5. Minimum Capabilities Tests

This chapter describes the methods used to test the minimum modeling capabilities of candidate ACMs. There are separate tests for space conditioning tests and water heating tests. Most of the space conditioning tests are performed using a simple square building prototype (see Figure R5-7). The water heating tests are performed relative to two prototype water heating systems. Most of the tests are performed in only five climate zones, but some are performed in all sixteen climate zones.

5.1 Overview

Two types of tests are performed: accuracy tests and standard design generator tests (or custom budget tests). While ACMs shall pass all these tests, the CEC, at its discretion, may require additional tests to justify the accuracy of the candidate ACM to confirm other required features.

5.1.1 Accuracy Tests

This section describes the general testing concept that is used for the accuracy tests. For the prototype buildings and the specified variations, candidate ACMs shall generate an estimate of TDV energy and this is compared to the TDV energy that is estimated with the reference method. The TDV energy of the candidate ACM shall be within an acceptable tolerance of the reference method in order for the ACM to pass the test. The margin of acceptability is defined below and may change for each group of tests. For the space conditioning tests, only the TDV energy for space conditioning is considered and for the water heating tests only the TDV energy for water heating is considered.

General Procedure

Basecase. Each test begins with a prototype building or system that exactly complies with the prescriptive criteria (package D); this is the basecase building or system. The basecase has a zero compliance margin, e.g. it exactly complies with the standard. In another parlance, it is the custom budget building.

Discrete Modifications. A set of discrete modifications are then made to the basecase building or system, e.g. the ducts are sealed, walls and ceilings are field verified for good construction quality or a different type of heating or cooling equipment is installed. The discrete modifications are defined for each test and may vary slightly for each climate zone identified for the test. The discrete modifications are selected to represent important compliance measures. The discrete modifications will either improve or degrade the TDV energy performance of the basecase building, e.g. the compliance margin of the modified basecase will become either positive or negative.

Continuous Variable. A continuous variable, which is identified for each test, is then increased or reduced so that the modified basecase complies by a specified tolerance and fails by a specified tolerance. The continuous variables have a predictable and continuous impact on the TDV energy of the proposed design. Examples are SEER, AFUE, and glass area (above 20% of the floor area). The value for the continuous variable that causes the modified basecase to pass by the specified tolerance is the “passing solution” and the value that causes failure by the specified tolerance is the “failing solution”. The “failing solution” shall result in TDV energy as close as possible to the negative tolerance, but shall be greater than the negative tolerance. The “passing solution” shall result in TDV energy as close as possible to the positive tolerance but shall be less than the positive tolerance. The positive and negative tolerances are defined for each test, but in general they are 1.0 kTDV/ft²-y or 3% of the baseline TDV energy whichever is greater.

The procedure is illustrated in Figure R5-1 through Figure R5-4. In these diagrams, the base case building is represented by point “A”. The vertical axis represents the compliance margin with a positive compliance margin (building or system passes) above the horizontal axis and a negative compliance margin (building or system fails) below the horizontal axis. Figure R5-1 and Figure R5-3show instances when the discrete modifications produce a positive compliance margin and Figure R5-2 and Figure R5-4 are examples of discrete modifications that produce a negative compliance margin. When the discrete modifications produce a change in TDV energy that is within the specified tolerances, the passing solution or failing solutions are equal to the basecase value of the continuous variable. This situations is illustrated in Figure R5-3 and Figure R5-4.

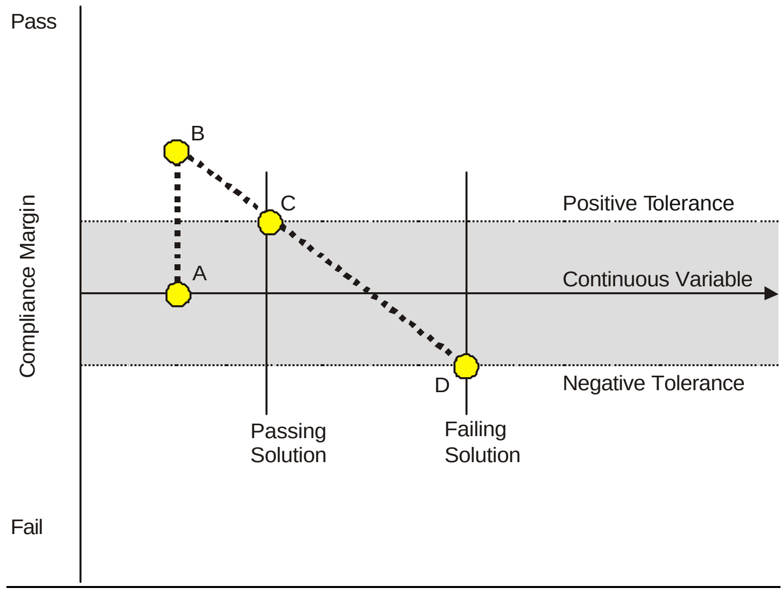


Figure R5-1 – Testing Concept – Discrete Modifications Produce Positive Compliance Margin
The discrete modifications produce a positive compliance margin that exceeds positive tolerance. Both the passing solution and the failing solutions for the continuous variable are determined.

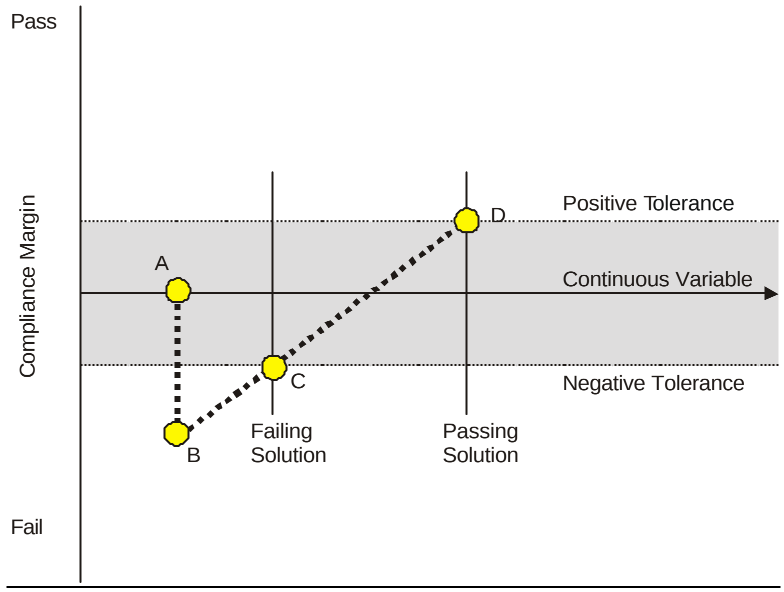


Figure R5-2 – Testing Concept – Discrete Modifications Produce Negative Compliance Margin
The discrete modifications produce a negative compliance margin that exceeds negative tolerance. Both the passing solution and the failing solutions for the continuous variable are determined.

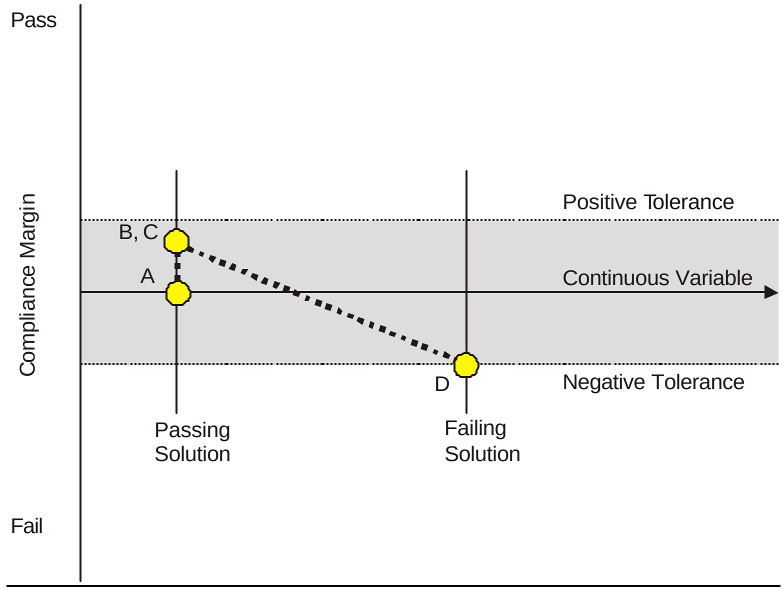


Figure R5-3 – Testing Concept – Discrete Modifications Produce Positive But Small Compliance Margin
The discrete modifications produce a positive compliance margin that is less than the positive tolerance. The passing solution for the continuous variable is equal to the basecase; the failing solution is determined by the vendor..

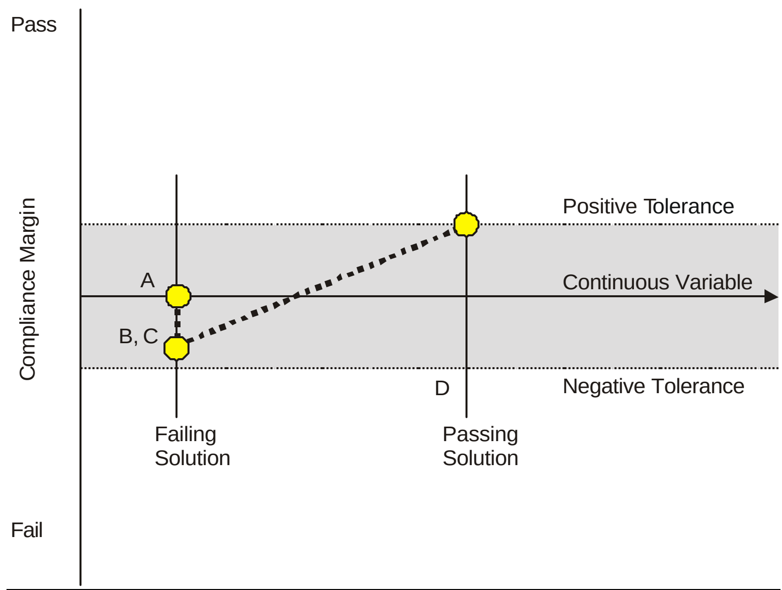


Figure R5-4 – Testing Concept – Discrete Modifications Produce Negative But Small Compliance Margin
The discrete modifications produce a negative compliance margin that is within the negative. The failing solution for the continuous variable is equal to the basecase; the passing solution is determined by the vendor.

