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). 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 Energy Commission, 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 test only the TDV for water heating is considered.

All

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~~Figure R5-1~~ through Figure R5-4~~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~~Figure R5-1~~ and Figure R5-3~~Figure R5-3~~show instances when the discrete modifications produce a positive compliance margin and Figure R5-2~~Figure R5-2~~ and Figure R5-4~~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 situation is illustrated in Figure R5-3~~Figure R5-3~~ and Figure R5-4~~Figure R5-4~~.

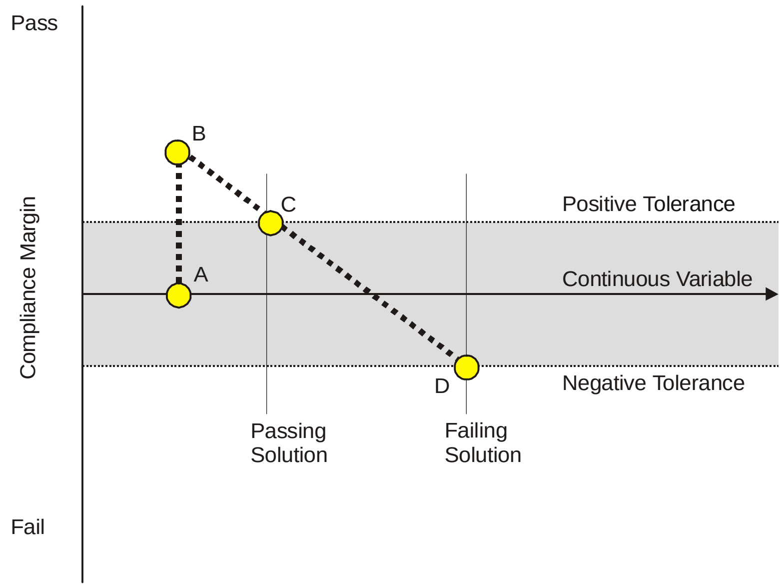


Figure R5-1 – Testing Concept – Discrete Modifications Produce Positive Compliance Margin
The discrete modifications produce a positive compliance margin that exceeds positive tolerance. Both the passing solution and the failing solutions for the continuous variable are determined.

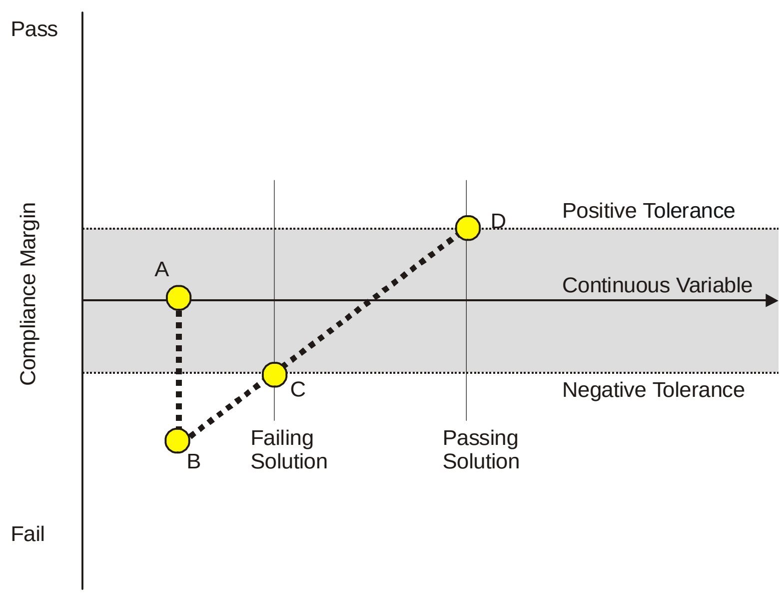


Figure R5-2 – Testing Concept – Discrete Modifications Produce Negative Compliance Margin
The discrete modifications produce a negative compliance margin that exceeds negative tolerance. Both the passing solution and the failing solutions for the continuous variable are determined.

