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Pacific Northwest
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Comparison of the Energy Efficiency Prescribed by ASHRAE/ANSI/IESNA Standard 90.1-1999 and ASHRAE/ANSI/IESNA Standard 90.1-2004

M Halverson
B Liu
E Richman
D Winiarski

December 2006

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

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1 Executive Summary

This document presents the qualitative comparison of DOE's formal determination of energy savings of ANSI/ASHRAE/IESNA Standard 90.1-2004. The term "qualitative" is used in the sense of identifying whether or not changes have a positive, negative, or neutral impact on energy efficiency of the standard, with no attempt made to quantify that impact. A companion document will present the quantitative comparison of DOE's determination. The quantitative comparison will be based on whole building simulation of selected building prototypes in selected climates.

This document presents a comparison of the energy efficiency requirements in ANSI/ASHRAE/IESNA 90.1-1999 (herein referred to as Standard 90.1-1999) and ANSI/ASHRAE/IESNA 90.1-2004 (herein referred to as Standard 90.1-2004). The comparison was done through a thorough review of all addenda to Standard 90.1-1999 that were included in the published ANSI/ASHRAE/IESNA Standard 90.1-2001 (herein referred to as Standard 90.1-2001) and also all addenda to Standard 90.1-2001 that were included in the published Standard 90.1-2004. A summary table showing the impact of each addendum is provided. Each addendum to both Standards 90.1-1999 and 90.1-2001 was evaluated as to its impact on the energy efficiency requirements of the standard (greater efficiency, lesser efficiency) and as to significance. The final section of this document summarizes the impacts of the various addenda and proposes which addenda should be included in the companion quantitative portion of DOE's determination. Addenda are referred to with the nomenclature **addendum 90.1-xxz**, where "xx" is either "99" for 1999 or "01" for 2001, and z is the ASHRAE letter designation for the addendum. Addenda names are shown in **bold face** in text.

DOE has chosen not to prepare a separate evaluation of Standard 90.1-2001 as that standard does not appear to improve energy efficiency in commercial buildings. What this means for the determination of energy savings for Standard 90.1-2004 is that the baseline standard for comparison is Standard 90.1-1999 and all addenda to both Standard 90.1-1999 and Standard 90.1-2001 must be considered to determine the overall change in efficiency between Standard 90.1-1999 and Standard 90.1-2004.

2 Overview

This document provides a summary comparison of the energy efficiency requirements of Standard 90.1-1999 and Standard 90.1-2004 in support of the U.S. Department of Energy's Determination of Energy Savings for Standard 90.1-2004. To facilitate the comparison, each addendum to Standard 90.-1999 and Standard 90.1-2001 that was included in the publishing of Standard 90.1-2004 was reviewed for its impact.

> Table 1 provides an overview of each addendum to Standard 90.1-1999 and indicates whether it represents an increase or reduction in the stringency of the energy efficiency requirements of Standard 90.1-1999.
>
> Table 2 provides an overview of each addendum to Standard 90.1-2001 and indicates whether it represents an increase or reduction in the stringency of the energy efficiency requirements of Standard 90.1-2001.

In Tables 1 and 2, each addendum is discussed in terms of the section of Standard 90.1 it impacts, the specific section modified in both the existing and new standard, a brief description of the changes and a rough estimate of its impact on stringency (+,0, -) with some indication of the uncertainty associated with this estimate.

All addenda to Standard 90.1-1999 are listed in Appendix F - Addenda Description Information of Standard 90.1-2001. A total of 34 addenda were processed in the creation of Standard 90.1-2001 and are listed in Table F-1 – Addenda to ANSI/ASHRAE/IESNA Standard 90.1-1999; Changes Identified. The complete text of each addendum, including the foreword describing the reasoning for the addendum, may be found online at http://www.ashrae.org/template/AssetDetail/assetid/30207;jsessionid=aaa8UZ3pgZsefu.

