Draft

Building Envelope and HVAC

Measure Evaluation Report
2008 California Building Energy Efficiency Standards

June 28, 2006

CONTENTS

Overview

Description

The following measures were taken from ASHRAE 90.1-2004 and are being proposed as cost effective measures for the 2008 Building Energy Efficiency Standards.

Envelope Measures

Loading Dock Weather Seals

The proposed change would introduce a requirement for cargo doors and loading dock doors to be equipped with weather seals to restrict infiltration when vehicles are parked in the doorway. This requirement would be a mandatory measure for doors adjacent to conditioned spaces in California climate zones 1 and 16 only.

Vestibules

The proposed change would introduce a requirement for vestibules or revolving doors in buildings with four or more stories for all California climate zones. A door that separates conditioned space from the exterior shall be protected with an enclosed vestibule to limit infiltration. Vestibule doors shall be equipped with self-closing devices and shall be adequately separated from each other to prevent interior doors and exterior doors from being open at the same time. There are several exceptions to the proposed change which are noted in the recommendations section.

Opaque Doors

The proposed change would introduce a prescriptive requirement for opaque doors to have a U-factor not greater than 0.70 for swinging doors and 1.45 for non-swinging doors in California climate zones 2 through 15. The requirement for climate zones 1 and 16 would be the same for swinging doors, but more stringent for non-swinging doors, with an allowable U-factor not to exceed 0.50. This requirement would apply to exterior doors of conditioned space.

Loose-fill Insulation

The proposed change would introduce a limitation prohibiting open-blown or poured loose-fill insulation in attic roof spaces when the slope of the ceiling is more than three in twelve. Loose-fill insulation has a tendency to settle downward when used above ceilings with a steep slope, leaving the top of the ceiling with insufficient insulation. This limitation would be applicable to both residential and nonresidential buildings.

HVAC Measures

Humidification and Dehumidification Controls

The proposed change would introduce a requirement for dead band controls within zones served by both humidification and dehumidification systems to prevent simultaneous operation. This would be a requirement for buildings in all California climate zones that have both humidification and dehumidification equipment. Exceptions to this requirement include zones served by desiccant systems that are used with direct evaporative cooling in series and zones where specific humidity levels are required, such as book archives, computer rooms and museums.

Hydronic Heat Pump Controls

The proposed change would introduce a requirement for water loop heat pump systems to be capable of at least a 20°F dead band supply temperature between heat rejection and heat addition. This requirement does not apply when a system loop temperature optimization controller is used to determine the most efficient operating temperature. The proposed change is intended to prevent the simultaneous operation of central heating and cooling devices.

Type of Change

The changes would add mandatory and prescriptive measures to the California Building Energy Efficiency Standards. The changes would affect the Standard and the Nonresidential ACM Manual.

Energy Benefits

The proposed changes would result in space conditioning energy savings.

- A loading dock weather seal requirement for cold climates (CZ 1 and 16) would reduce the unintended exchange of air between conditioned and unconditioned spaces, thereby reducing the energy required for space conditioning.
- Vestibule doors at a building entrance would reduce the flow of unconditioned air into the conditioned space. Additionally, air trapped inside the vestibule would act as a buffer to the transfer of heat through the vestibule, thereby increasing the thermal resistance of the passageway.
- As U-factor is a measure of heat flow through a material, a U-factor requirement for exterior doors would reduce the energy required for space conditioning.
- Limiting the installation of loose-fill insulation to attics with gently sloped ceilings will improve insulation quality and continuity and subsequently reduce space conditioning loads.
- The water loop heat pump loop temperature deadband would reduce energy used to cool and heat the loop.
- The deadband for humidity control will reduce energy use for the systems covered.

Non-Energy Benefits

The proposed changes would reduce drafts and improve thermal comfort, resulting in greater occupant productivity. Higher property values may result if energy bills and comfort are taken into account in property valuation. In the case of loading dock weather seals, the loading dock would provide more isolated from inclement weather conditions such as rain and snow that could create hazardous conditions for workers. The proposed changes would have an insignificant effect on maintenance and operation.

Environmental Impact

Apart from reduced energy use, which is a positive impact, there are no significant environmental impacts associated with the proposed changes.

Technology Measures

The technologies that would be required by the proposed changes are already mature in the market. Furthermore, there are no issues related to useful life, persistence or maintenance.

Performance Verification

Performance verification or acceptance testing is not applicable to the proposed changes.

Cost Effectiveness

The proposed changes are cost effective. See Analysis and Results section.