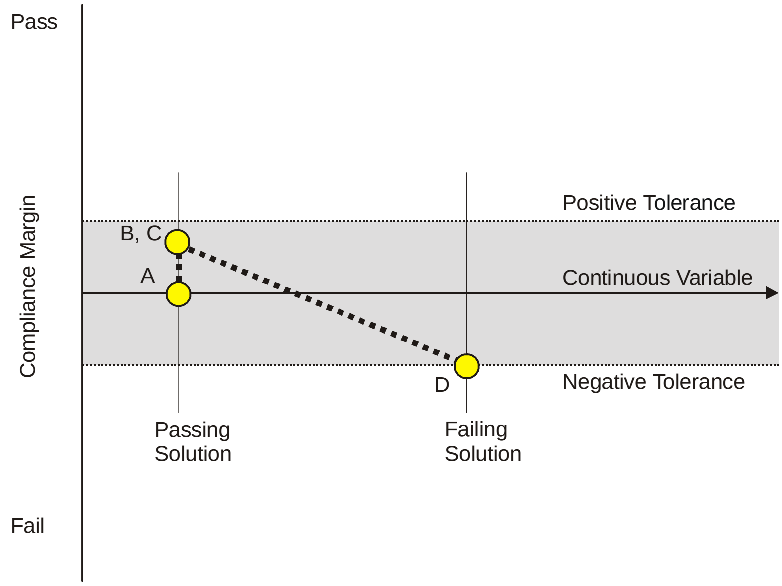


Figure R5-3 – Testing Concept – Discrete Modifications Produce Positive But Small Compliance Margin
The discrete modifications produce a positive compliance margin that is less than the positive tolerance. The passing solution for the continuous variable is equal to the basecase; the failing solution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

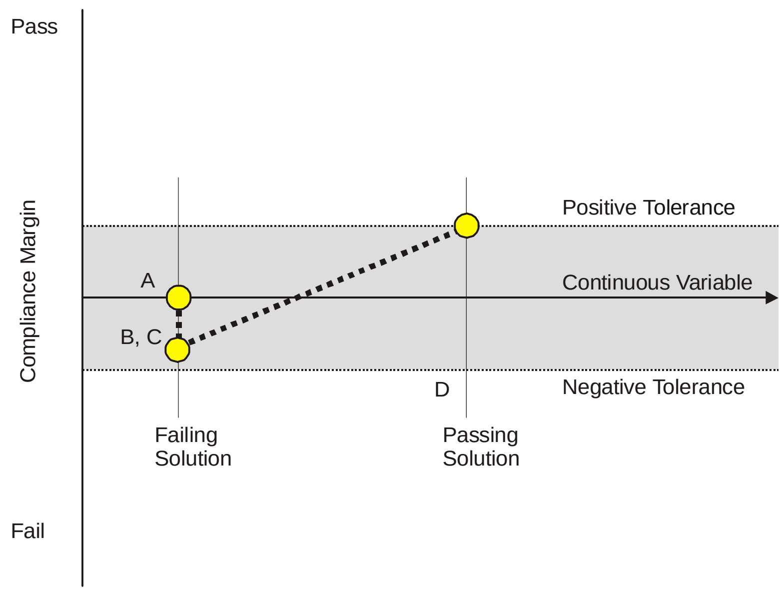


Figure R5-4 – Testing Concept – Discrete Modifications Produce Negative But Small Compliance Margin
The discrete modifications produce a negative compliance margin that is within the negative. The failing solution for the continuous variable is equal to the basecase; the passing solution is determined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

Acceptance Criteria

For every test, the Energy Commission 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 use 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.