All addenda to Standard 90.1-2001 are listed in Appendix F - Addenda Description Information of Standard 90.1-2004. A total of 31 addenda[1] were processed in the creation of Standard 90.1-2004 and are listed in Table F-1 – Addenda to ANSI/ASHRAE/IESNA Standard 90.1-2001; Changes Identified. The complete text of each addendum, including the foreword describing the reasoning for the addendum, may be found online at http://www.ashrae.org/template/AssetDetail/assetid/30208;jsessionid=aaa8UZ3pgZsefu.

[1] Note that Table F-1 does contain a listing for an additional addendum 90.1-01ak that was not included in the development of Standard 90.1-2004 and that is included in Table F-1 as a typographical error. This addendum will be processed by ASHRAE as addendum 90.1-04ak and included in Standard 90.1-2007.

Table 1. Summary of Differences between Standards 90.1-1999 and 90.1-2001, by Addenda

No	Addenda to 90.1-1999	Section Affected	Location in 90.1-1999 Edition	Location in 90.1-2001 Edition	Description of Changes	Impact on Energy Stringency
1	90.1-99a	5. Building Envelope	Section 5.5.1.2 Substantial Contact	Section 5.2.1.2 Substantial Contact	Clarification to Substantial Contact	0 (editorial only)
2	90.1-99b	5. Building Envelope	Exception to 5.3.1.1 Roof Insulation	Exception to 5.3.1.1 Roof Insulation	Editorial clarification by including additional ASTM test methods	0 (editorial only)
3	90.1-99d	5. Building Envelope	Appendix A, A6 Slab-on-Grade Floor Insulation	Appendix A, A6 Slab-on-Grade Floor Insulation	Clarification on F-factors to be used for trade-offs in Section 5.3.1.5. Allows combined vertical and horizontal placement of insulation to substitute for horizontal insulation of same length and R-value. A given length of combined vertical and horizontal will typically be more stringent than purely horizontal placement.	0 (simply adds another option that is typically more stringent, but still an option)
4	90.1-99e	Appendix A, A9 Determination of Alternative U-Factors, C-Factors, and F-Factors	Appendix A, A9 Determination of Alternative U-Factors, C-Factors, and F-Factors	Appendix A, A9 Determination of Alternative U-Factors, C-Factors, F-Factors, or Heat Capacities	Clarifies that the calculation procedures in A9 can also be used fro determining heat capacity of assemblies not covered in Table A6 and A7.	0 (clarification only)
5	90.1-99f	Appendix B, Building Envelope Criteria	Table B-19 and Table B-20 Building Envelope Requirements	Table B-19 and Table B-20 Building Envelope Requirements	Changes the unheated slab-on-grade floor F-Factors for residential spaces. . This change removes requirements for unheated slab-on-grade insulation for residential buildings in most of New Hampshire, Minnesota, Maine, all of South Dakota, Wyoming, Wisconsin, and some of Alaska	- (removes requirements for slab insulation)
6	90.1-99g	Appendix B, Building Envelope Criteria	Table B-19 through Table B-26 Building Envelope Requirements	Table B-19 through Table B-26 Building Envelope Requirements	Increases the allowed heated slab-on-grade floor F-Factors for both nonresidential and residential spaces.	- (increases F-factor requirements for slab insulation)
7	90.1-99j	6. Heating, Ventilating, and Air Conditioning	Exception to 6.2.1, Table 6.2.1C, Table 6.2.1H and Table 6.2.1J	Exception to 6.2.1, Table 6.2.1C, Table 6.2.1H, Table 6.2.1J, Table 6.2.1k, Table 6.2.1L and Table 6.2.1M	1. Correction on the conflict of the minimum efficiency requirements of centrifugal water cooled chillers between Table 6.2.1C and Table 6.2.1H. The correction lowers the base design COP of the nonstandard centrifugal chiller tables to that in table 6.2.1C and reflects the original intent of Standard 90.1-1999. 2. Incorporates revised standards for nonstandard centrifugal chillers. All of the chiller IPLVS in Table 6.2.1C have been modified to reflect new test procedures. In addition, new NPLV tables	0 (essentially editorial related to test procedure changes)