Acceptance Criteria

For every test, the CEC reference method shall pass the modified basecase when data for the passing solution is entered and fail the modified basecase when data for the failing solution is entered. The acceptance criteria shall be satisfied for all tests. In addition to producing estimates that are within the tolerances, the tests are also used to verify that the standard reports are correctly produced, as required in Chapter 2. For instance, many of the discrete modifications trigger measures that shall be listed in the “Special Features and Modeling Assumptions” section of the Certificate of Compliance. Finally, the tests will be used to verify that the standard design building is correctly defined, as specified in Chapter 3.

5.1.2 Standard Design Tests

The acceptance criteria for the standard design generator tests uses a different approach from the accuracy tests. Two types of tests are used to verify that the standard design is created according to the rules specified in Chapter 3: These are defined below along with the acceptance criteria for each.

Standard Design Equivalent Tests

The standard design equivalent tests consist of matched pairs of computer runs: a proposed design and its standard design equivalent. The standard design equivalent is the proposed design reconfigured according to the standard design rules in Chapter 3 to be in exact compliance with the prescriptive requirements (package D). The ACM vendor is required to create the proposed design and standard design equivalent input files and submit them with the application for approval.

Two Certificates of Compliance are produced: one for the proposed design and one for the standard design equivalent. The standard design TDV energy budget on the proposed design Certificate of Compliance shall be equal to the TDV energy use shown in both the standard design energy budget and proposed design columns of the standard design equivalent computer run. See Figure R5-5.

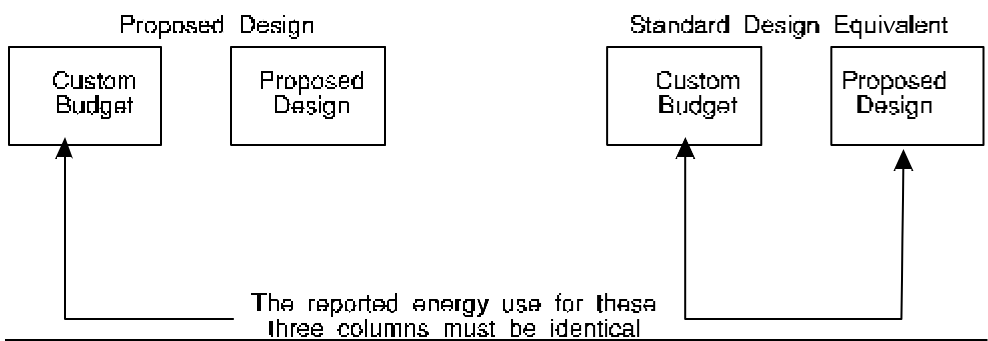


Figure R5-5 – Custom Budget Tests

Neutral Variable Tests.

The second series of standard design equivalent tests are the neutral variable tests. Neutral variables are building features that are unchanged between the standard design and the proposed design. An example of a neutral variable is glass area, below the prescriptive limit of 20%. In this series of tests, a change is specified in one of the neutral variables and the compliance margin has to remain within a certain tolerance.

5.1.3 Labeling Tests and Computer Simulations

Each of the tests has a specific label that includes the test series, the number of the test, the prototype used in the test and the climate zone for which the test is performed. Using a precise designation to make it easier to keep track of the many computer simulations will ease the CEC review process. The following labeling scheme described in Figure R5-6 shall be used:

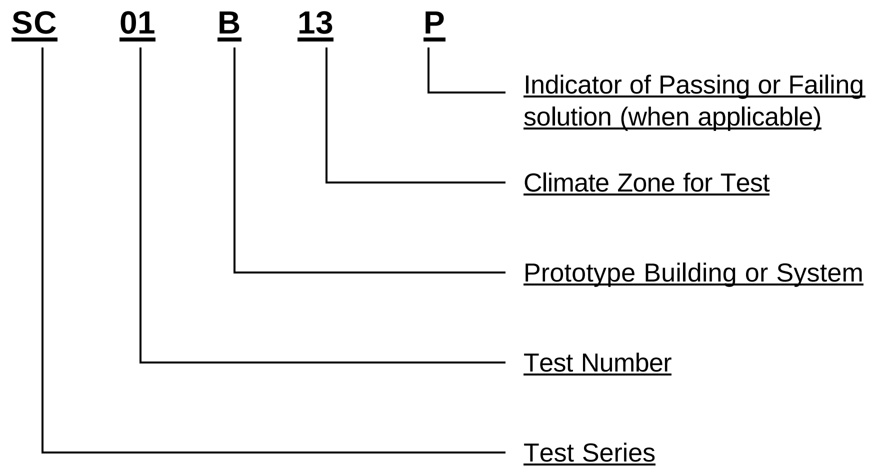


Figure R5-6 – Labeling of Computer Simulations

ACM input and output files shall use the same labeling scheme, but with a “P” or “F” concatenated on the end to indicate if the file represents the passing or failing solution.

5.1.4 Documentation

The ACM vendor shall record the results of the tests on the forms provided in Appendix RA-2005 and provide electronic copies of the input files to the CEC. The filenames shall include the test label (see below) with a “P” or “F” concatenated to the file name to indicate if the file represents the passing solution or the failing solution. The form (Appendix RA-2005) includes an entry for the TDV energy for the passing solution and the failing solution. The forms also include the continuous variable values for the passing and failing solutions as well as the ACM filenames for the passing and failing cases.

5.2 Space Conditioning Tests

This section describes the space conditioning tests that shall be performed by the ACM vendor. Three groups of tests are described. The first verify that space conditioning TDV energy is predicted with an acceptable tolerance of that predicted by the reference method. The second series of tests verify that the custom budget or standard design is correctly defined. The third series of tests verify that the ACM calculates TDV energy correctly for additions and alterations to low-rise residential buildings.

5.2.1 Accuracy Tests (SC)

The accuracy tests verify that the candidate ACM passes and fails buildings in a manner consistent with the reference method.

Prototype Buildings

The space conditioning accuracy tests are performed with two prototype buildings. The geometry of the prototype buildings and other features are described below and illustrated in Figure R5-7. The attic is not shown in Figure R5-7 since the ACM modeling rules do not require the attic to be explicitly modeled as a separate thermal zone.

Both prototype A and B are a square box measuring 40 ft by 40 ft and 10 ft tall. A single 80 ft² window on each façade (total window area is 20% of the floor area). The facades face exactly north, east, south and west. The thermal performance of all building envelope elements is in exact compliance with the prescriptive requirements (package D in the standards). The prototypes have a gas furnace and a split system air conditioner with air distribution ducts located in an attic.

A Prototype A has a slab-on-grade.

B Prototype B has raised floor construction.

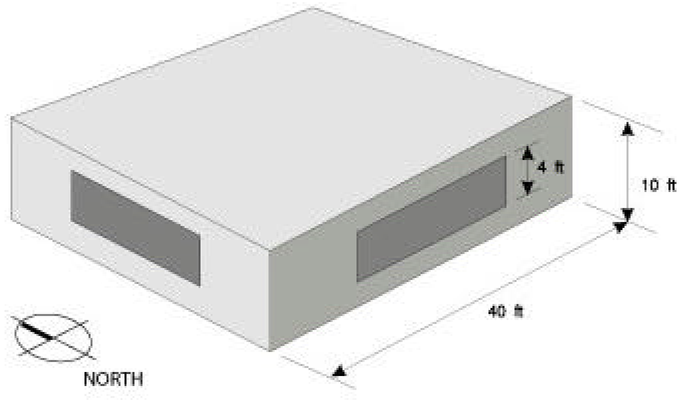


Figure R5-7 – Prototype Buildings A and B

Test Descriptions

Table R5-1 describes each of the space conditioning tests that shall be performed. The space conditioning accuracy tests use the series designation “SC”.

Table R5-1 – Summary of the Space Conditioning Tests

Series	Number	Prototypes	Climates	Discrete Modification(s)	Continuous Variable
SC	0	A, B	All	None	None
SC	1	A	3, 9, 12, 14, 16	**SEER**. Increase the cooling equipment efficiency (SEER) from the basecase condition of 12.0 to 14.0.. Use the default EER for both the SEER 12.0 and SEER 14.0 cases. Make no changes to the air distribution system or other HVAC system components. Produces a positive compliance margin.	**AFUE**. Reduce the heating equipment AFUE to find the Passing Solution and the Failing Solution.
SC	2	A	3, 9, 12, 14, 16	**Ceiling U-factor**. Reduce the ceiling U-factor from the basecase condition to R-60. The U-factor for this condition shall be taken from ACM Joint Appendix IV. Do not assume field verification for construction quality. Produces a positive compliance margin.	**South Glass Area**. Increase south glass area to find the Passing Solution and the Failing Solution.
SC	3	A	3, 9, 12, 14, 16	**Wall U-factor**. Increase wall insulation to the equivalent of R-22 in a 2x6 wood framed cavity with R-14 continuous insulation. The U-factor for this condition shall be taken from ACM Joint Appendix IV. Do not assume field verification for construction quality. Produces a positive compliance margin.	**West Glass Area**. Increase w est glass area to find the Passing Solution and the Failing Solution.
SC	4	A	12, 14, 16	**Slab F-factor**. Add R-7 slab insulation for climate zones 12 and 14. In climate zone 16, increase slab edge insulation from the basecas e R-7 to R-21. Produces a positive compliance margin.	**North Glass Area**. Increase north glass area to find the Passing Solution and the Failing Solution.
SC	5	A	3, 9, 12, 14, 16	**Fenestration Type**. Replace the basecase fenestration with a super high performance product with a U-factor of 0.25 and a SHGC of 0.40. Produces a positive compliance margin.	**North Glass Area**. Increase north glass area to find the Passing Solution and the Failing Solution.
SC	6	A	3, 9, 12, 14, 16	**Fenestration Type**. Replace the basecase fenestration with a product that fails to comply with the package D requirements. The replacement product shall have a U-factor of 0.90 and an SHGC of 0.70. Produces a negative compliance margin.	**AFUE**. Increase or reduce the heating equipment AFUE to find the Passing Solution and the Failing Solution.
SC	7	A	12, 14, 16	**Exposed Thermal Mass**. Increase the percent of the slab-on-grade that is exposed from the basecase condition of 20% to 40%. Produces a positive compliance margin.	**South Glass Area**. Increase south glass area to find the Passing Solution and the Failing Solution.
SC	8	A	3, 9, 12, 14, 16	**Exposed Thermal Mass**. Increase the percent of the slab-on-grade that is exposed from the basecase condition of 20% to 40%. Produces a positive compliance margin.	**West Glass Area**. Increase west glass area to find the Passing Solution and the Failing Solution.
SC	9	A	3, 9, 12, 14, 16	**Exposed Thermal Mass**. Increase the percent of the slab-on-grade that is exposed from the basecase condition of 20% to 40%. Produces a positive compliance margin.	**North Glass Area**. Increase north glass area to find the Passing Solution and the Failing Solution.
SC	10	A	3, 9, 12, 14, 16	**Exposed Thermal Mass**. Increase the percent of the slab-on-grade that is exposed from the basecase condition of 20% to 40%. Produces a positive compliance margin.	**East Glass Area**. Increase east glass area to find the Passing Solution and the Failing Solution.