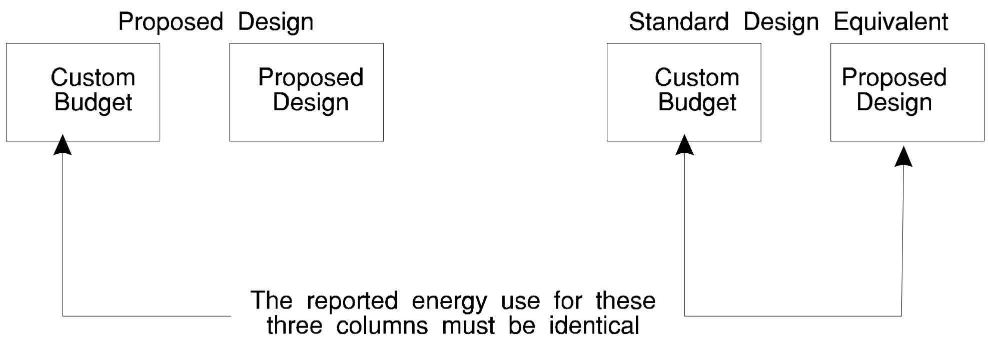


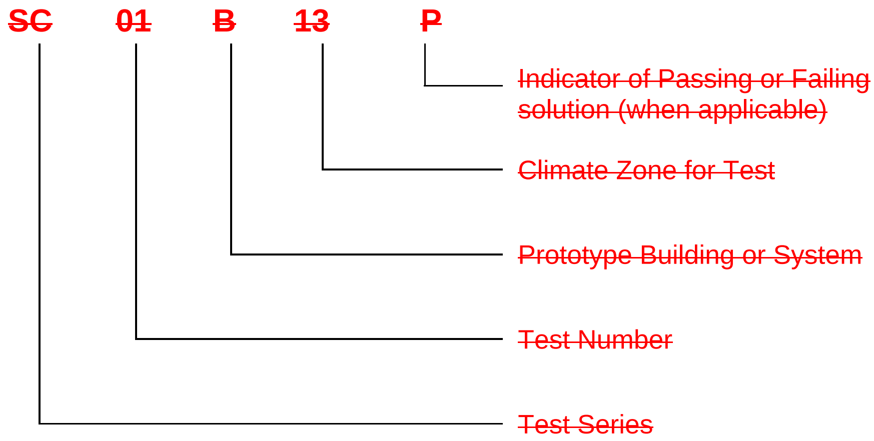
Figure R5-5 – Custom Budget Tests

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 Energy Commission review process. The following labeling scheme described in 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.~~

~~5.1.4Documentation~~

~~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 Energy Commission. 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

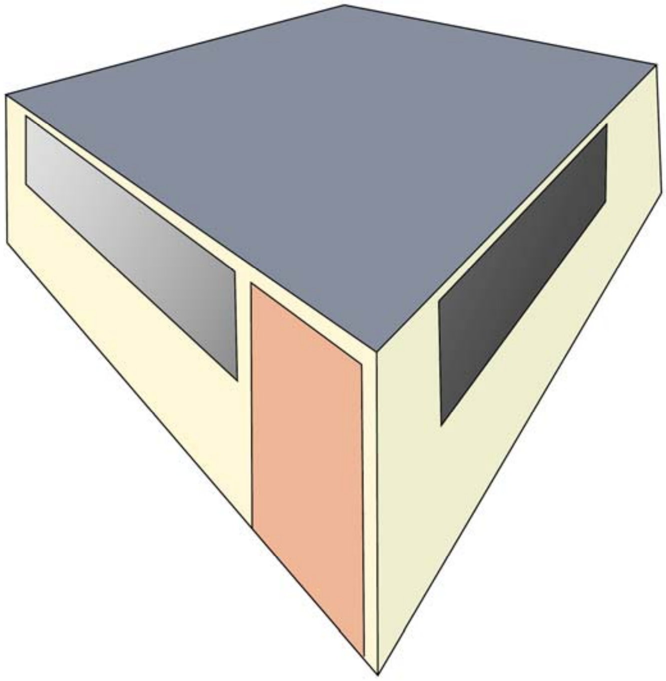
Prototypes Buildings

One Story Prototype

Figures 1, 2, 3 and Table 5 define the 2100 ft2 prototype.

This prototype is used to verify the standard design. Wall area and fenestration area are equally distributed to the four cardinal orientations.