No	Addenda to 90.1-1999	Section Affected	Location in 90.1-1999 Edition	Location in 90.1-2001 Edition	Description of Changes	Impact on Energy Stringency
					have been introduced to reflect the wider difference between COP and NPLV brought about by the change in test procedure.	
8	90.1-99k	6. Heating, Ventilating, and Air Conditioning	Exceptions to 6.2.3.1.1 Zone Thermostatic Controls	Exceptions to 6.2.3.1.1 Zone Thermostatic Controls	Rewords the exceptions to the zone thermostatic controls for clarity and consistency.	0 (editorial only)
9	90.1-99m	6. Heating, Ventilating, and Air Conditioning	Section 6.2.3.2.4 Shutoff Damper Controls	Section 6.2.3.3.3 Shutoff Damper Controls	Adds a climatic limitation and rewords the low leakage requirement to the motorized dampers	- (limits applicability of shutoff damper controls)
10	90.1-99n	6. Heating, Ventilating, and Air Conditioning	Exception to 6.2.3.2.4 Shutoff Damper Controls	Exception to 6.2.3.3.3 Shutoff Damper Controls	1. Revised for consistency with the requirements 6.1.3(n). 2. Allows gravity dampers for small HVAC system application	- (allows gravity dampers for small systems)
11	90.1-99o	6. Heating, Ventilating, and Air Conditioning	Section 6.2.3.2.5 Zone Isolation	Section 6.2.3.2.4 Zone Isolation	Removed explicit allowance for supply air into non-occupied isolation areas.	+ (reduces supply air usage)
12	90.1-99q	6. Heating, Ventilating, and Air Conditioning	Section 6.2.3.5 Enclosed Parking Garage Ventilation	Deleted	Deleted the permissive and unenforceable requirements in its entirety.	0 (essentially editorial)
13	90.1-99r	6. Heating, Ventilating, and Air Conditioning	Exception to 6.3.1(b) Economizers	Exception to 6.3.1(b) Economizers	Clarifies the gas phase air cleaning is excluded from the economizer requirement.	0 (editorial only)
14	90.1-99s	6. Heating, Ventilating, and Air Conditioning	Exception 6.3.1.4 Economizer Heating System Impact	Exception 6.3.1.4 Economizer Heating System Impact	This exception was added to ensure that code officials would allow economizer operation where reheat was allowed and is a clarification of the original intent of the 90.1 Committee.	0 (clarification only)
15	90.1-99t	6. Heating, Ventilating, and Air Conditioning	Section 6.2.5.3.1 & 6.2.5.3.2 System Balancing	Section 6.2.5.3.1 & 6.2.5.3.2 System Balancing	1. Deleted the system balancing requirement within 10% design rate 2. Removed the exception for a calibrated VAV box	– (relaxes system balancing requirements)
16	90.1-99u	6. Heating, Ventilating, and Air Conditioning	Table 6.2.1B Unitary and Applied Heat Pump	Table 6.2.1B Unitary and Applied Heat Pump	Adds pre- October 29, 2001 water source, ground water, and ground source heat pumps minimum efficiency requirements based on the ISO 13256-1 test procedure.	0 (merely reflects existing equipment efficiencies)
17	90.1-99v	9. Lighting	Section 9.2.1.1 Item c Automatic Lighting Shutoff	Section 9.2.1.1 Item c Automatic Lighting Shutoff	Replaced the vague term “occupant intervention” with a correct term describing a third automatic lighting control option based on some other occupancy based system.	0 (editorial only)
18	90.1-99w	9. Lighting	Section 9.3.1.2 Additional	Section 9.3.1.2.1 Additional	This change clarifies the intended use of the space-by-space	0

