; as well as compliance forms CF-1R, CF-4R, and CF-6R.

Energy Benefits	Field results have shown that the mere presence of a TXV does not insure that the air conditioner will perform as designed by the manufacturer. It is necessary that a TXV be properly installed and functioning as designed as well as have the proper refrigerant charge to ensure full design efficiency. This measure will prevent the overcharging or undercharging of TXV systems that are not doing proper refrigerant metering because of misinstallation or TXV failure. Adding the Charge Indicator Display will present another method of meeting the prescriptive standard. Having a proper functioning metering device with proper refrigerant charge avoids the problem of overcharge, which can cause high peak watt draw and lowered efficiency. This is most important on peak where the Time Dependent energy values are higher. Changing the level of evaporator airflow for adequate airflow credit to 350 cfm per ton will bring the standard in line with the optimum values found in recent research on air conditioners for hot dry climates.
Non-Energy Benefits	Properly charge and functioning refrigerant metering devices help attain the full design capacity and efficiency of the air conditioner. This provides comfort under hot conditions and avoids equipment failure due to compressor flooding or overheating. Widening the range of acceptable values for superheat, subcooling, and temperature split on inspection will reduce the possibility that a unit will pass when tested by the installer, but fail when tested by the inspector. Eliminating the specified difference between wet and dry coil acknowledges that there is only a very small difference between wet and dry coil airflow and simplifies the calculations.
Environmental Impact	The change has only positive potential environmental impact. There is no effect on water consumption. It potentially could improve indoor air quality, and may reduce the release of ozone depleting gasses.
Technology Measures	
Performance Verification	This change implements performance verification to assure optimum performance of the air conditioner. The charge diagnostic testing consists of measuring the superheat and subcooling of the air conditioner and comparing it against a standard.
Cost Effectiveness	The change is cost effective. It produces the savings expected from proper refrigerant charge.
Analysis Tools	The energy savings and peak benefits can be quantified using the current reference method.
Relationship to Other Measures	This does not impact any other measures.

METHODOLOGY

This change is necessary to achieve the performance assumed in the current Standards base case. The current Standards assume that all TXVs perform at their optimum level, which has been shown to not be true.

ANALYSIS AND RESULTS

Field data have shown that TXVs are not performing to their assumed potential with respect to maintaining proper refrigerant metering and overcoming improper refrigerant charge. A review of 4384 field tests of TXVs that had subcooling within proper range (indicating proper refrigerant charge) showed that 8.7% of the units had a superheat of less than 4 °F and 13.8% of the units had superheat greater than 25 °F (both indicating improper refrigerant control). When refrigerant control is not proper the unit will not perform as assumed in the current Standards.

RECOMMENDATIONS

The Standards and ACM Manual would eliminate the verification of the presence of a TXV for compliance and substitute the presence of a TXV that is functioning properly and properly charged.

Standards Section 151

7. **Space heating and space cooling.** When refrigerant charge measurement is shown as required by TABLE 151-B or TABLE 151-C , ducted split system central air conditioners and ducted split system heat pumps shall have refrigerant charge measurement confirmed through field verification and diagnostic testing in accordance with procedures set forth in the ACM Manual or shall be equipped with a charge indicator display clearly visible to the occupant. The display shall demand attention when the air conditioner fails to meet the standards contained in Appendix RJ of the ACM Manual. The display shall be constantly visible and within one foot of the thermostat. All space-heating and space-cooling systems must comply with minimum Appliance Efficiency Regulations as specified in Sections 110 through 112.[1]

TABLE 151-B ALTERNATIVE COMPONENT PACKAGE C

Climate Zone	1, 16	3	4	5	6	7	8, 9	10	2, 11-13	14	15
SPACE-COOLING											
SEER =	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
If split system, Refrigerant charge measurement	NR	NR	NR	NR	NR	NR	REQ	REQ	REQ	REQ	REQ
DUCTS											
Duct sealing	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ
Duct Insulation	R-8	R-8	R-8	R-8	R-8	R-8	R-8	R-8	R-8	R-8	R-8
WATER-HEATING	System shall meet Section 151 (f) 8 or Section 151 (b) 1 [7]										

1 New appliance standards pursuant to Section 111 for single phase air-cooled air conditioners and single phase air-source heat pumps with cooling capacity less than 65,000 Btu per hour become effective January 23, 2006.