Figure 1 - One Story Prototype Front -



Modify

Figure 2 - One Story Prototype Floor Plan - Modify

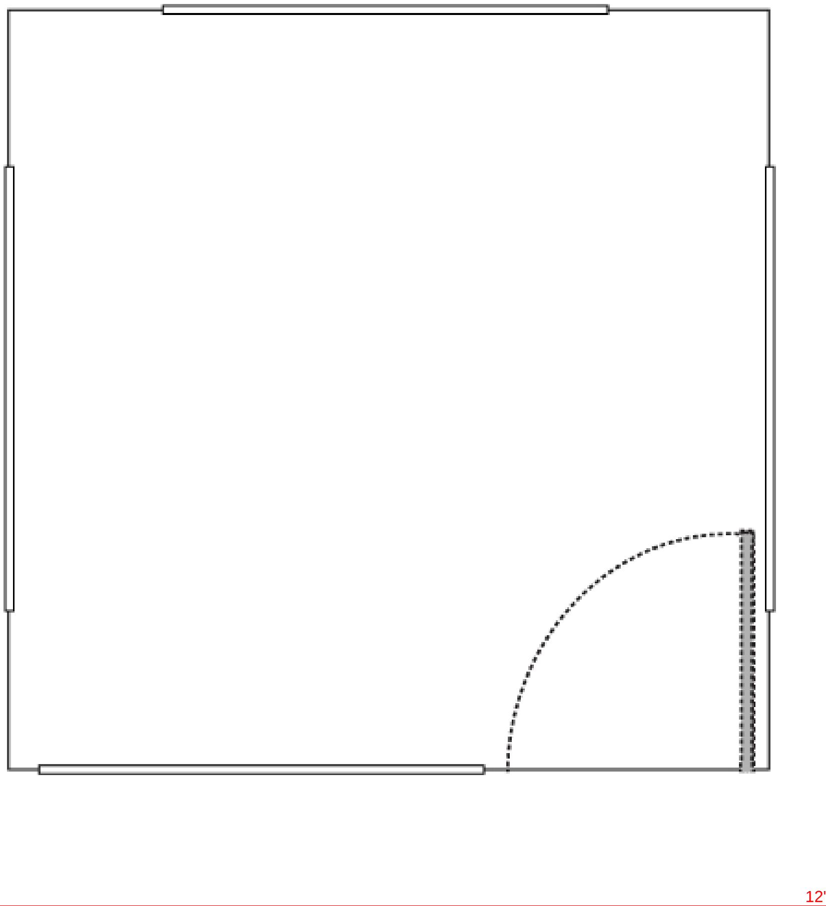


Table 5 – One Story Prototype Description Modify

Component	**Description**
Ceiling Height	**9**
Conditioned floor area	**2100**
Conditioned Volume	**18900**
Gross Areas	
Slab	**2100**
Slab Perimeter outside	**159.3**
Slab Perimeter garage	**24**
Ceiling	**2100**
Front Wall	**412.4**
Right Wall	**412.4**
Left Wall	**412.4**
Back Wall	**412.4**
Door (north)	**40**
Overhang	**None**

Two Story Prototype

Figures 3,4, 5, 6 and Table 6 define the 2700 ft2 prototype.
Prototype B is used to verify correct performance of the compliance software for single family buildings.

Figure 3 - Two Story Prototype Front View

Figure 4 - Two Story Prototype Back View

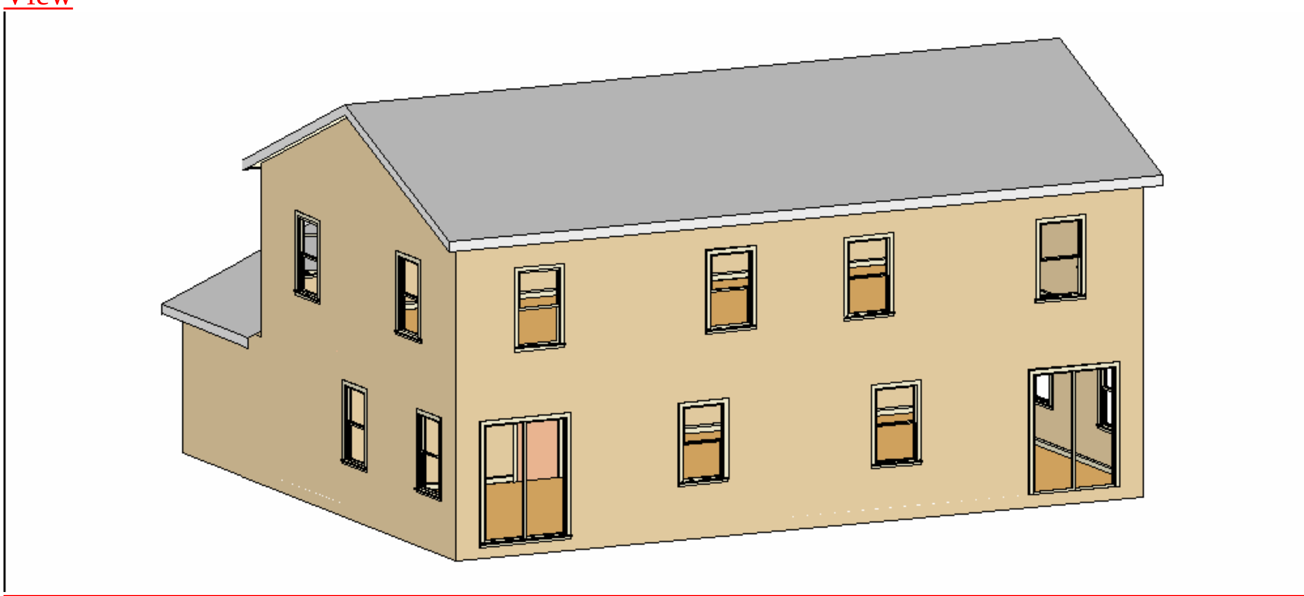
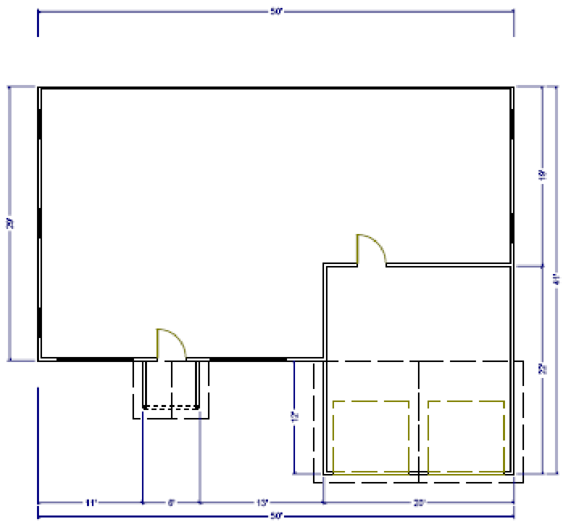