Series	*Number*	*Prototypes*	*Climates*	*Discrete Modification(s)*	*Continuous Variable*
SC	11	A	3, 9, 12, 14, 16	**South Overhangs**. Add a two foot projection from the surface of the south glass. Its bottom edge is located six inches above the top of the window. The window is assumed to be 6 ft 6 in. high and the overhang is assumed to extend an infinite distance beyond the sides of the windows. (see Figure R5-). Produces a positive compliance margin.	**South Glass Area**. Increase south glass area to find the Passing Solution and the Failing Solution.
SC	12	A	3, 9, 12, 14, 16	**Building Envelope Sealing**. Reduce the building (SLA) from 4.9 to 2.9 through diagnostic testing and sealing. Produces a positive compliance margin.	**Glass Area**. Increase glass area uniformly on all orientations to find the Passing Solution and the Failing Solution.
SC	13	A	3, 9, 12, 14, 16	**Building Envelope Sealing and Mechanical Ventilation**. The building leakage (SLA) is reduced from 4.9 to 2.9 through diagnostic testing and sealing. In addition, mechanical ventilation is added that provides 80 cfm (0.375 air changes per hour) of continuous ventilation and consumes 20 watts of power continuously. Produces a positive compliance margin.	**Glass Area**. Increase glass area uniformly on all orientations to find the Passing Solution and the Failing Solution.
SC	14	A	3, 9, 12, 14, 16	**Construction Quality**. Assume that the proposed design has been field verified to have quality wall and ceiling insulation quality. Produces a positive compliance margin.	**AFUE**. Reduce the heating equipment AFUE to find the Passing Solution and the Failing Solution.
SC	15	A	9, 12, 14	**Cool Roofs / Radiant Barrier**. Remove the radiant barrier (or equivalent cool roof) from the proposed design. Produces a negative compliance margin.	**SEER**. Increase the SEER (using default EER) to find the Passing Solution and the Failing Solution.
SC	16	A	9, 12, 14	**Natural Ventilation**. Change the window types to increase the free ventilation area from the default of 10% of the total window area to 20% of the window area, and assume a 10 ft elevation difference between the air inlet and the outlet. Produces a positive compliance margin.	**SEER**. Reduce the SEER (using default EER) to find the Passing Solution and the Failing Solution.
SC	17	A	3, 9, 12, 14, 16	**Duct Leakage**. Do not seal the ducts as required by the prescriptive standards. Produces a negative compliance margin.	**SEER**. Increase the SEER (using default EER) to find the Passing Solution and the Failing Solution.
SC	18	A	3, 9, 12, 14, 16	**Duct Surface Area.** Through diagnostic verification, reduce duct surface area from the default of 27% of the floor area to 10% of the floor area. Produces a positive compliance margin.	**SEER**. Reduce the SEER (using default EER) to find the Passing Solution and the Failing Solution.
SC	19	B	9, 12, 14	**Duct Location.** Move the HVAC ducts from the crawlspace (the default for one story, raised floor buildings) to the attic. Produces a negative compliance margin.	**SEER**. Reduce the SEER (using default EER) to find the Passing Solution and the Failing Solution.
SC	20	A	9, 12, 14	**Duct Insulation.** Reduce the duct R-value from the R-8 prescriptive requirement to R-4.2. Produces a negative compliance margin.	**SEER**. Increase the SEER (using default EER) to find the Passing Solution and the Failing Solution.
SC	21	A	9, 12, 14	**Energy Efficiency Ratio (EER)**. Instead of using the default EER of 10.415 for the default SEER 12 assume an EER of 11.5 with the same SEER of 12). Produces a positive compliance margin.	**SHGC**. Increase the SHGC of the windows on all orientations to find the Passing Solution and the Failing Solution.
SC	22	A	9, 12, 14	**TXV / Charge Testing**. Do not install a TXV 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.

Series	Number	Prototypes	Climates	Discrete Modification(s)	Continuous Variable
SC	23	A	9, 12, 14	**Airflow Across Evaporator Coil**. Verify through field verification that there is adequate airflow for compliance credit (400 cfm/ton for a wet coil) across the evaporator coil. Produces a positive compliance margin.	**SHGC**. Increase the SHGC of the windows on all orientations to find the Passing Solution and the Failing Solution.
SC	24	A	9, 12, 14	**Air Conditioner Fan Power**. Reduce fan power through field verification. The default is 0.51 W/cfm. Reduce this to 0.20 W/cfm. Produces a positive compliance margin.	**SHGC**. Increase the SHGC of the windows on all orientations to find the Passing Solution and the Failing Solution.
SC	25	A	3, 9, 12, 14, 16	**Electric Heat**. Replace the gas furnace and air distribution system in the basecase with electric resistance baseboards (no air distribution or duct losses). In addition, increase the ceiling insulation to R-60. The U-factor for this condition shall be taken from ACM Joint Appendix IV. Do not assume field verification for construction quality. Produces a negative compliance margin.	**Fenestration U-factor**. Reduce the fenestration U-factor on all orientations to find the Passing Solution and the Failing Solution.
SC	26	A	9, 12, 14	**Side Fins**. For this test side fins are added to the east and west facades of prototype A. The side fins extend 40 feet from the surface of a window that is assumed to be 10 feet wide. The fins are 5 feet from the edge of the window. The top of the side fins are 20 feet above the top of the window. See Figure R5-9. Sidefins are expected to produce a positive compliance margin.	**SEER**. Vary the SEER (keep EER at the default) to find the passing solution and fail the failing solution.

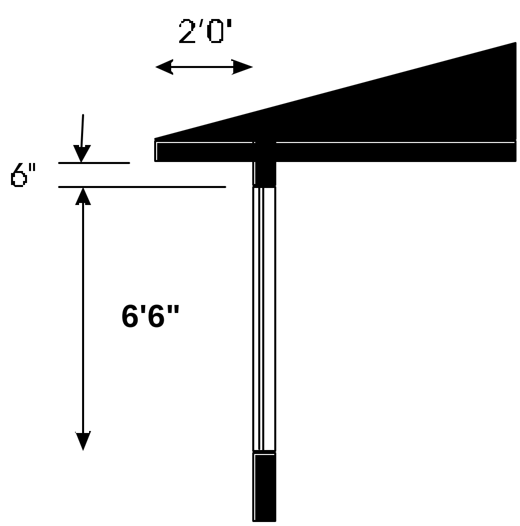


Figure R5-8 – Overhang Characteristics

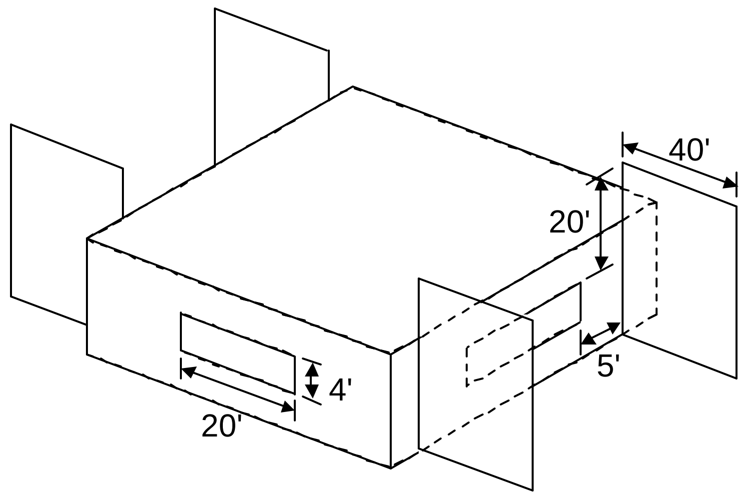


Figure R5-9 – Side Fins for Optional Capabilities Test

The north and south façades are the ones that do not have the sidefins.

Acceptance Criteria

The positive tolerance is the basecase TDV energy for space conditioning plus 3% or 1 kTDV/ft²-y, whichever is greater. The negative tolerance is the basecase TDV energy for space conditioning less 3% or 1 kTDV/ft²-y, whichever is greater. The CEC reference method shall pass the modified basecase when data for the passing solution is entered and fail the modified basecase when data for the failing solution is entered.

In addition to producing estimates that are within the tolerances, the tests are also used to verify that the standard reports are correctly produced, as required in Chapter 2. For instance, many of the discrete modifications trigger measures that shall be listed in the "Special Features and Modeling Assumptions" section of the Certificate of Compliance.

5.2.2 Standard Design Generator Tests (*SD*)

This section describes the standard design tests that shall be performed by the ACM vendor. The standard design tests use the series designation "SD". ACMs shall automatically create the standard design building, as defined in Chapter 3. The standard design run is made automatically at the same time as the proposed design run, and the results are reported together on the Certificate of Compliance discussed in Chapter 2. The tests described in this section verify that the standard design is correctly defined for the proposed design and that the custom budget is correctly calculated. These tests supplement the SC tests, which also verify certain standard design features. .

Prototypes Buildings

The custom budget tests use three prototype buildings as described below.

C Prototype C is a 1,761 ft² , one and two-story, single-family detached home which is widely used to analyze the impact of the standards and the cost effectiveness of measures. Two versions of this prototype are used in the tests. One has a slab floor and one has a raised floor. Details are available from the CEC.