No	Addenda to 90.1-1999	Section Affected	Location in 90.1-1999 Edition	Location in 90.1-2001 Edition	Description of Changes	Impact on Energy Stringency
			Interior Lighting Power	Interior Lighting Power	method of calculating additional interior lighting power in retail spaces.	(editorial only)
19	90.1-99y	9. Lighting	Table 9.3.1.2 Lighting Power Densities Using the Space-by-Space Method	Table 9.3.1.2 Lighting Power Densities Using the Space-by-Space Method	Clarifies the definitions of "General Low Bay and General High Bay" under the industrial buildings.	0 (editorial only)
20	90.1-99z	9. Lighting	Section 9.3.2 Exterior Building Lighting Power Table 9.3.2 Lighting Power Limits for Building Exteriors	Section 9.3.2 Exterior Building Lighting Power Table 9.3.2 Lighting Power Limits for Building Exteriors	Clarifies the language and intent of exterior building lighting power by separating the exterior building facade lighting power from all other exterior building applications. Reflects Interpretation IC 90.1-1999-1.	0 (editorial only)
21	90.1-99aa	8. Power	Section 8.2.1 Voltage Drop	Section 8.2.1 Voltage Drop	This change to 8.2.1.1 Feeders and 8.2.1.2 Branch Circuits relaxes the limitation of the sizing method in electrical design.	0 (negligible at best)
22	90.1-99ab	9. Lighting	Section 9.3.1.2 Additional Interior Lighting Power	Section 9.3.1.2.1 Additional Interior Lighting Power	Clarifies that additional interior lighting power allowances apply to any lighted area that meets the criteria as discussed in 90.1-1999 interpretation number 4.	0 (editorial only)
23	90.1-99ac	7. Service Water Heating	Section 7.2.1 Sizing of Systems	Section 7.2.1 Load Calculations	Provides the designers the flexibility to determine the load calculation method to size the system and equipment.	0 (adds option)
24	90.1-99ad	6. Heating, Ventilating, and Air Conditioning	Table 6.2.1A and Table 6.2.1B	Table 6.2.1A and Table 6.2.1B	Incorporates the fourth footnote into the table, which allows a 0.2 deduction from EERs and IPLVs for units with heating sections other than electric resistance heat.	0 (editorial only)
	90.1-99ad	6. Heating, Ventilating, and Air Conditioning	Section 6.3.2.2.3	Section 6.3.2.2.3	Limit the use of dampers on closed circuit cooling towers in place of water bypass	+ (limits use of dampers in cooling towers)
	90.1-99ad	6. Heating, Ventilating, and Air Conditioning	Table 6.2.1D	Table 6.2.1D	Corrects editorial mistakes.	0 (editorial only)
	90.1-99ad	6. Heating, Ventilating, and Air Conditioning	Table 6.2.4.2A and Table 6.2.4.2B	Table 6.2.4.2A and Table 6.2.4.2B	Adds insulation requirements for buried ductwork	+ (adds new requirement)
	90.1-99ad	6. Heating, Ventilating, and Air Conditioning	Section 6.3.2.1	Section 6.3.2.1	Relaxed requirements for limiting volume of supply air that is reheated or re-cooled.	- (relaxes requirements)
	90.1ad	6. Heating, Ventilating, and Air Conditioning	Section 6.3.3.2.1 Section 6.2.3.2.1	Section 6.3.3.2.1 Section 6.2.3.2.1	Provide prescriptive allowance for VAV systems to use variable speed drives or vane axial fans with variable pitch blades Allowed the use of residential system controllers that have only two (as opposed to seven) day types.	0 (allows other options)