Figure 5 - Two Story Prototype Floor Plan – 1st Floor

41'



22' 19'

50'

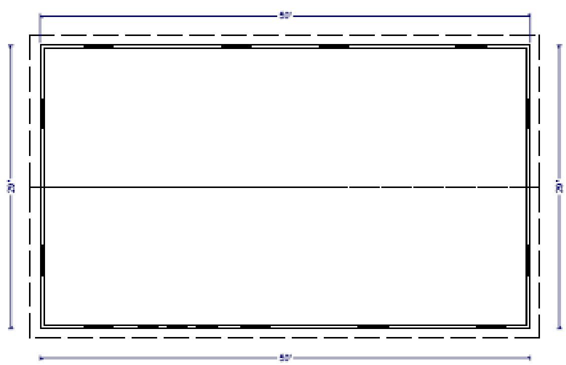
11' 6' 13' 20'

50'

12'

29'

Figure 6- Two Story Prototype Floor Plan – 2nd Floor



29'

50'

50'

29'

Table 6 – Two Story Prototype Description

Component	Description
Ceiling height	9 ft
Conditioned floor area	2700 ft2
Conditioned volume	25750 ft2
Gross areas	
Slab	1250 ft2
Slab perimeter, outside	128 ft
Slab perimeter, garage	30 ft
Ceiling	1450 ft2, vented attic
Floor over garage	200 ft2
Front wall	270 ft2
Front garage wall	180 ft2, shaded
Left wall	551 ft2
Back wall	950 ft2
Right wall	461 ft2
Right garage wall	90 ft2, shaded
Doors	
Front door	20 ft2
Garage door	20 ft2
Overhangs	1 ft (when modeled)

Component Description

Multifamily Prototype

For 2008, a 6960 ft2 eight unit two story apartment building consisting of four 780 ft2 (26 ft wide by 30 ft deep) one bedroom apartments and four 960 ft2 (32 ft wide by 30 ft deep) two bedroom apartments is proposed. The units share common walls and either common floors or ceilings. Multiples of this layout may be combined to represent other typical multifamily configurations. Figures 7, 8, 9, 10 and Table 7 define the 6960 ft2 prototype.

.