D Prototype D is identical to prototype C, except that it is has a raised floor. Details are available from the CEC.

E Prototype E is an eight-unit, two-story multi-family building. Details are available from the CEC.

Standard Design Equivalent Tests

The standard design equivalent tests are described in Table R5-2. For each of these tests, the standard design equivalent budget and proposed design TDV energy shall equal each other. In addition, the TDV energy shall equal the budget TDV energy for the proposed building.

Table R5-2 – Standard Design Tests

Series	*Number*	*Prototypes*	*Climates*	*Description*
SD	0	A, B	All	**Basecase Prototypes**. These tests were also performed in the SC series. For each of these tests, the standard design and proposed design TDV energy shall be equal. There is no proposed design case for these tests.
SD	1	C	All	**Slab-On-Grade**. The purpose of this test is to verify that the standard design generator correctly defines the standard design for proposed designs using slab-on-grade designs. The "SC01C**" files are run in all 16 climate zones.
SD	2	D	All	**Raised Floor**. The purpose of this test is to verify that the standard design generator correctly defines the standard design for proposed designs using raised floor buildings. The "SC01D**" files are run in all 16 climate zones.
SD	3	E	All	**Multi-Family.** The purpose of this test is to verify that the standard design generator correctly defines the standard design for multi-family buildings. The "SC01E**" files are run in all 16 climate zones.

Neutral Variable Tests

The neutral variable tests are described in Table R5-3. For each of these tests, the compliance margin shall remain within one percent of zero.

Table R5-3 – Neutral Variable Design Tests – Space Conditioning

Series	*Number*	*Prototypes*	*Climates*	*Description*
SD	4	A	3, 9, 12, 14, 16	**Window Area**. Reduce window area from 20% of the floor area to 15% of the floor area. Reduce the size of the window on each façade to 60 ft². Do not change any other features.
SD	5	A	3, 9, 12, 14, 16	**Wall Area.** Increase the gross wall area on each façade from 400 ft² to 600 ft².

5.2.3 Additions and Alternations (AA)

This section describes the tests for alternations and additions that shall be performed by the ACM vendor. The additions and alternations tests use the series designation "AA."

Additions are treated as new buildings except that internal heat gains are allocated on a fractional dwelling unit basis. With the Addition + Existing + Alternation approach, energy credit may be taken for improvements to the existing building. This series of tests exercises the various default assumptions (see Table 3-11 in Section 3.8.4) based on the vintage of the existing building and the various reporting requirements for modeling an addition with an existing building. In addition, these tests verify the proper determination of the energy budget and compliance criteria for an addition with an improved existing building.

Prototype Buildings

The prototype used in these tests consists of an existing building and an addition. The existing building has the same physical configuration as Prototype A but the thermal performance of building envelope components are downgraded to be more typical of older existing building. Prototype E has the thermal characteristics of 19775 construction practice and Prototype F has the thermal characteristics of 1989 construction practice. See the Additions and Alternations section of Chapter 3 for details on construction assemblies. Each window is 4 ft high and 20 ft wide centered on the facade. The addition is 12 ft deep by 40 ft long and 10 ft high and covers the whole west side of the existing building.

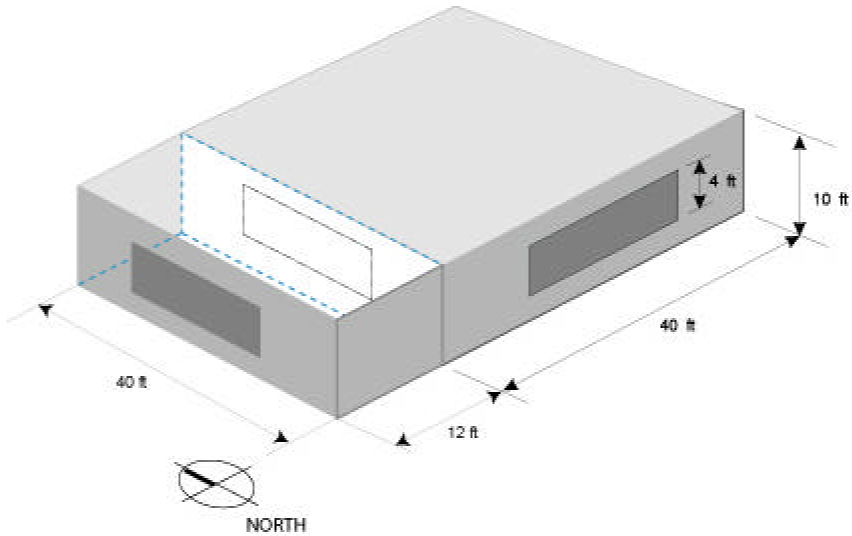


Figure R5-10 – Prototypes E and F

Test Descriptions

These tests are also be used to confirm that reporting requirements are met when modeling an addition with an existing building and that the appropriate budgets have been correctly determined. Two of the three compliance approaches for additions and alternations are evaluated with these tests: the addition-alone approach and the Existing + Addition + Alteration approach. The whole building approach is not evaluated since this is identical to new construction. Table R5-4 describes the tests to perform with the Addition-Alone approach. Table R5-5 describes the tests to perform with the Existing + Addition + Alteration approach.

Table R5-4 – Summary of the Addition-Alone Tests

Series	*Number*	*Prototypes*	*Climates*	*Discrete Modification(s)*	*Continuous Variable*
AA	1	E 1977	3, 9, 12, 14, 16	**Baseline**. The features of the addition shall all exactly meet the prescriptive requirements. The addition is served by an HVAC system in the existing house.	**None**. This is a standard design generator test.
AA	2	E 1977	3, 9, 12, 14, 16	**Increase Glass**. Increase fenestration area on the west side of the addition to 144 ft². This discrete change will fail compliance because the glass area exceeds 20% of the floor area.	**Fenestration Area U-factor**. Reduce the fenestration U-factor in the addition to find the Passing Solution and the Failing Solution.
AA	3	EF 1989	3, 9, 12, 14, 16	**New HVAC**. Install a separate HVAC split system gas/electric system for the addition that has an SEER of 14 and an EER of 13. This will create a positive compliance margin.	**Fenestration U-factor**. Increase the fenestration U-factor in the addition to find the Passing Solution and the Failing Solution.

Table R5-5 – Summary Existing + Addition + Alternation Tests

Series	*Number*	*Prototypes*	*Climates*	*Discrete Modification(s)*	*Continuous Variable*
EA	1	E 1977	3, 9, 12, 14, 16	**Baseline**. The features of the addition shall all exactly meet the prescriptive requirements. The addition is served by an HVAC system in the existing house. Remove 80 ft² from the existing west wall and include 80 ft² with the addition (no net increase in glass area)	**None**. This is a standard design generator test.
EA	2	E 1977	3, 9, 12, 14, 16	**Increase Glass**. Increase fenestration area on the west side of the addition to 144 ft². This discrete change will fail compliance because the glass area exceeds 20% of the floor area.	**Fenestration U-factor**. Reduce the fenestration U-factor in the addition to find the Passing Solution and the Failing Solution.
EA	3	EE 1989	3, 9, 12, 14, 16	**New HVAC**. Install a separate HVAC split system gas/electric system for the addition that has an SEER of 14 and an EER of 13. This will create a positive compliance margin.	**Fenestration U-factor**. Increase the fenestration U-factor in the addition to find the Passing Solution and the Failing Solution.

Acceptance Criteria

For each test, the CEC reference method shall pass the addition plus existing building when data for the passing solution is entered and fail the addition plus existing building when data for the failing solution is entered. The positive tolerance is the TDV space conditioning energy for the basecase plus 3% or 1 kBtu/ft²-y, whichever is greater, and the negative tolerance is also 3% or 1 kBtu/ft²-y, whichever is greater. In addition to producing estimates that are within the tolerances, the CEC will also verify that the correct performance factors are used, based on the vintage of the existing building, and that the standard reports are correctly produced, as required in Chapter 2.

5.3 Water Heating Tests (WH)

This section describes the water heating tests that shall be performed by the ACM vendor. The water heating tests use the series designation “WH”. The water heating tests are defined in a similar manner as the space conditioning tests, except that the tests are performed relative to a water heating system, not whole building TDV energy. See the Overview section of this chapter for a description of the procedures. For the water heating tests, only the TDV energy for water heating is considered in the comparison.

5.3.1 Prototype Systems

Two prototype water heating systems are used. The first is a system which serves the single family home represented by space conditioning prototype C (the water heating system also uses the “C” designation). The second is a system that serves the multi-family apartment building represented by prototype E (this uses the “E” designation). More information on the buildings served is provided above in the prototype descriptions for the space conditioning tests. The water heating systems for the two prototypes are described in Table R5-6.

Table R5-6 – Base Case Water Heating Systems

Prototype	Prototype C	Prototype E
Building Information		
Dwelling Units	1	16
Total Building Area	1,761 ft²	11,616 ft²
Average Dwelling Unit Size	1,761 ft²	726 ft²
Water Heating Equipment		
Number of Water Heaters	1	4
Water Heater Type	Storage Gas (SG)	Storage Gas (SG)
Energy Factor	0.575	0.480
Tank Size	50	4 @ 100
Distribution System	Standard (PIK)	Recirculation with timer controls
Multi-Family Recirculation System		
Linear Feet of Pipe (Note 1)	n.a.	200
PF Outdoor Air	n.a.	0.10
PF Ground	n.a.	0.20
PF ~~Plenum~~ Conditioned or semi-conditioned air within the building envelope	n.a.	0.70
Pipe Diameter for Recirculation System	n.a.	1.5 in.
Recirculation Pipe Insulation	n.a.	1.0 in.
Pump Size (brake horsepower)	n.a.	½ hp
Pump Motor Efficiency	n.a.	0.85

Note 1. Total Linear feet used for recirculation between dwelling units (input to Section 3.5~~Eqn. RG-16~~). PF is the fraction of the total linear feet that is used either outside, in the ground or in the ~~plenum~~ conditioned or semi-conditioned air within the building envelope, as defined in Section RG~~N~~3.5~~4~~.