No	Addenda to 90.1-1999	Section Affected	Location in 90.1-1999 Edition	Location in 90.1-2001 Edition	Description of Changes	Impact on Energy Stringency
25	90.1-99af	4. Administration and Enforcement	Section 4.1.2.2 Alterations to Existing Buildings	Section 4.1.2.2 Alterations to Existing Buildings	Strengthens and weakens the standard in various ways.	0 (has both positive and negative aspects)
26	90.1-99ag	5. Building Envelope	Section 5.2.2.1, 5.2.2.2, Section A8, Table A-17, A-18 and A-19	Section 5.5.2.1, 5.5.2.2, Section A8, Table A-17, A-18 and A-19	Removed default values for U-factor and SHGC for glazed wall systems.	0 (removes default options)
27	90.1-99ah	9. Lighting	Section 9.3.1.1 Building Area Method of Calculating Interior Lighting Power Allowance	Section 9.3.1.1 Building Area Method of Calculating Interior Lighting Power Allowance	Allows the building area method to be used for buildings with multiple building area types	0 (allow additional options)
28	90.1-99ai	9. Lighting	Table 9.3.1.1 Lighting Power Densities Using the Building Area Method	Table 9.3.1.1 Lighting Power Densities Using the Building Area Method	Adds a footnote to clarify the use of specific building types when available in the table.	0 (editorial only)
29	90.1-99ak	Appendix B	Table B-1 to B-26 (SI Edition Only)	Table B-1 to B-26 (SI Edition Only)	Revises all U-factors in the SI version of tables by correcting the conversion factor from IP to SI units.	0 (editorial only)
30	90.1-99al	3. Definitions, Abbreviations, and Acronyms 6. Heating, Ventilating, and Air Conditioning	Section 3 and Section 6.3.2.1 Section 6.2.5.3	Section 3 and Section 6.3.2.1 Section 6.2.5.3	1. Changes the term “Mechanical Refrigeration” to “Mechanical Cooling”. 2. Revises the definition of Nominal Power Demand. 3. Adds definitions of “Balancing Air” and “Balancing, Hydronic”. 4. Deletes certain requirements for system balancing to 10% of design flows (repeat of 90.1t).	0 (editorial or repeat of other addenda)
31	90.1-99am	4. Administration and Enforcement	Section 4.1.2 Existing Buildings	Section 4.1.2 Existing Buildings	Clarified different treatments given to additions and alternations to existing buildings.	0 (editorial only)
32	90.1-99an	11. Energy Cost Budget Method	Section 11.4.2 Building Envelope	Section 11.4.2 Building Envelope	Clarifies the wording to keep consistent with Section 4.1.2	0 (editorial only)
33	90.1-99ao	5. Building Envelope	5. Building Envelope	5. Building Envelope	Editorial and structural changes to the entire section to make it easier to read and use.	0 (editorial only)
34	90.1-99ap	11. Energy Cost Budget Method	Section 11.4.3(e) and (f)	Section 11.4.3(e) and (f)	Wording changes to clarifies the rules for air and water economizers.	0 (modifies ECB option only)

Table 2. Summary of Differences between Standards 90.1-2001 and 90.1-2004, by Addenda