Figure 7– Multifamily Prototype Front View

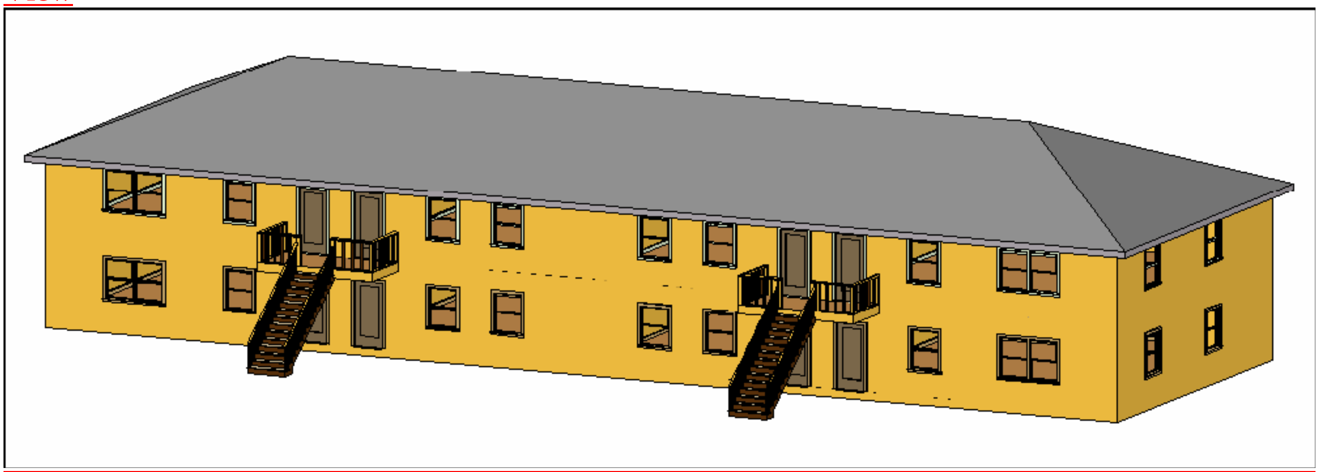


Figure 8– Multifamily Prototype Back View

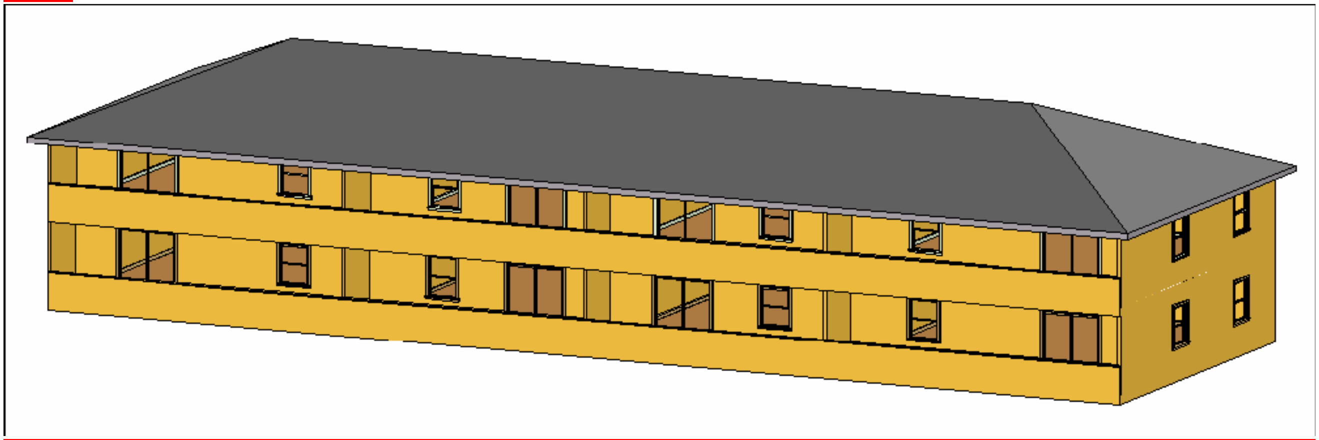
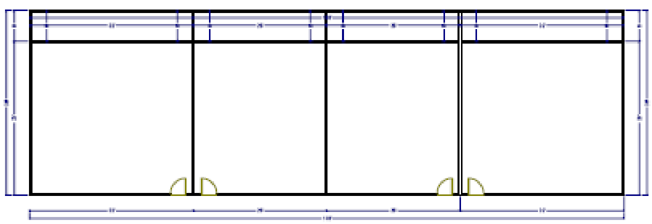


Figure 9- Multifamily Prototype Floor Plan – 1st Floor

6'

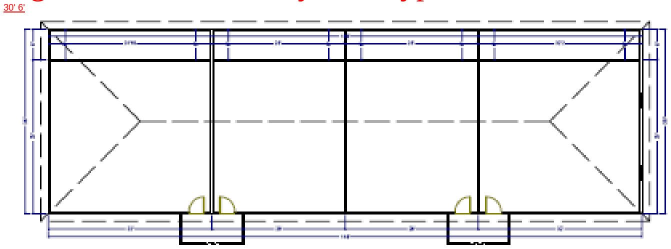


6'