TABLE 151-C ALTERNATIVE COMPONENT PACKAGE D

Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
SPACE-COOLING																
SEER =	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
If split system, Refrigerant charge measurement	NR	REQ[9]	NR	NR	NR	NR	NR	REQ[9]	REQ[9]	REQ[12]	REQ[12]	REQ[12]	REQ[13]	REQ[14]	REQ	NR
DUCTS																
Duct sealing	REQ[8]	REQ[9]	REQ[10]	REQ[11]	REQ[10]	REQ[10]	REQ[10]	REQ[9]	REQ[9]	REQ[12]	REQ[12]	REQ[12]	REQ[13]	REQ[14]	REQ	REQ[8]
Duct Insulation	R-6	R-6	R-6	R-6	R-6	R-4.2	R-4.2	R-4.2	R-6	R-6	R-6	R-6	R-6	R-8	R-8	R-8
WATER-HEATING	System shall meet Section 151 (f) 8 or Section 151 (b) 1															

Footnote requirements to TABLE 151-B and TABLE 151-C

9 As an alternative under Package D in climate zones 2, 8, and 9, glazing with a maximum 0.38 U-factor and maximum 0.31 SHGC may be substituted for duct sealing and either refrigerant charge measurement. All other requirements of Package D must be met.

ACM Manual Chapter 2

HVAC Systems

- *Verified Refrigerant Charge.* The choices are 'Yes' or 'No' where 'Yes' means that either refrigerant charge is verified or a charge indicator display is installed and operational. Refrigerant charge credit is applicable to split system air conditioners and heat pumps only. The two equipment types that can comply by verifying refrigerant charge are SplitAirCond, and SplitHeatPump.

ACM Manual Chapter 4

Equation R4-1
$$EER_{nf} = \left(1.0452 \times EER + 0.0115 \times EER^2 + 0.000251 \times EER^3\right) \times F_{txv} \times F_{air} \times F_{size}$$

(replace Ftxv with Fchg)

where

SEER = Seasonal energy efficiency ratio for the air conditioner. The EER shall be used in lieu of the SEER for equipment not required to be tested for a SEER rating.

EER = Energy efficiency ratio at ARI test conditions, if not input, then values are taken from

F_{chg} = The refrigerant charge factor, default = 0.9. For systems with a charge indicator display or verified refrigerant charge (ACM RD-2005), the factor shall be 0.96.

F_{air} = The system airflow factor, default = .925. For systems with airflow verified according to 4.7.4, F_{air} shall be 1.00.

F_{size} = Compressor sizing factor, default = 0.95. For systems sized according to the Maximum Cooling Capacity for ACM Credit (see SectionXXX), the factor shall be 1.0.

Compressor Sizing

The Design Cooling Capacity shall be calculated using the procedure in ACM RF-2005. The Maximum Cooling Capacity for ACM Credit shall be calculated using the procedure in ACM RF-2005. For ACM energy calculations all loads are assumed to be met in the hour they occur regardless of the compressor size.

Correctly sized systems installed so they operate at full capacity are desirable because oversized cooling systems have been shown to result in larger peak electrical demands. Systems which have the combination of verified adequate airflow, sealed and tested new duct systems, and proper charge(or alternatively a charge indicator display) and also meet the requirements for Maximum Cooling Capacity for ACM Credit may take credit in ACM calculations by setting the Fsize factor (see XXX and Equation R4-1) to 0.95. For all other systems the Fsize factor shall be set to 1.0.

Cooling System Refrigerant Charge

Proper refrigerant charge is necessary for electrically driven compressor air conditioning systems to operate at full capacity and efficiency. Field measurements indicate that typical California air conditioning systems are installed without proper charge, and for ACM energy calculations, the F_{chg} factor is set to 0.90 to account for the impact of this condition. If the system is properly charged or a charge indicator display is installed according to the procedures of ACM RD or RJ the F_{chg} factor may be set to 0.96 for ACM energy calculations. See XXX and Equation R4-1. Credit for refrigerant charge is not available for package systems.

ACM Manual Chapter 5

SC	1	A	9, 12, 14	**Charge Testing.** Do not install a charge indicator display and do not field verify that the split system has the correct refrigerant charge. Produces a negative compliance margin.	**SHGC**. Reduce the SHGC of the windows on all orientations to find the Passing Solution and the Failing Solution.