5.3.2 Accuracy Tests (WH)

As described in the Overview of this chapter, the ACM vendor shall find the passing and failing solution for each test described in Table R5-7. The CEC reference method shall then pass the modified basecase when data for the passing solution is entered and fail the modified basecase when data for the failing solution is entered. The acceptance criteria shall be satisfied for all tests. The water heating tests use a 2% passing tolerance and a 2% failing tolerance, or 1.0 kTDV/ft²-y, whichever is greater.

Table R5-7 – Accuracy Tests – Water Heating

Type	*Test*	*Prototypes*	*Climates*	*Discrete Modification(s)*	*Continuous Variable*
WH	0	C, E	All	None	None
WH	1	C, E	3, 9, 12, 14, 16	**Electric Storage Water Heater.** Change the water heater type from Gas Storage to Electric Storage. Use an Energy Factor of 0.91 for prototype C and 0.87 for E. This produces a negative compliance margin.	**Solar Savings Fraction (SSF).** Increase the SSF to find the passing and failing solutions.
WH	2	C, E	3, 9, 12, 14, 16	**Electric Instantaneous Water Heater.** Change the water heater type from gas storage to electric Instantaneous and use a point of use (POU) distribution system. This produces a negative compliance margin.	**Solar Savings Fraction (SSF).** Increase the SSF to find the passing and failing solutions.
WH	32	C	3, 9, 12, 14, 16	**Distribution Type.** Change the distribution system from the default to pipe insulation on all lines (PIA) system. This produces a positive compliance margin.	**Energy Factor.** Reduce the EF for the proposed building until the passing and failing solutions are reached.
WH	4	E	3, 9, 12, 14, 16	**Recirculation Control.** Add temperature and timer controls (RTmTp) for the recirculating system. This produces a positive compliance margin.	**Energy Factor (EF).** Reduce the EF to find the passing and failing solutions.
WH	5	E	3, 9, 12, 14, 16	**Large Storage Water Heater.** Change water heater type to a 400 gallon large gas storage, SBL = 0.1, thermal (recovery) efficiency= 0.75.	**Thermal Efficiency.** Decrease or increase thermal efficiency (recovery efficiency or AFUE) until the passing and failing solutions are reached.
WH	6	E	3, 9, 12, 14, 16	**Recirculation Piping Insulation.** Increase recirculation piping insulation from 1 in. to 1.5 in. This produces a positive compliance margin.	**Energy Factor.** Reduce the energy factor to find passing and failing solutions.
WH	7	C	3, 9, 12, 14, 16	**Number of Water Heaters.** Use 2 water heaters for the single residence; both are the same size and performance as the basecase. This will produce a negative compliance margin	**Energy Factor.** Increase the energy factor of both water heaters together to find passing and failing solutions.
WH	8	E	3, 9, 12, 14, 16	**Pump Controls.** Baseline assumes timer pump controls. Change to no pump control. This produces a negative compliance margin.	**Energy Factor.** Increase the energy factor of both water heaters together to find passing and failing solutions.

5.3.3 Standard Design Tests (WD)

This section describes a series of tests that verify that the standard design is being correctly defined for water heating systems. The acceptance criteria for these tests is different from the accuracy tests. For this series of tests, a change is defined, which according to the rules for defining the standard design should be neutral. Being neutral means that the change is reflected for both the standard design and the proposed design. The compliance margin shall be within plus or minus 2% of the standard design TDV energy for water heating (space conditioning is not considered). In addition, TDV energy for water heating shall move in the direction indicated in each test description.

Standard Design Equivalent Tests

For water heating the standard design equivalent tests consist of running the basecase water heating systems in all 16 climates. For each case, the standard design TDV energy shall equal the proposed design TDV energy. See Table R5-8.

Table R5-8 – Standard Design Equivalent Tests – Water Heating

Type	Test	Prototypes	Climates	Discrete Modification(s)	Continuous Variable
WD	0	C, E	All	None	None

Neutral Variable Tests

The neutral variable tests are shown in Table R5-9. For these tests, the compliance margin shall remain at zero, unchanged.

Table R5-9 – Neutral Variable Tests – Water Heating

Type	Test	Prototypes	Climates	Discrete Modification(s)
WD	1	C	3, 9, 12, 14, 16	**House Size**. Increase house size to 2,500 ft². TDV energy for both the *Standard Design* and the *Proposed Design* shall increase.
WD	2	C	3, 9, 12, 14, 16	**House Size**. Increase house size to 3,500 ft². The TDV energy for both the *Standard Design* and the *Proposed Design* shall equal the TDV energy for test 1.
WD	3	D	3, 9, 12, 14, 16	**Pipe Length**. Increase recirculation piping length to 400 ft. TDV energy for both the *Standard Design* and the *Proposed Design* shall increase.
WD	4	D	3, 9, 12, 14, 16	**Pipe Location**. Move all the piping outdoors. PF ground and plenum become zero and PF outdoors becomes 1.00. TDV energy for both the *Standard Design* and the *Proposed Design* shall increase.
WD	5	D	3, 9, 12, 14, 16	**Individual Water Heaters.** Replace the central water heating system with individual water heaters in each dwelling unit, which meet the basecase specification for single-family homes (see Table R5-6)

~~5. Minimum Capabilities Tests~~

~~This section describes the methods used to test the minimum modeling capabilities of candidate ACMs. There are three sets of tests: space conditioning tests, water heating tests and standard design generator tests. The space conditioning tests are performed using a simple square building prototype. The water heating tests are performed relative to several prototype water heating systems. The standard design generator tests use a single prototype building designed to have a wide variety of features. Most of the tests are performed in only five climate zones, but some require consideration in all sixteen climate zones.~~

Note: Except for tests 39 through 42, the minimum capabilities tests and optional capability tests do not include the SSEER adjustment added as part of the 2000 update as described in Chapter 3. This enables the runs used for the 1998 standards to be reused in this document. This requires that ACMs be programmed with some type of switch to allow the SEER ($SEER_{temperature}$) to be set to the input SEER, and the installation ($F_{install}$) and TXV (F_{txv}) factors to be set to 1.0 for these tests. This feature may not be used for compliance runs and should not be accessible by compliance users.

5.1 Prototype Buildings

The prototype buildings are illustrated below and described in the following paragraphs. Each is presented in much greater detail on diskettes available from the California Energy Commission. Letter designations are used for the prototype buildings. The letter is used as part of the label for each computer run.

A This prototype is a square box used for most of the space conditioning tests.

B The second prototype building is identical to the first except that it has raised floor construction, instead of a slab-on-grade.

C This prototype is a 3,534 ft², one and two-story, single-family detached custom home.

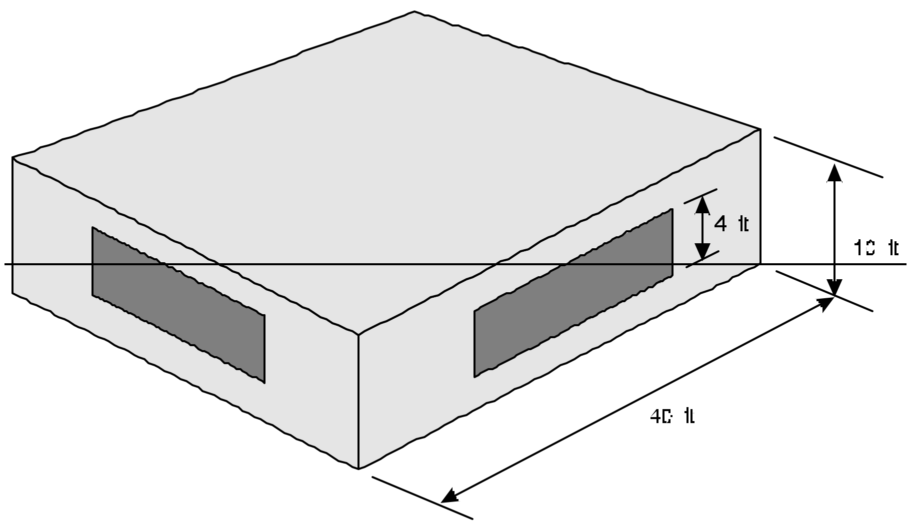


Figure 5-1 - Prototype Buildings A and B

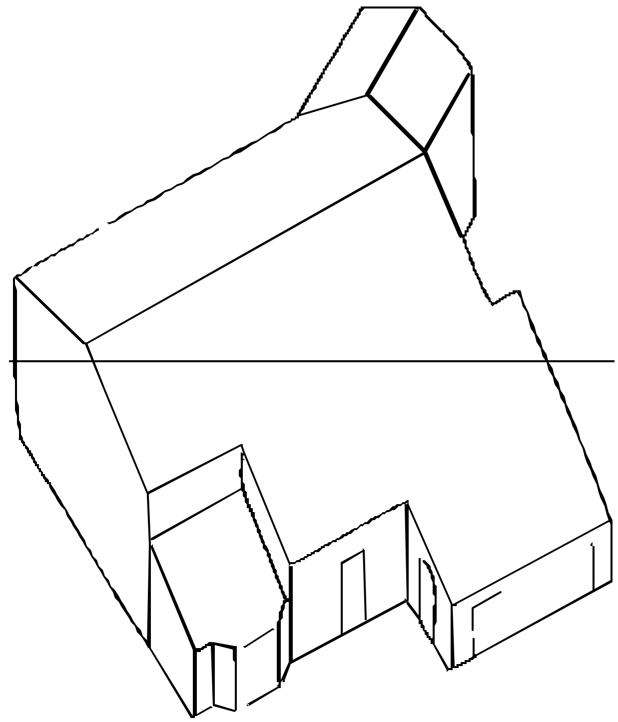


Figure 5-2 - Prototype C

Prototype buildings A and B have the same conservation features in all climate zones (see Table 5-1 below). The specific values associated with each of the basecase conservation measures is also summarized in the CALRES input files available from the Commission (see footnote 1 for this Chapter).

Table 5-1 - Basecase Conditions for Prototypes A and B

Component	**Basecase Level**	**Notes**
Roof U-value	0.034	
Wall U-value	0.088	
Floor U-value	0.037	
Slab F2 factor	0.76	4
Door U-value	0.330	
Thermal Mass	Slab 20% exposed, 80% covered	3
SHGC (exterior device) - (bugscreen)	0.76	
SHGC (interior)	0.68	
SHGC (fenestration - includes framing)	0.70	
Window type	Sliders	5
Fenestration U-Value	0.75	
Gas furnace AFUE	0.78	1
Air conditioner SEER	10.0	
HVAC ducts	R-4.2 Ducts in Attic	2
SLA	4.9	6

Notes:

1 The AFUE(eff) is 0.7629 when the heat contribution and energy use of the fan is considered.

2 Duct efficiencies are as described for the standard design in Chapter 3 using the default values for an air conditioner with 36,000 Btu/hr cooling capacity.