Analysis Tools

Opaque door U-factor requirements and WLHP controls are prescriptive measures and the standard design modeling assumptions must be updated to incorporate these measures. The proposed prescriptive measures can be modeled by the reference method.

Relationship to Other Measures

None.

Methodology

The approach used to develop the recommendations was to perform a systematic comparison of ASHRAE 90.1-2004 and Title 24 2005. The six changes proposed in this document are all requirements under ASHRAE 90.1-2004, and are applicable to but not currently required under Title 24. The following table is a summary of ASHRAE 90.1-2004 measures and the corresponding requirements for California. This table shows measures that are not recommended and measures that may be considered at a later time.

Table 1 – Summary of Significant Differences between ASHRAE 90.1-2004 and Title 24 2005

P	*Proposed change*
F	*Flagged for possible future consideration*
N	*No change*

Status	Type	Topic	90.1 2004 Requirement	Title 24 2005 Requirement	Recommendation
P	All	Scope	§2.3 No building types excluded	Excludes UBC Type I occupancies	An adoption matrix for is recommended for OSHPD that identifies Title 24 requirements that apply to hospitals.
P	Env	Loading Dock Weatherseals	§5.4.3.3 requires loading dock weather seals in ASHRAE climate zones 4 through 8.	No requirement	Yes. Make this a requirement for California climate zones 1 and 16.
P	Env	Vestibules	§5.4.3.4 Requires a vestibule in buildings with four or more stories in ASHRAE climate zones 3 through 8, with a few other exceptions.	No requirement	Yes. Incorporate the requirement into Title 24 for all California climate zones (only a small part of CEC CZ 15 is in ASHRAE zone 2)
P	Env	Opaque Doors	§5.5.3.6 U-factor requirements for opaque doors are specified in Tables 5.5-1 through 5.5-8.	No requirement	Yes. Require a U-factor of 0.70/1.45 for swinging and non-swinging doors. Bump the requirement to 0.70/0.50 in climate zones 1 and 16.
P	Env	Loose-fill Insulation	§5.8.1.3 prohibits loose-fill insulation in applications where the ceiling slopes more than 3 in 12	No requirement	Yes. Incorporate this requirement into Title 24.
N	Env	Baffles	§5.8.1.4 When eave vents are installed, baffling of the vent openings should be provided to deflect the incoming air above the surface of the insulation	No requirement	No change. This is an issue related to removing moisture and is already addressed in the CBC and other codes
N	Env	Insulation Protection	§5.8.1.7 requires that -Exterior insulation be covered with a protective material to prevent damage from sunlight, moisture, landscaping operations, equipment maintenance, and wind	Requirement only for heated slab floor insulation	No change. This is an issue related to removing moisture and is already addressed in the CBC and other codes
N	HVAC	HVAC alternations and additions	§6.1.1.6 (exception) says HVAC equipment can be installed to match existing.	All new equipment must meet the efficiency requirements (112)	No change.
N	HVAC	Simple systems path	§6.3 Single zone units on small buildings can use a simplified approach.	Doesn't exist	No change.

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P	*Proposed change*
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N	*No change*

Status	Type	Topic	90.1 2004 Requirement	Title 24 2005 Requirement	Recommendation
F	HVAC	Equipment not listed	§6.4.1.3 allows the equipment not listed in the tables referenced in 6.4.1.1 and 6.4.1.2 to be used.	§112 allow any space-conditioning equipment listed in this section may be installed only if the manufacturer has certified that the equipment complies with all the applicable requirements of this section.	No change for now.
F	HVAC	Load calculations	§6.4.2 Load calculations must be done	Prescriptive requirement limiting oversizing and prescribing how to calculate loads. (§144(a) and (b)	No change for now.
N	HVAC	Damper leakage	§6.4.3.3.4 Required by climate for exhaust, return (§6.5.1.1.4) and outside air	Not required	No change,
P	HVAC	Dead band for humidity controls	§6.4.3.6 requires this type of control.	Not required	Yes. Add the 90.1 language
N	HVAC	DCV	§6.4.3.8 Required on occupancies <=10 ft²/per person	Required on single zone systems only for occupancies <=30 ft²/person (§121c3 & 4)	No change
F	HVAC	Duct leakage testing	§6.4.4.2.2 requires duct leakage testing required for a sample of 25% of the ducts in systems that operate at a pressure over 3 in. w.c.	§125(a) requires acceptance testing per NJ5.1. §144(k) requires residential style duct sealing for certain single zone systems. §149(b)1D & E require duct sealing per §144(k) for certain retrofit applications.	No change for now.
F	HVAC	Climatic dependant threshold for economizer requirement	§6.5.1	None	No change for now.
N	HVAC	Design requirements for water-side economizers	§6.5.1.2.2 Includes maximum pressure drop	Sizing only (144e)	No change. There are very few water side economizers installed in California.
P	HVAC	Mechanical Ventilation	§6.5.2.1 (exception) Uses Standard 62 as a basis (not fully explicit).	Uses T24 rules (121b)	This is addressed in a separate measure evaluation report.
P	HVAC	Natural Ventilation	§6.5.2.1 (exception) Uses Standard 62 as a basis <= 25 feet all occupancies (not explicit)	<= 25 feet from openings in hotel/motel up <= 25 feet from openings in all others	This is addressed in a separate measure evaluation report.
F	HVAC	Limitations of reheating and recooling on hydronic system	§6.5.2.2 limits change-over and 3 pipe systems	None	Worth considering in the future, however, not many of these systems are installed in California. .
P	HVAC	Deadband on WLHP loop controls	§6.5.2.2.3 requires a minimum deadband of 20°F min per loop.	None	Yes. Add the 90.1 language