6'
6'
36'
30' 6'
116'
32' 26' 26' 32'
116'
32' 26' 26' 32'
6'
6'
6'
6'
36'
30' 6'

Figure 10 – Multifamily Prototype Floor Plan – 2nd Floor

30' 6'



36'

6'
6'
6'
6'
31'10 26' 26' 32'2
116'
32' 26' 26' 32'
116'
30' 6'
36'
6'
6'
6'
6'

Table 6 – Two Story Prototype

Component	Description
Ceiling height	8 ft
Conditioned floor area	6960 ft2
Conditioned volume	118320 ft2
Dwelling units	8
Gross areas	
Slab	3480 ft2
Slab perimeter, outside	292 ft
Ceiling	1450 ft2, vented attic
Front wall	1972 ft2

2008 California Building Energy Efficiency Standards March 27, 2006

Description

Left wall	510 ft2
Back wall	1972 ft2
Right wall	510 ft2
Doors	
Front door	160 ft2
Overhangs	1 ft (when modeled)

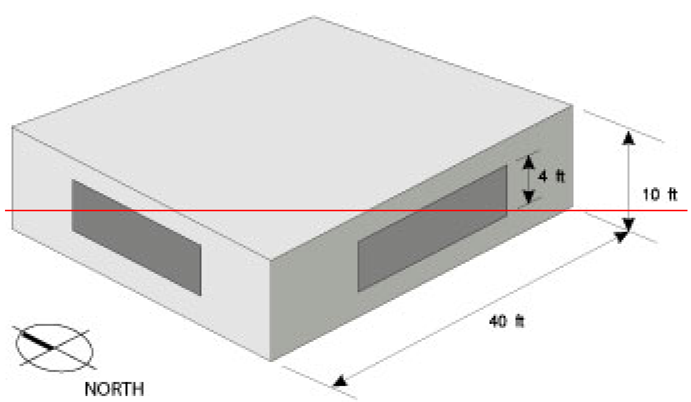
~~*Prototype Buildings*~~

~~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~~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 west 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 basecase 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.
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 R5-8). 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.

Series	*Number*	*Prototypes*	*Climates*	*Discrete Modification(s)*	*Continuous Variable*
SC	13	B~~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	B~~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	B~~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	B~~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	B~~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	B~~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	B~~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	B~~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	B~~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.
SC	23	B~~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	B~~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	B~~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.

Series	*Number*	*Prototypes*	*Climates*	*Discrete Modification(s)*	*Continuous Variable*
SC	26	BA	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 R5-7Figure 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.

Additional tests to be added

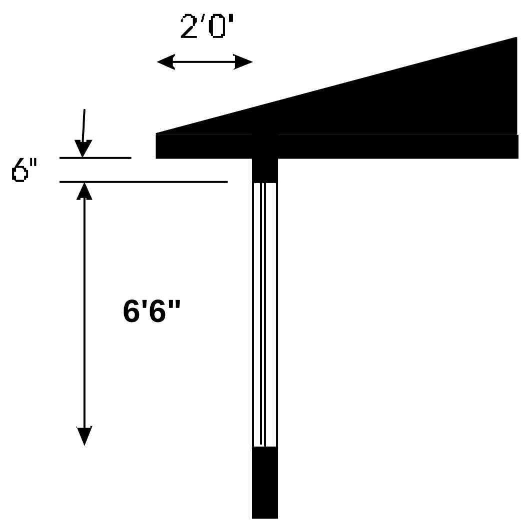


Figure R5-68 – Overhang Characteristics

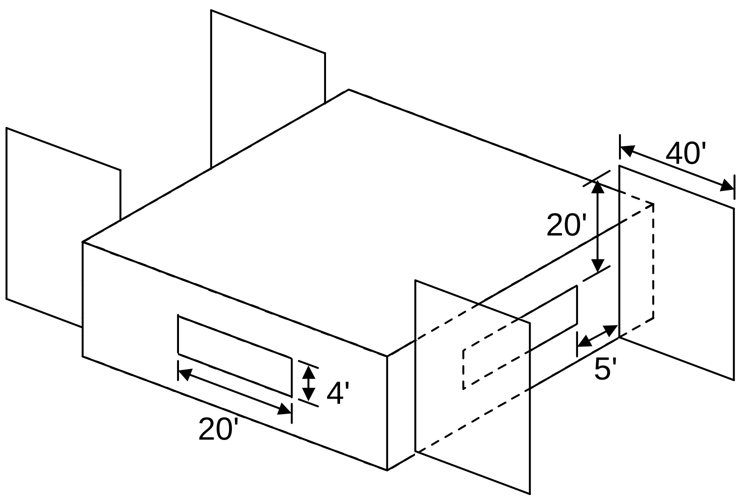


Figure R5-79 – Side Fins for Optional Capabilities Test
The north and south façades are the ones that do not have the sidefins.