No	Addenda to 90.1-2001	Section Affected	Location in 90.1-2001 Edition	Location in 90.1-2004 Edition	Description of Changes	Impact on Energy Stringency
1	90.1-01a	4. Administration and Enforcement	Section 4.4.7 Transformers	NA	Removes requirement for labeling transformers.	0 (only a labeling requirement)
2	90.1-01b	6. Heating, Ventilating, and Air Conditioning	Section 6.2.1 Mechanical Equipment Efficiency	Section 6.4.1.4 Verification of Equipment Efficiencies	Wording changes to the requirements for the certification program for product performance verification	0 (editorial)
3	90.1-01c	6. Heating, Ventilating, and Air Conditioning	Table 6.2.4.3B Duct Seal Levels	Table 6.4.4.2B Duct Seal Levels	Wording changes related to pressure-sensitive tape.	0 (editorial)
4	90.1-01d	6. Heating, Ventilating, and Air Conditioning	Table 6.2.1D Packaged Terminal and Room Air Conditioners and Heat Pumps	Table 6.8.1D Packaged Terminal and Room Air Conditioners and Heat Pumps	Establishes minimum efficiency standards for single-package vertical air-conditioners (SPVAC) and heat pumps (SPVHP) consistent with EPAct.	0 (Standard 90.1 is merely reflecting equipment efficiencies that already exist)
5	90.1-01e	11. Energy Cost Budget Method	NA	G. Performance Rating Method	Adds new informative appendix for use in rating the performance of building designs.	0 (Informative only)
6	90.1-01g	9. Lighting	Tables 9.3.1.1 and 9.3.1.2 Lighting Power Densities	Tables 9.5.1 and 9.6.1 Lighting Power Densities	Complete replacement of lighting power density requirements	+ (Provides more stringent requirements)
7	90.1h	12. Normative References and Normative Appendix A	12. Normative References and Sections A9.3.1 Building Material Thermal Properties and A9.3.2 Assembly U-Factors	12. Normative References and Sections A9.3.1 Building Material Thermal Properties and A9.3.2 Assembly U-Factors	Updates references	0 (Simple reference updates)
8	90.1-01i	6. Heating, Ventilating, and Air Conditioning	Tables 6.2.1A Air Conditioners and Condensing Units and 6.2.1B Heat Pumps	Tables 6.8.1A Air Conditioners and Condensing Units and 6.8.1B Heat Pumps	Updates minimum efficiency for single-phase air conditioners and heat pumps less than 65,000 Btu/h to reflect new DOE efficiency standards	0 (Standard is simply reflecting national manufacturing standards)
9	90.1-01j	9. Lighting	Section 9.2.1.2 Space Control and Section 9.3.1 Interior Lighting Power	Section 9.4.1.2 Space Control and Section 9.2.2.3 Interior Lighting Power	Modifies format of space control requirements Modifies exception n for athletic playing areas	0 (editorial)

No	Addenda to 90.1-2001	Section Affected	Location in 90.1-2001 Edition	Location in 90.1-2004 Edition	Description of Changes	Impact on Energy Stringency
10	90.1-01k	6. Heating, Ventilating, and Air Conditioning	Section 6.2.3.1.1 General	Section 6.4.3.1.1 General	Modifies requirement for zone and loop controllers	0 (editorial)
11	90.1-01m	7. Service Water Heating	Table 7.2.2 Performance Requirements for Water Heating Equipment	Table 7.8 Performance Requirements for water Heating Equipment	Adds requirement for heat pump pool heaters	+ (adds new requirement but for relatively uncommon system)
12	90.1-01n	6. Heating, Ventilating, and Air Conditioning	Section 6.1.3 Simplified Approach Option for HVAC Systems, part g	Section 6.3.2 Criteria, part g	Provides detailed explanations of control means to clarify the intent of the supplemental heat control requirements	0 (editorial)
13	90.1-01o	6. Heating, Ventilating, and Air Conditioning	Section 6.3.1 Economizers, Exception (d)	Section 6.5.1 Economizers, Exception (d)	Modifies exception language for systems that are required to include a condenser heat recovery system	0 (editorial)
14	90.1-01p	11. Energy Cost Budget Method	Section 11.2.1.4 (new) (no title)	Section 11.2.1.4 (no title)	Adds a new section that references ASHRAE Standard 140	0 (modifies tradeoff methodology only)
15	90.1-01q	9. Lighting	Sections 9.2.1.3 Exterior Lighting Control and 9.3.2 Exterior Building Lighting Power and Table 9.3.2 Lighting Power Limits for Building Exteriors	Sections 9.4.1.3 Exterior Lighting Control and 9.4.5 Exterior Building Lighting Power and Table 9.4.5 Lighting Power Densities for Building Exteriors	Revises exterior lighting requirements to clarify lighting control requirement language and to provide a more prescriptive set of lighting power densities for building exteriors.	+ (provides additional requirements)
16	90.1-01r	6. Heating, Ventilating, and Air Conditioning	Table 6.2.4.2B Minimum Duct Insulation	Table 6.8.2B Minimum Duct Insulation	Clarifies that requirements for return air ducts for combined heating and cooling supply ducts	0 (editorial)
17	90.1-01s	6. Heating, Ventilating, and Air Conditioning	Section 6.3.6.1 Exhaust Air Energy Recovery, Exceptions (g) and (i)	Section 6.5.6.1 Exhaust Air Energy Recovery, Exceptions (g) and (i)	Revises exceptions (g) and (i) to correct what was a long-standing typographical error in exception g and to revise exception i to allow it to apply to any series energy recovery technology. *(Exception (g) is revised again in addenda am below.)*	0 (editorial)
18	90.1-01t	9. Lighting	Section 9.2.1.1 Automatic Lighting Shutoff	Section 9.4.1.1 Automatic Lighting Shutoff	Revises exceptions to automatic control device requirement for building lighting to clarify language and to add an exception for spaces where automatic lighting shutoff could conceivably endanger occupants	0 (editorial, since life safety concerns would have excluded automatic shutoff