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N	*No change*

Status	Type	Topic	90.1 2004 Requirement	Title 24 2005 Requirement	Recommendation
F	HVAC	Economizer exception for humidity control	§6.5.2.4 Humidification. Systems with hydronic cooling and humidification systems designed to maintain inside humidity at greater than 35°F dew-point temperature shall use a water economizer if an economizer is required by 6.5.1.	Blanket EXCEPTION 4 to Section 144 (d): Zones in which specific humidity levels are required to satisfy process needs.	No change for now.
F	HVAC	Fan power limitation trigger	§6.5.3 5 hp	25 hp per 144c	No change for now.
F	HVAC	Fan power budgets	§6.5.3.1 Varies by size and motor hp. Adjustment allowed for low temperature systems. CV ranges from 0.89 to 0.82 w/cfm, VAV ranges from 1.27 to 1.12 w/cfm	0.8 w/cfm CV and 1.25 w/cfm VAV all sizes using design bhp (144c)	No change for now.
N	HVAC	VSD threshold for VAV systems	§6.5.3.2.1 sets it at 15 hp	10 hp (144c)	No change
N	HVAC	Air side supply pressure reset	§6.5.3.2.3 Required based on zone demand	Not required on VAV systems (EXCEPTION 1 to Section 144 (f))	No change
N	HVAC	VFDs on pumps for variable flow systems	§6.5.4.1 Required on all systems with pumps >50hp	Required on CHW and CW systems with pumps >5hp (144j6)	No change
N	HVAC	Chilled and hot water temperature reset	§6.5.4.3 Required on system >300 kBtu/h	Required on system >500 kBtu/h (144j4)	No change
N	HVAC	WHLP Variable flow	§6.5.4.4 Required on all systems	Required where pumps >5 hp (144j5)	No change this threshold was developed by LCC analysis. It is unlikely that there are systems smaller than 5hp
F	HVAC	Exhaust air energy recovery	§6.5.6.1 Required on air systems with >=5,000 cfm and %OA >-75%	No requirement	No change for now.
F	HVAC	Heat recovery for water heating	§6.5.6.2 Required on 24/7 facilities with large HW loads and heat rejection	No requirement	No change for now.
F	HVAC	Exhaust hoods	§6.5.7.1 Requires tempered or unconditioned MUA	No requirement	No change for now.
F	HVAC	Fume hoods	§6.5.7.2 Requires VAV, heat recovery or direct makeup for systems with >=15,000 cfm	No requirement	No change for now.
F	HVAC	Radiant heating for unenclosed space heating	§6.5.8 Radiant heaters must be used for unenclosed spaces and loading docks (unless provided with air curtain)	No requirement	No change for now.
N	HVAC	Hot gas bypass limitation	§6.5.9 Minimum unloading required	No requirement	No change.
N	HVAC	O&M documentation	§6.7.2 Both Drawings O&M Manuals are required	O&M Manuals required per 10-103c2 Record drawings are referenced in 10-103a2	No change
F	HVAC	System Balancing	§6.7.2.3 TAB report due for buildings >5,000 ft2. Air systems shall be balanced to 1bhp for fans and to 5% for pumps		No change for now.