3 Prototype B has thermal mass equivalent to 5% of the raised floor area in 2 inch thick exposed concrete per Section 3.6..

4 Assumes 80% of the slab at building perimeter is carpeted or covered.

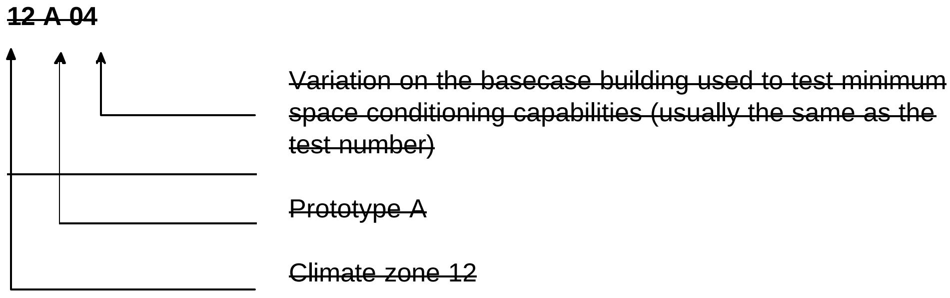
5 The default natural ventilation assumptions are used. 10% of the window area is operable (half of this is inlet and half is outlet). Height difference between inlet and outlet is 2 feet.

6 Based on having ducts in unconditioned attic space.

The computer runs used to generate the ACM tests are based on the standard modeling assumptions described in Chapter 4. Copies of these computer runs are available to assist candidate ACMs in setting their programs up for CEC approval. These input files may be obtained by writing the Residential Buildings Office, California Energy Commission, 1516 Ninth Street (MS-25), Sacramento, California 95814.

5.2 Labeling Computer Runs

Each computer run used to test the minimum space conditioning capabilities is given a precise designation to make it easier to keep track of the runs and to facilitate analysis. The following scheme is used:



5.2.1 Basecase Runs

The first series of runs establish the basecase against which the other runs are compared. The variation number for the basecase run is "00". The basecase energy use is calculated for prototype A in all sixteen climate zones. The energy usage for the other prototypes is calculated only for climate zones 3, 9, 12, 14 and 16. It is important to note that only two input files are required for these computer runs since measures do not change from climate zone to climate zone. The label for these tests are shown in the table below. Total of 21 Runs.

Table 5-2 Basecase Run Labels

Climate Zone	Building Prototype A	Building Prototype B
1	01A00	–
2	02A00	–
3	03A00	03B00
4	04A00	–
5	05A00	–
6	06A00	–
7	07A00	–
8	08A00	–
9	09A00	09B00
10	10A00	–
11	11A00	–
12	12A00	12B00
13	13A00	–
14	14A00	14B00
15	15A00	–
16	16A00	00B16

5.2.2 Test One

The purpose of the first test is to check the prediction of the ACM for relative heating and cooling loads. The heating efficiency is increased and the cooling equipment efficiency is decreased. When the changes in heating and cooling efficiency are made, additional energy use must result. *Total of 19 Runs.*

Table 5-3- Test One Inputs

Run Label	New Heating Efficiency	New Cooling Efficiency
02A01	0.85	8.0
03A01	0.85	5.5
04A01	0.85	7.0
05A01	0.85	5.5
06A01	0.95	6.5
07A01	0.95	7.0
08A01	0.95	7.5
09A01	0.95	8.0
10A01	0.95	8.5
11A01	0.95	8.1
12A01	0.95	7.8
13A01	0.95	8.8
14A01	0.95	8.4
16A01	0.85	5.5
03B01	0.85	6.0
09B01	0.95	8.8
12B01	0.95	7.5
14B01	0.95	8.2
16B01	0.85	5.8

5.2.3 Test Two

Test two is similar to test one except that the cooling efficiency is increased and the heating efficiency is decreased, just the opposite of test one. When the changes in heating and cooling efficiency are made, additional energy use must result. *Total of 19 Runs.*

Table 5-4 Test Two Inputs

Run Label	New Heating Efficiency	New Cooling Efficiency
02A02	0.65	12.5
03A02	0.72	12.5
04A02	0.66	12.5
05A02	0.65	12.5
06A02	0.55	12.5
07A02	0.50	12.5
08A02	0.49	12.5
09A02	0.45	12.5
10A02	0.45	12.5
11A02	0.63	12.5
12A02	0.62	12.5
13A02	0.52	12.5
14A02	0.57	12.5
16A02	0.75	12.5
03B02	0.70	12.5
09B02	0.46	12.5
12B02	0.61	12.5
14B02	0.59	12.5
16B02	0.74	12.5

5.2.4 Test Three

Test three is performed only for prototype A in five climate zones, 3, 9, 12, 14 and 16. The ceiling U-value is reduced to 0.023 from the basecase of 0.033. The south glass area is increased a specific amount for each climate zone. Each of these computer runs must result in greater energy use than the prototype A basecase. *Total of five runs.*

Table 5-5 - Test Three Inputs

Run Label	Roof U-value	South Glass Area
03A03	0.023	200
09A03	0.023	120
12A03	0.023	140
14A03	0.023	160
16A03	0.023	160

5.2.5 Test Four

Test four is performed only for prototype A in five climate zones, 3, 9, 12, 14 and 16. The wall U-value is reduced to 0.060 from the basecase of 0.088. The west glass area is increased a specific amount for each climate zone. Each of these computer runs must result in greater energy use than prototype A. *Total of five runs.*

Table 5-6 - Test Four Inputs

Run Label	Wall U-value	West Glass Area
03A04	0.060	170
09A04	0.060	130
12A04	0.060	119
14A04	0.060	121
16A04	0.060	150

5.2.6 Test Five

Test five is performed only for prototype A in five climate zones, 3, 9, 12, 14 and 16. R-7 slab edge insulation is added, i.e. an F2 factor of 0.65 is used instead of the 0.76 used in the basecase. The north glass area is increased a specific amount for each climate zone. Each of these computer runs must result in greater energy use than prototype A. *Total of five runs.*

Table 5-7 - Test Five Inputs

Run Label	**F2 Factor**	**North Glass Area**
03A05	0.51	220.5
09A05	0.51	150
12A05	0.51	170
14A05	0.51	160
16A05	0.51	180

5.2.7 Test Six

Test six is performed only for prototype A in four climate zones: 9, 12, 14 and 16. The glazing Uvalue is changed to 0.54 instead of the 0.75 used in the basecase. The north glass area is increased a specific amount for each climate zone. Each of these computer runs must result in greater energy use than prototype A. *Total of four runs.*

Table 5-8 - Test Six Inputs

Run Label	Glazing U-value	North Glass Area
09A06	0.54	192
12A06	0.54	286
14A06	0.54	269
16A06	0.54	300

5.2.8 Test Seven

Test seven is performed only for prototype A in five climate zones: 3, 9, 12, 14 and 16. The fenestration U-value is increased to 1.28 (single glass) from the basecase 0.75 (mild climate zone standard) . The solar heat gain coefficients for the window are also changed to account for the single glass ($SHGC_{fen}$ = 0.80). The glass area is reduced uniformly on all orientations. Ventilation area also varies with glass area, remaining at 10% of the total area. Each of these computer runs must result in greater energy use than prototype A. *Total of five runs*

Table 5-9 - Test Seven Inputs

Run Label	Glass U-value	$SHGC_{fen}$	Glass Area on Each Orientation
03A07	1.28	0.80	55
09A07	1.28	0.80	71
12A07	1.28	0.80	65
14A07	1.28	0.80	63
16A07	1.28	0.80	51

5.2.9 Test Eight

Test eight is performed only for prototype A in five climate zones: 3, 9, 12, 14 and 16. The percent of the slab-on grade that is exposed thermal mass is increased: 500 ft^2 is exposed and 1100 ft^2 is carpeted. The slab edge heat loss, however, is unaffected; the F2 factor remains at 0.76. The south glass area is increased a specific amount for each climate zone. Each of these computer runs must result in greater energy use than prototype A. *Total of five runs.*

Table 5-10 - Test Eight Inputs

Run Label	Exposed Mass	South Glass Area
03A08	31.25%	195
09A08	31.25%	128
12A08	31.25%	131
14A08	31.25%	160
16A08	31.25%	128

5.2.10Test Nine

Test nine is identical to test eight except west glass area is increased. This test is performed only for prototype A in five climate zones: 3, 9, 12, 14, and 16. Each of these computer runs must result in greater energy use than prototype A. *Total of five runs.*

Table 5-11 - Test Nine Results

Run Label	Exposed Mass	West Glass Area
03A09	31.25%	158
09A09	31.25%	131
12A09	31.25%	118
14A09	31.25%	113
16A09	31.25%	128

5.2.11Test Ten

Test ten is identical to test eight except north glass area is increased. This test is performed only for prototype A in five climate zones: 3, 9, 12, 14 and 16. Each of these computer runs must result in greater energy use than prototype A. *Total of five runs.*

Table 5-12 - Test Ten Results

Run Label	Exposed Mass	North Glass Area
03A10	31.25%	152
09A10	31.25%	199
12A10	31.25%	141
14A10	31.25%	126
16A10	31.25%	112

5.2.12Test Eleven

Test eleven is identical to test eight except east glass area is increased. This test is performed only for prototype A in five climate zones: 3, 9, 12, 14 and 16. Each of these computer runs must result in greater energy use than the prototype A basecase. *Total of five runs.*

Table 5-13 - Test Eleven Results

Run Label	Exposed Mass	East Glass Area
03A11	31.25%	184
09A11	31.25%	150
12A11	31.25%	127
14A11	31.25%	117
16A11	31.25%	119

5.2.13Test Twelve

Test twelve is performed only for prototype A in five climate zones, 3, 9, 12, 14 and 16. The floor is changed from a slab-on-grade floor to a raised wooden floor over a crawl space with an overall U-value of 0.037. Exterior shading devices are used in other climate zones 9, 12 and 14 on all windows, to achieve the $SHGC_{fen}$ values indicated below. Glass area on the west facade is increased a specific amount for each climate zone. Each of these computer runs must result in greater energy use than prototype A. *Total of five runs.*