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 Energy Commission 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 Energy Commission.
- D Prototype D is identical to prototype C, except that it is has a raised floor. Details are available from the Energy Commission.
- E Prototype E is an eight-unit, two-story multi-family building. Details are available from the Energy Commission.

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.

5.2.35.2.2 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 is downgraded to be more typical of older existing buildings. Prototype BE (Figure R5-10) has the thermal characteristics of 1977 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 façade. The addition is 12 ft deep by 40 ft long and 10 ft high and covers the whole west side of the existing building.

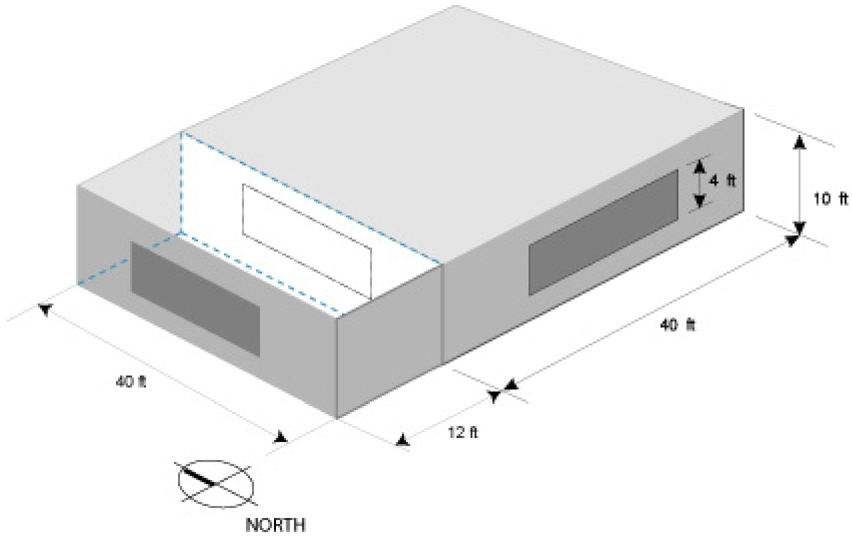


Figure R5-8~~10~~ – Prototypes E and F CREATE REVISED PROTOTYPE

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 R5-2~~Table R5-4~~ describes the tests to perform with the Addition-Alone approach. Table R5-3~~Table R5-5~~ describes the tests to perform with the Existing + Addition + Alteration approach.

Table R5-2~~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	F 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 R5-35 – 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	F 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 Energy Commission 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 Energy Commission 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 R5-4Table R5-6.

Table R5-46 – 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
Number of Stories – Vent Height	2 – 8 feet	2 – 8 feet
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 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.	0.760.85

Note 1. Total Linear feet used for recirculation between dwelling units (input to Section 3.5). PF is the fraction of the total linear feet that is used either outside, in the ground, or in the conditioned or semi-conditioned air within the building envelope, as defined in Section RG3.5.

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 R5-5Table R5-7. The Energy Commission 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 R5-57 – 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 with an efficiency of 0.95and 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 single 400 gallon large gas storage, SBL = =1%0.1, thermal (recovery) efficiency= 0.75, pilot energy 0, input 100K, and insulation level R-10..	**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 are 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 R5-6Table R5-8.

Table R5-68 – 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 R5-7Table R5-9. For these tests, the compliance margin shall remain at zero, unchanged.

Table R5-79 – 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. The total energy use (-Square footage *Kbtu/sqft/yr in 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 total energy use (-Square footage *Kbtu/sqft/yr in TDV 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. The total energy use (-Square footage *Kbtu/sqft/yr inTDV 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. The total energy use (-Square footage *Kbtu/sqft/yr in TDV 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 base case specification for single-family homes (see Table R5-4Table R5-6).