Table 1 – Summary of Significant Differences between ASHRAE 90.1-2004 and Title 24 2005

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N	*No change*

Status	Type	Topic	90.1 2004 Requirement	Title 24 2005 Requirement	Recommendation
N	HVAC	Acceptance testing	§6.7.2.4 System commissioning required for buildings over 50,000 ft².	Acceptance tests required for all of the following: ✓ Interior lighting controls (131(f)) ✓ OSA controls (full and part-load for VAV systems) (121(f)) ✓ DCV systems (121(d)5) ✓ Package HVAC thermostats (125(h)) ✓ VAV fan controls (125(c)) ✓ Variable volume pump controls (125(d)) ✓ Shut-off of valves on variable flow systems (125(d)) ✓ Air-side economizers (124(b))	Issues related to acceptance testing are being addressed through separate research.
N	HVAC	CTI rating of cooling towers	§6.8.1 Not required (Table 6.8.1G)	Required (footnote to Table 112-G)	No change.
N	HVAC	Pipe insulation	§6.8.3	Some differences with 90.1 (Table 123-A)	No change

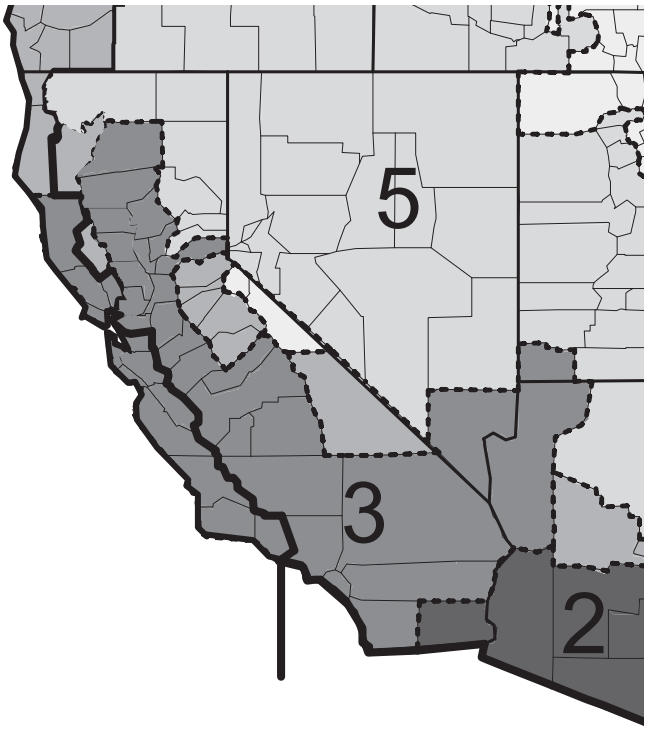

Figure 1 – ASHRAE Climate Zones for California

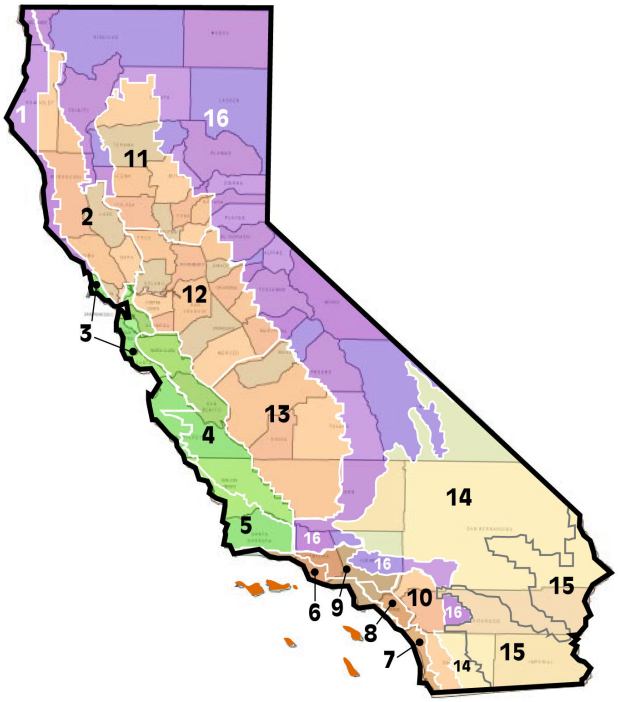

Figure 2 – California Climate Zones

Analysis and Results

The California cost effectiveness criteria as documented in the life-cycle cost methodology report places a higher value on future energy savings than did ASHRAE in the development of the national standard (see Table 2). California uses TDV energy as the basis of the life-cycle cost methodology and establishes the present value per thousand Btu (kBtu) at $0.0844 for lighting and HVAC measures which are considered over a 15-year time horizon and $0.1460 for building envelop measures which are considered over a 30-year life cycle.