ACM Manual Chapter 7

Table R7-1 – Summary of Measures Requiring Field Verification and Diagnostic Testing

Measure Title	Description	Protocol or Test Procedure
	Air Conditioner Measures	
Improved Refrigerant Charge	Package D requires in some climate zones that split system air conditioners and heat pumps be diagnostically tested in the field to verify that they have the correct refrigerant charge (sec Section 4.7.3). The Proposed Design is modeled with less efficiency if diagnostic testing and field verification is not performed.	ACM RD-2005

ACM Appendix RA

Test SC22 –Charge Testing vs. SHGC

Label	Space Conditioning TDV Energy (kBtu/ft²/y)		SHGC Solution		ACM Filenames	
	Passing Case	Failing Case	Passing Case	Failing Case	Passing Case	Failing Case
SC22A09						
SC22A12						
SC22A14						

ACM Appendix RD

SEE APPENDIX A OF THIS DOCUMENT.

ACM Appendix RD Temperature Split Table

SEE APPENDIX B OF THIS DOCUMENT.

ACM Appendix RE

Table RE-2 – Summary of Diagnostic Measurements

Input to the Algorithms	Variables and Equation Reference	Description	Standard Design Value	Proposed Design	
				Default Value	Procedure
Fan Power Ratio	FanW/Btu (Eq. R4-45)	The ratio of fan power in Watts to the cooling capacity in Btu/h.	0.051 W/Btu.	0.051 W/Btu.	Section RE4.4.3
Fan Flow over Evaporator	F_{air} (Eq. R4.42 and R4.43)	The term F_{air} depends on the measured airflow over the evaporator coil. A value of 0.925 is used as a default, but a value of 1.000 can be used if the airflow exceeds 350 cfm/ton.	F_{air} = 1.000 when refrigerant charge testing is required by Package D.	F_{air} = 0.925	Section RE4.4.1
Refrigerant Charge Prerequisite	n. a.	An airflow of at least300 cfm/ton must be obtained before a valid refrigerant charge test may be performed	n. a.	n. a.	Section RE4.4.1

ACM Appendix RI

Appendix RI – Procedures for Verifying or High Energy Efficiency Ratio Equipment

RI-1 Purpose and Scope

The purpose of these procedures is to verify that residential space cooling systems and heat pumps have the required components to achieve the energy efficiency claimed in the compliance documents. The procedures only apply when an EER higher than the default is claimed. For dwelling units with multiple systems, the procedures shall be applied to each system separately.

The installer shall certify to the builder, building official and HERS rater that he/she has installed all the correct components.

The reference method algorithms adjust (improve) the efficiency of air conditioners and heat pumps when field verification indicates the specified components are installed. Table RI1 summarizes the algorithms that are affected.

Table RI-1 – SUMMARY OF FIELD VERIFICATION

Diagnostic	Variables and Equation Reference	Description	Standard Design Value	Proposed Design	
				Default Value	Procedure
Presence of a matched High Efficiency Compressor Unit, Evaporator Coil, Refrigerant Metering Device, and (where specified) Air Handling Unit and/or Time Delay Relay.	EER	The EER is the Energy Efficiency Ratio at 95 F outdoors specified according to ARI procedures for the matched combination	Systems are assumed to have the default EER based on SEER, see ACM Equation 4.44.	Default EER	RI2, RI 3 and RI4

RI-2 TXV Verification Procedure

The procedure shall consist of visual verification that the TXV is installed on the system.

RI-3 Time Delay Relay Verification Procedure

When a high EER system specification includes a time delay relay, the installation of the time delay relay shall be verified. .

The procedure shall be:

1) Turn the thermostat down until the compressor and indoor fan are both running.

2) Turn the thermostat up so the compressor stops running.

3) Verify that the indoor fan continues to run for at least 30 seconds.

RI-4 Matched Equipment Procedure

When installation of specific matched equipment is necessary to achieve a high EER, installation of the specific equipment shall be verified.

The procedure shall consist of visual verification of installation of the following equipment and confirmation that the installed equipment matches the equipment required to achieve the high EER rating:

1) The specified labeled make and model number of the outdoor unit.

2) The specified labeled make and model number of the inside coil.

3) The specified labeled make and model of the furnace or air handler when a specific furnace or air handler is necessary to achieve the high EER rating,

4) The specified metering device when a specific refrigerant metering device (such as a TXV or an EXV) is necessary to achieve the high efficiency rating.

ACM Appendix RJ (new appendix)

SEE APPENDIX C OF THIS DOCUMENT.

BIBLIOGRAPHY AND OTHER RESEARCH

These changes are based on the field tests compiled by Proctor Engineering Group and Robert Mowris and Associates. Additional information was obtained from Tim Topham of Energy Calc Services Inc. and Max McKinney of Energy Analysis and Comfort Systems, Inc.

APPENDICES