No	Addenda to 90.1-2001	Section Affected	Location in 90.1-2001 Edition	Location in 90.1-2004 Edition	Description of Changes	Impact on Energy Stringency
						anyway)
19	90.1-01u	6. Heating, Ventilating, and Air Conditioning	Tables 6.3.1.1.3A High-Limit Shutoff Control Options for Air Economizers and 6.3.1.1.3B High-Limit Shutoff Control Settings for Air Economizers	Tables 6.5.1.1.3A High-Limit Shutoff Control Options for Air Economizers and 6.5.1.1.3B High-Limit Shutoff Control Settings for Air Economizers	Adds dew point and dry bulb temperature as an economizer shutoff control options and adds a high-limit value for this type of control. *(These tables are revised again in addenda am below)*	0 (simply adds another option)
20	90.1-01x	6. Heating, Ventilating, and Air Conditioning	Sections 6.1.3 Simplified Approach Option for HVAC Systems – part i, 6.2.3.2 Off-Hour Controls, and 6.2.3.3.5 Ventilation Fan Controls (new)	Section 6.3.2i, 6.4.3.2 *(should be 6.3.3.3)* Off-Hour Controls, and 6.4.3.3.5 Ventilation Fan Controls	Revises requirements for off hour controls in both simple and complex systems and adds requirements for ventilation fan controls. *(The printed version of Standard 90.1-2004 contains a section numbering error.)*	+ (adds new requirements)
21	90.1-01y	6. Heating, Ventilating, and Air Conditioning	Section 6.3.3.2.1 Part-Load Fan Power Limitation	Section 6.5.3.2.1 Part-Load Fan Power Limitation	Revises part-load fan power limitation to reduce the requirement for VAV fans with motors from 30 hp to 15 hp.	+ (applies requirement to smaller systems)
22	90.1-01z	6. Heating, Ventilating, and Air Conditioning	Section 6.2.1 Mandatory Equipment Efficiency, Exception	Section 6.4.1.2 Minimum Equipment Efficiencies – Listed Equipment – Nonstandard Conditions	Clarifies exception for chillers designed to operate at nonstandard conditions, including chillers requiring secondary coolants such as glycol or brine.	0 (editorial only)
23	90.1-01aa	12. Normative References	12. Normative References	12. Normative References	Updates, adds, and deletes a number of references	0 (updates references)
24	90.1-01ab	6. Heating, Ventilating, and Air Conditioning	Section 6.3.6.1 Exhaust Air Energy Recovery, Exception (d)	Section 6.5.6.1 Exhaust Air Energy Recovery, Exception (d)	Changes exceptions to Exhaust Air Energy Recovery for commercial kitchen hoods to allow exception for any commercial kitchen hood collecting and removing grease vapors and smoke	- (expands exemption to additional hoods)
25	90.1-01ac	11. Energy Cost Budget Method	Sections 11.3.1, 11.3.6, 11.3.8, and 11.3.9 and Tables 11.4.3A, and 11.4.3	Sections 11.3.1, 11.3.6, 11.3.8, and 11.3.9 and Tables 11.4.3A, and 11.4.3	Makes changes to add clarity and specificity to a number of different sections	0 (editorial only)
26	90.1-01ae	9. Lighting	Section 9.2.1.2 Space Control	Section 9.4.1.2 Space Control	Adds an occupancy sensor requirement for classrooms, conference/meeting rooms, and break and lunch rooms	+ (adds requirement for occupancy sensors)
27	90.1-01ag	9. Lighting	Table 9.3.1.2 Lighting Power Densities Using the Space-by-Space Method	Table 9.6.1 Lighting Power Densities Using the Space-by-Space Method	Revises retail sales area lighting power density to correct a value that should have been changed in addendum g.	+ (lowers existing requirement for retail sales area)