By comparison, ASHRAE places a value of $0.291 per kBtu of TDV energy savings for electricity and $0.0448 per kBtu of TDV energy savings for gas. These present values represent from 20% to 53% of the value that California places on future energy savings. The costs of the measures in California are essentially the same as they are nationwide, therefore, if the initial cost is the same and the present value of energy savings is greater, then the measure will be several times more cost effective with the California life-cycle cost criteria than it is with the ASHRAE criteria.

Table 2 – Comparison of California and ASHRAE Life-Cycle Cost Criteria

Term	15-Year Time Horizon (Envelope Measures) ($/kBtu)	30-Year Time Horizon (HVAC Measures) ($/kBtu)	Notes
CEC Present Value	0.0844	0.1460	Present value per unit of TDV energy savings over the life of the measure.
ASHRAE Present Value (Electricity)	0.0291 (34% of California)	0.0291 (20% of California)	Present value per unit of TDV energy savings over the live of the measure used by ASHRAE for the purposes of cost effectiveness. This represents the present value of electricity savings.
ASHRAE Present Value (Gas)	0.0448 (53% of California)	0.0448 (31% of California)	Present value per unit of TDV energy savings over the live of the measure used by ASHRAE for the purposes of cost effectiveness. This represents the present value of gas savings.

The ASHRAE life-cycle cost methodology is based on the following assumptions:

- The cost of electricity is $0.08/kWh
- The cost of gas is assumed to be $0.56 per therm.
- A scalar ratio of 8 is used to represent the present value multiplier for future energy savings.

Based on these assumptions, the present value per kWh of electricity savings is $.64/kWh and the present value per therm of gas savings is $4.48/therm. If you assume a typical pattern of nonresidential electricity use throughout the year, kWh can be converted to kBtu of TDV energy at the rate of about 22 kBtu/kWh. Dividing $0.64 by 22 kBtu/kWh results in the $0.291 value shown in Table 2. TDV values are normalized against gas, so one therm is equal to approximately 100,000 Btu or 100 kBtu of TDV energy. Dividing $4.48/therm by 100 kBtu/therm results in the $0.0448 value shown in Table 2.

Recommendations

Standard Modifications

SECTION 101 – DEFINITIONS AND RULES OF CONSTRUCTION

(b) Definitions.

DOORS are operable opening areas (which are not fenestration) in the building envelope, including swinging and roll-up doors, fire doors, and access hatches. Doors that are more than one-half glass are considered fenestration. For the purposes of determining building envelope requirements, doors can be classified as one of the following:

Non-swinging doors include roll-up, sliding, and all other doors that are not swinging doors.

Swinging doors include all operable opaque panels with hinges on one side and opaque revolving doors.

SECTION 116 – MANDATORY REQUIREMENTS FOR FENESTRATION PRODUCTS AND EXTERIOR DOORS

(a) Certification of Fenestration Products and Exterior Doors other than Field-fabricated.

5. Vestibules. Vestibules shall be required in buildings with four or more stories in all California climate zones. Any door separating conditioned space from the exterior shall be protected with an enclosed vestibule, with all doors opening into and out of the vestibule equipped with self-closing devices. Vestibules shall be designed such that in passing through the vestibule it is not necessary for the interior and exterior doors to open at the same time. Interior and exterior doors shall have a minimum distance between them of not less than 7 ft when in the closed position.

EXCEPTION 1 to Section 116 (a) 5: Doors not intended to be used as a building entrance door.

EXCEPTION 2 to Section 116 (a) 5: Doors opening directly from a dwelling unit.

EXCEPTION 3 to Section 116 (a) 5: Doors opening directly from a space less than 3,000 square feet in area.

EXCEPTION 4 to Section 116 (a) 5: Doors in building entrances with revolving doors.

EXCEPTION 5 to Section 116 (a) 5: Doors used primarily to facilitate vehicular movement or material handling and adjacent personnel doors.

6. Loading Dock Weatherseals. Cargo doors and loading dock doors shall be equipped with weather seals when they are adjacent to conditioned space in California climate zones 1 and 16.

SECTION 118 – MANDATORY REQUIREMENTS FOR INSULATION AND COOL ROOFS

(e) Placement of roof/ceiling insulation.