Table 5-14 - Test Twelve Inputs

Run Label	Raised Floor – U-value	$SHGC_{fen}$	West Glass Area
03A12	0.037	0.80	64
09A12	0.037	0.40	180
12A12	0.037	0.40	125
14A12	0.037	0.40	140
16A12	0.037	0.80	120

5.2.14Test Thirteen

In test thirteen, an interior shading device is used on all windows which has a solar heat gain coefficient of 0.47 when the device is used with single pane, metal-framed fenestration ($SHGC_{fen}$ = 0.80) and is closed. The area of south glass is increased a specific amount for each climate zone. This test is performed for the prototype A building in five climates. Each of these computer runs must result in greater energy use than the prototype A basecase. *Total of five runs.*

Table 5-15 - Test Thirteen Inputs

Run Label	SHGC Interior Shade	South Glass Area
03A13	0.47	200
09A13	0.47	200
12A13	0.47	222
14A13	0.47	244
16A13	0.47	160

5.2.15Test Fourteen

Test fourteen evaluates how the ACM treats south overhangs. It is performed for the prototype A building in five climate zones: 3, 9, 12, 14 and 16. In each case a south overhang is added to the building. The overhang has a two foot projection from the surface of the south glass. Its bottom edge is located six inches above the top of the window. It is assumed that the south glazing consists of six-foot six-inch high windows. The overhang is assumed to extend an infinite distance beyond the sides of the windows. The overhang characteristics are illustrated below. South glazing area is then increased by increasing its width. Each case must result in greater energy use than prototype A. *Total of five runs.*

Table 5-16 - Test Fourteen Inputs

Run Label	South Overhang	South Glass Area
03A14	yes	169
09A14	yes	132
12A14	yes	144
14A14	yes	129
16A14	yes	100

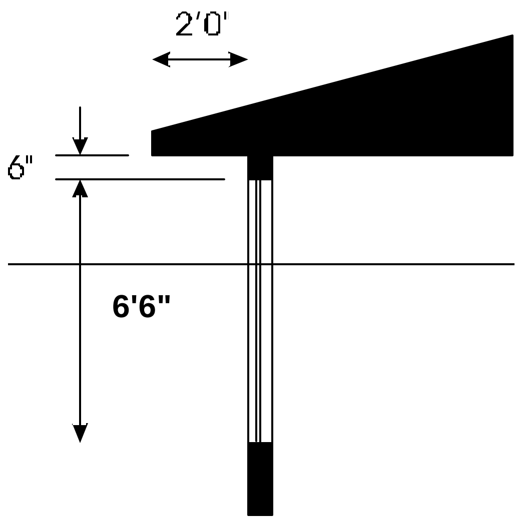


Figure 5-3 - Overhang Characteristics

5.2.16 Test Fifteen

This test is for the infiltration and ventilation model. It is performed for the prototype A building in five climate zones: 3, 9, 12, 14 and 16. The basecase building has ducts in unconditioned space, therefore, the fixed and restricted inputs specify a SLA of 4.9. In this test building leakage is reduced to an SLA of 2.9 by infiltration reduction measures and is modeled with and without 80 cfm (0.375 air changes per hour) of mechanical ventilation which consumes 20 watts of power continuously. Glass area is increased on all orientations so that the building fails to comply. *Total of ten runs*.

Table 5-17 - Test Fifteen Inputs

Run Label	Specific Leakage Area	Fan Volume & Wattage	Maximum Glass Area on Each Orientation A/B
03A15A	2.90	0 cfm/0 watts	131
03A15B	2.90	80 cfm/20 watts	110
09A15A	2.90	0 cfm/0 watts	100
09A15B	2.90	80 cfm/20 watts	96
12A15A	2.90	0 cfm/0 watts	100
12A15B	2.90	80 cfm/20 watts	80
14A15A	2.90	0 cfm/0 watts	100
14A15B	2.90	80 cfm/20 watts	80
16A15A	2.90	0 cfm/0 watts	100
16A15B	2.90	80 cfm/20 watts	72

5.3 Water Heating Tests

Testing of ACM minimum capabilities for water heating is completely separate from the space conditioning tests. One of the principal differences between water heating and space conditioning is that fixed energy budgets are used for water heating rather than custom budgets. The testing procedures are, therefore, fundamentally different. Candidate ACMs must exactly replicate the results of the official CEC water heating methodology for various system types.

5.3.1 Prototype Water Heaters

There are seven water heaters that are used for the tests. These systems are labeled E, F, G, and J. Detailed specifications for each water heating system are given in Table **Error! Reference source not found.** below. The energy use of each of the water heating systems is calculated with several distribution systems.

Table 5-18 - Water Heating Systems

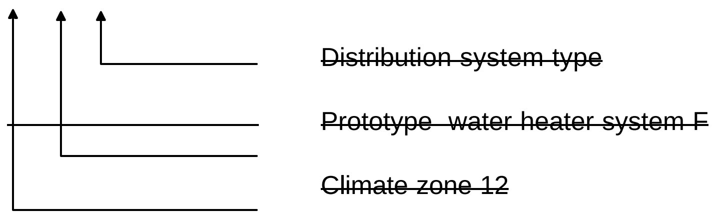
		E	F	G	J
System Level Information					
Climate Zone		3	7	16	5
Dwelling Units		10	1	1	3
Average Dwelling Unit Size		1200	1500	3500	800
Number of Water Heaters		5	1	2	6
Water Heating Equipment					
Water Heater Type		LG	HP	HP	IE
Energy Factor (Note 1)		0.77	2.00	1.80	0.95
Tank Size	Gal	100	50	75	na.
Standby Loss	%	3%.	n.a.	n.a.	n.a.
Input Rating	kBtu/h	100	n.a.	n.a.	n.a.

Notes
1. For instantaneous gas (IG) and large gas (LG) water heaters the value reported in this row is the recovery efficiency or thermal efficiency.

5.3.2 Labeling Computer Runs

Each water heating calculation is given a precise designation to make it easier to keep track of the runs and to facilitate analysis. The following scheme is used:

12 F POU



5.3.3 Test Results

Water heater types E, F, G, and J are analyzed in just one climate zone (except for heat pumps, the results should not change by climate zone). The results must exactly replicate the values shown in the following tables. A summary sheet is provided in Appendix A that must be completed by the vendor. *Total of 40 calculations.*

Table 5-19 - Water Heater Results (kBtu/yr)

		E	**F**	**G**	**J**
Energy Budget		221.900	23.645	28.495	60.750
Distribution System	DSM				
Standard	1	218.208	18.064	45.731	85.085
POU/HWR	0.82	na	15.875	43.940	na
Pipe Insulation	0.92	207.304	17.100	47.178	78.278
Recirc/NoControl	1.52	289.082	24.080	65.630	129.329
Recirc/Timer	1.28	na	21.345	58.427	na
Recirc/Demand	0.98	na	17.824	49.096	na
Recirc/Time+Temp	0.96	na	17.583	48.459	na
Recirc/Temp	1.05	225.023	18.660	51.310	89.339
Parallel Piping	0.86	199.126	16.367	45.242	73.123

5.4 Standard Design Generator Tests

The standard design generator must automatically define the standard design which is the basis of the custom budget. The standard design run is made automatically at the same time as the proposed design run, and the results are reported together on the Computer Method Summary discussed in Chapter 2. This test verifies that the standard design is correctly defined for the proposed design and that the custom budget is correctly calculated.

The standard design test consists of matched pairs of computer runs: a proposed design and its standard design equivalent. The standard design equivalent is the proposed design reconfigured according to the standard design rules in Chapter 3.

Two Computer Method Summaries are produced: one for the proposed design and one for the standard design equivalent. The standard design energy budget on the proposed design Computer Method Summary must be equal to the energy use shown in both the standard design energy budget and proposed design columns of the standard design equivalent computer run.

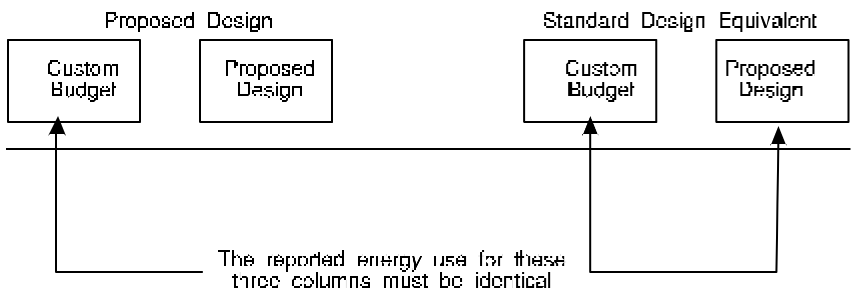


Figure 5-4 - Custom Budget Tests

5.4.1 Slab Floor Test

The purpose of this test is to verify that the standard design generator correctly defines the standard design for proposed designs using slab-on-grade designs. Package D is now the basis of the standard design for all buildings including slab-on-grade buildings. The rules for determining how much thermal mass is modeled in buildings with both raised and slab-on-grade construction are contained in Chapters 3 and 4. The prototype C variation used for this test has both raised floors and slab-on-grade floors.

Prototype "xxC31" is run in all sixteen climate zones, and the standard design equivalent in each climate zone is also run. The results must be exactly identical as discussed above. The labels for this series of runs are summarized in the following table. *Total of 32 runs.*

Table 5-20 - Slab Floor Standard Design Tests

Climate Zone	Proposed Design	Standard Design Equivalent
1	01C31	01C31C
2	02C31	02C31C
3	03C31	03C31C
4	04C31	04C31C
5	05C31	05C31C
6	06C31	06C31C
7	07C31	07C31C
8	08C31	08C31C
9	09C31	09C31C
10	10C31	10C31C
11	11C31	11C31C
12	12C31	12C31C
13	13C31	13C31C
14	14C31	14C31C
15	15C31	15C31C
16	16C31	16C31C

5.4.2 Raised Floor Test

The purpose of this test is to verify that the standard design generator correctly defines the standard design for a proposed design for a dwelling with a raised floor. This is a parallel test to the previous one except that a modification of the prototype building is used which is the prototype C building with no slab floor but with 5% of the nonslab floor covered with 2 inches of exposed concrete. This modification is labeled "xxC32" and is contained in Appendix C in the standard format of the Computer Method Summary.