5. Loose-fill Insulation Limitation. Open-blown or poured loose-fill insulation shall not be installed in attic roof spaces when the slope of the ceiling is more than three in twelve.

SECTION 122 – REQUIRED CONTROLS FOR SPACE-CONDITIONING SYSTEMS

(i) Humidification and Dehumidification Controls. Where a zone is served by a system or systems with both humidification and dehumidification capability, means shall be provided to prevent the simultaneous operation of humidification and dehumidification equipment.

EXCEPTION 1 to Section 122 (i): Zones served by desiccant systems, used with direct evaporative cooling in series.

EXCEPTION 2 to Section 122 (i): Systems serving zones where specific humidity levels are required as approved by the authority having jurisdiction.

SECTION 143 – PRESCRIPTIVE REQUIREMENTS FOR BUILDING ENVELOPES

(a) Envelope Component Approach.

7. Exterior Doors. ~~Exterior doors have no R-value, U-factor, or area requirements.~~ All opaque exterior doors for conditioned spaces shall have a U-factor not greater than 0.70 for swinging doors and 1.45 for non-swinging doors in California climate zones 2 through 15. The U-factor requirement in climate zones 1 and 16 will remain the same for swinging doors, but will be more stringent for non-swinging doors with a maximum U-factor of 0.50.

Incorporate into Tables 143-A and 143-B

	Climate Zones				
	1, 16	**3-5**	**6-9**	**2, 10-13**	**14, 15**
Opaque Doors U-factor					
Non-swinging	0.50	1.45	1.45	1.45	1.45
Swinging	0.70	0.70	0.70	0.70	0.70

Incorporate into Table 143-C

	ALL CLIMATE ZONES
Opaque Doors U-factor	
Non-swinging	1.45
Swinging	0.70

The following term should be added to the building envelope tradeoff equation in Section 143(b) of the Standards:

$$\sum_{i=1}^{nD} c_D (A_D \times U_D)$$

where

$c_D =$ Coefficient for the exterior door (same as wall coefficient).

$A_D =$ Exterior door area of the proposed building (in ft^2).

$U_D =$ The exterior door U-factor for the corresponding A_D.

SECTION 144 – PRESCRIPTIVE REQUIREMENTS FOR SPACE CONDITIONING SYSTEMS

(j) Hydronic System Measures.

7. Hydronic Heat Pump (WLHP) Controls. Hydronic heat pumps connected to a common heat pump water loop with central devices for heat rejection and heat addition shall have controls that are capable of providing a heat pump water supply temperature dead band of at least 20°F between initiation of heat rejection and heat addition by the central devices.

EXCEPTION 1 to Section 144 (j) 7: Where a system loop temperature optimization controller is used to determine the most efficient operating temperature based on real-time conditions of demand and capacity, dead bands of less than 20°F shall be allowed.

ACM Manual Modifications

2.3.5.3 Exterior Doors

Tradeoffs	~~Neutral~~ Yes
Modeling Rules for Standard Design (All):	The reference method shall model the exterior doors ~~in a manner identical to the proposed design~~ by using a door U-factor determined from Table N2-1, based on climate zone and door type (swinging or non-swinging).

Incorporate into Table N2-1

Type	ACM Joint Appendix IV Table	Class	Climate Zone	Non-residential	High Rise Residential and Hotel/Motel Guestrooms	Relocatable Classrooms
Doors	Table IV.28 – Opaque Doors	Swinging	1, 16	IV28-A2	IV28-A2	
			3-5	IV28-A2	IV28-A2	
			6-9	IV28-A2	IV28-A2	IV28-A2
			2, 10-13	IV28-A2	IV28-A2	
			14, 15	IV28-A2	IV28-A2	
	Table IV.28 – Opaque Doors	Non-swinging	1, 16	IV28-A3	IV28-A3	
			3-5	IV28-A1	IV28-A1	
			6-9	IV28-A1	IV28-A1	IV28-A1
			2, 10-13	IV28-A1	IV28-A1	
			14, 15	IV28-A1	IV28-A1	

NJ.10.4 Water-loop Heat Pump Controls

NJ.10.4.1 Construction Inspection

Prior to acceptance testing, verify and document the following:

- Controls were installed that are capable of maintaining a 20 degree difference in heat pump water supply temperature between the initiation of heat rejection and heat addition.

Bibliography and Other Research

ASHRAE 90.1-2004

Building Energy Efficiency Standards, California Energy Commission, 2005