The modified prototype C building is run in all sixteen climate zones, and the standard design equivalent in each climate zone is also run. The results must be exactly identical. The labels for this series of runs are summarized in the following table. *Total of 32 runs.*

Table 5-21 - Raised Floor Standard Design Tests

Climate Zone	Proposed Design	Standard Design Equivalent
1	01C32	01C32C
2	02C32	02C32C
3	03C32	03C32C
4	04C32	04C32C
5	05C32	05C32C
6	06C32	06C32C
7	07C32	07C32C
8	08C32	08C32C
9	09C32	09C32C
10	10C32	10C32C
11	11C32	11C32C
12	12C32	12C32C
13	13C32	13C32C
14	14C32	14C32C
15	15C32	15C32C
16	16C32	16C32C

5.4.3 Electric Heat Test

The purpose of this test is to verify that the standard design generator correctly defines the standard design for proposed designs with electric heating systems. This a parallel test to the previous custom budget tests, except that a modification of the prototype building is used. This modification is labeled "xxC33" and is contained in Appendix C in the standard format of the Computer Method Summary.

The modified prototype C building with electric resistance heating is run in all sixteen climate zones, and the standard design equivalent which uses an electric heat pump with an HSPF of 6.8 in each climate zone is also run. The results for the *Standard Designs* for both runs and the *Proposed Design* for the *Standard Design* equivalent must be exactly identical. The labels for this series of runs are summarized in the following table. *Total of 32 runs.*

~~Table 5-22 - Electric Heat Standard Design Tests~~

~~Climate Zone~~	~~Proposed Design~~	~~Standard Design Equivalent~~
~~1~~	~~01C33~~	~~01C33C~~
~~2~~	~~02C33~~	~~02C33C~~
~~3~~	~~03C33~~	~~03C33C~~
~~4~~	~~04C33~~	~~04C33C~~
~~5~~	~~05C33~~	~~05C33C~~
~~6~~	~~06C33~~	~~06C33C~~
~~7~~	~~07C33~~	~~07C33C~~
~~8~~	~~08C33~~	~~08C33C~~
~~9~~	~~09C33~~	~~09C33C~~
~~10~~	~~10C33~~	~~10C33C~~
~~11~~	~~11C33~~	~~11C33C~~
~~12~~	~~12C33~~	~~12C33C~~
~~13~~	~~13C33~~	~~13C33C~~
~~14~~	~~14C33~~	~~14C33C~~
~~15~~	~~15C33~~	~~15C33C~~
~~16~~	~~16C33~~	~~16C33C~~

~~5.4.4HVAC Distribution Efficiency Tests~~

~~The Standard Design uses the defaults of the HVAC distribution efficiency calculation method found in Appendix F to determine the HVAC distribution efficiency. These defaults result in seasonal HVAC distribution efficiencies of about 72-76% depending on the climate zone. The calculation method detailed in Appendix F gives efficiency credits for certain specific improvements in the HVAC distribution system, such as, higher duct insulation levels, careful duct design and layout, and reduced duct leakage due to better sealing techniques. HVAC distribution efficiency improvements must be independently verified and some are subject to site diagnostic testing by a certified HERS rater.~~

~~For these tests prototype building A is used. For the first series of tests, the ducts are designed to conform to ACCA Manual D specifications with room-by-room load calculations and have a duct layout design on the plans. The ducts are sealed and tested. The results must replicate the values shown in the following table.~~

Table 5-23 - Duct Efficiency Tests

Run Label	Standard Heating Duct Efficiency	Standard Cooling Duct Efficiency	ACCA Manual D Design	Tested Duct Leakage	Heating Duct Efficiency	Cooling Duct Efficiency
03A34	0.759	0.730	Yes	Yes	0.827	0.850
09A34	0.753	0.702	Yes	Yes	0.822	0.838
12A34	0.743	0.674	Yes	Yes	0.815	0.817
14A34	0.709	0.617	Yes	Yes	0.789	0.775
16A34	0.686	0.730	Yes	Yes	0.773	0.850
03A35	0.759	0.730	No	Yes	0.827	0.786
09A35	0.753	0.702	No	Yes	0.822	0.775
12A35	0.743	0.674	No	Yes	0.815	0.756
14A35	0.709	0.617	No	Yes	0.789	0.717
16A35	0.686	0.730	No	Yes	0.773	0.786

For the second series of tests, duct location is run for six tests with 10 lineal feet of ducts and the air handler are in an unconditioned garage and the remainder of the ducts are in conditioned space. The tests are rerun with all of the ducts and the air handler in the conditioned space. For all of the tests in this series, ducts are sealed and tested. The results must replicate the values shown in the following table.

Table 5-24 – Duct Efficiency Tests

Run Label	Standard Heating Duct Efficiency	Standard Cooling Duct Efficiency	Duct Location	Tested Duct Leakage	Heating Duct Efficiency	Cooling Duct Efficiency
03A36	0.759	0.730	Cond./InEx12	Yes	0.920	0.860
09A36	0.753	0.702	Cond./InEx12	Yes	0.917	0.846
12A36	0.743	0.674	Cond./IInEx12	Yes	0.914	0.836
14A36	0.709	0.617	Cond./IInEx12	Yes	0.902	0.815
16A36	0.686	0.730	Cond./IInEx12	Yes	0.894	0.860

The ACM or its research version must report the duct efficiencies for the HVAC distribution efficiency tests.

5.4.5 Addition Plus Existing Building Test

Additions are treated as new buildings except that internal heat gains are allocated on a fractional dwelling unit basis. When an addition is modeled in conjunction with an existing building, energy credit may be taken for improvements to the existing building. This series of tests exercises the various default assumptions based on the vintage of the existing building and the various reporting requirements for modeling an addition with an existing building. In addition, these tests verify the proper determination of the energy budget and compliance criteria for an addition with an improved existing building.

For these tests the existing building has the same physical configuration as Prototype A but has single pane, metal-framed windows on all four sides with a window on each vertical elevation that is 4' high and 20' wide centered on the facade. The 12' deep by 40' long addition covers the whole west side of the existing building. The addition faces west and has west-facing glazing with a U-value of 0.75 and an $SHGC_{fen}$ of 0.70. The addition covers 80 ft^2 of existing glass. For test series 37, the mandatory minimum R-values are used in the addition's roof/ceiling and walls. Hence for test series 37, the U-value for the roof/ceiling of the addition is 0.047 corresponding to R-19 insulation and the wall U-value is 0.088 corresponding to R-13 wall insulation. For test series 38, the existing building's roof and the addition roof insulation is brought up to the requirements for a new dwelling. The addition's west-facing glazing is increased until the building no longer complies with the budget determined from modeling the existing building and modeling the addition and area weighting the heating and cooling budgets for those runs.

These tests will also be used to confirm that output requirements are met when modeling an addition with an existing building and that the appropriate budgets have been correctly determined.

Table 5-25 Additions Tests Inputs

Run Label	Vintage of Existing Building	$SHGC_{fen}$	Covered Existing Glazing	U-Value of Roof/Ceiling Existing/Add.	West-Facing Glazing for the Addition (ft^2)
03D37	1977	0.70	80 ft^2	0.077/0.047	380
09D37	1977	0.70	80 ft^2	0.077/0.047	270
12D37	1977	0.70	80 ft^2	0.077/0.047	320.
14D37	1977	0.70	80 ft^2	0.077/0.047	360
16D37	1977	0.70	80 ft^2	0.077/0.047	370
03D38	1989	0.70	80 ft^2	0.034/0.034	20
09D38	1989	0.70	80 ft^2	0.034/0.0-34	100
12D38	1989	0.70	80 ft^2	0.034/0.034	80
14D38	1989	0.70	80 ft^2	0.028/0.028	80
16D38	1989	0.70	80 ft^2	0.028/0.028	8

5.4.6 Cooling System SSEER Tests

Calculation of the source SEER (SSEER) for air conditioners is described in Chapter 3. To test this calculation, a series of different air conditioner configurations are modeled using prototype building A. The $SSEER_{prototype}$ parameters assume a split system air conditioner, 10 SEER, with duct sealing. Duct design is not used and TXVs are included in climate zones 9, 12 and 14. Ducts are located in the attic with R4.2 insulation for all tests. Four separate $SSEER_{test}$ configurations are used as specified in the following table. The results must replicate the values shown in the following table.

Table 5-26 – SSEER Tests

Run Label	SSEER prototype	System Type	SEER	TXV	Duct Sealing	ACCA Manual D Duct Design	SSEER test
03A39	6.528	SplitAirCond	12	Yes	Yes	Yes	8.977
09A39	6.899	SplitAirCond	12	Yes	Yes	Yes	8.435
12A39	6.591	SplitAirCond	12	Yes	Yes	Yes	8.001
14A39	6.003	SplitAirCond	12	Yes	Yes	Yes	7.182
16A39	6.495	SplitAirCond	12	Yes	Yes	Yes	8.915
03A40	6.528	SplitAirCond	10.5	Yes	No	No	7.068
09A40	6.899	SplitAirCond	10.5	Yes	No	No	6.553
12A40	6.591	SplitAirCond	10.5	Yes	No	No	6.161
14A40	6.003	SplitAirCond	10.5	Yes	No	No	5.413
16A40	6.495	SplitAirCond	10.5	Yes	No	No	7.026
03A41	6.528	SplitAirCond	19	No	No	No	10.004
09A41	6.899	SplitAirCond	19	No	No	No	8.207
12A41	6.591	SplitAirCond	19	No	No	No	7.210
14A41	6.003	SplitAirCond	19	No	No	No	5.563
16A41	6.495	SplitAirCond	19	No	No	No	9.823
03A42	6.528	PkgAirCond	11.7	No	Yes	Yes	8.201
09A42	6.899	PkgAirCond	11.7	No	Yes	Yes	7.731
12A42	6.591	PkgAirCond	11.7	No	Yes	Yes	7.348
14A42	6.003	PkgAirCond	11.7	No	Yes	Yes	6.621
16A42	6.495	PkgAirCond	11.7	No	Yes	Yes	8.145