No	Addenda to 90.1-2001	Section Affected	Location in 90.1-2001 Edition	Location in 90.1-2004 Edition	Description of Changes	Impact on Energy Stringency
28	90.1-01ah	D. Climate Data	Tables D-1 U.S. and U.S. Territory Climatic Data and D-3 International Climatic Data	Tables D-1 U.S. and U.S. Territory Climatic Data and D-3 International Climatic Data	Adds weather data for nine locations, including US Territories and Clark AFB in the Philippines.	0 (only adds weather data)
29	90.1-01ai	9. Lighting	Section 9.2.3 Exit Signs	Section 9.4.3 Exit Signs	Revises exit sign requirements to a maximum of 5 watt per face	+ (lowers energy usage)
30	90.1-01al	Appendix E, Informative References	Appendix E, Informative References	Appendix E, Informative References	Updates references to building energy simulation software and annual weather data	0 (informative only)
31	90.1-01am	5. Building Envelope and 6. Heating, Ventilating, and Air Conditioning, B. Building Envelope Criteria and D. Climate Data	5. Building Envelope and 6. Heating, Ventilating, and Air Conditioning, Appendix B. Building Envelope Criteria and Appendix D. Climate Data	5. Building Envelope and 6. Heating, Ventilating, and Air Conditioning, Appendix B. Building Envelope Criteria and Append D. Climate Data	Reduces climate data tables from 26 to 8 by adopting new climate zones consistent with DOE and IECC climate tables and replaces all references to specific climate parameters with references to the new climate zones.	+ (mapping of old envelope tables to new tables plus changes in economizer requirements)

3 Discussion of Detailed Textual Analysis

This section outlines in detail the changes brought about by each addenda to the standard. The description of changes is in order of section to the standard and the approved addenda.

3.1 Title, Purpose and Scope Changes

No changes were made to the Title, Purpose and Scope of either Standard 90.1-1999 or Standard 90.1-2001. The title, purpose and scope of these standards are identical to that of Standard 90.1-2004.

3.2 Definitions Changes

Two addenda were identified that made changes to the definitions in Standard 90.1-1999.

Addendum 90.1-99j added a definition for non-standard part load value (NLPV). This definition by itself does not impact any efficiency requirements of the standard.

Addendum 90.1-99al modified several of the definitions in Standard 90.1-1999 and their use in other sections. These were 1) changing the previously defined term "Mechanical Refrigeration" to "Mechanical Cooling". 2) revising the definition of pump system energy demand to eliminate an "at nominal efficiency" clause which was irrelevant to measured or nominal pump power, 3) adding definitions for "Balancing, Air" and "Balancing, Hydronic". In addition, this addendum modified Section 6.3.2.1 Zone Controls to refer to Mechanical Cooling rather than Mechanical Refrigeration. None of these definitions by themselves impact any efficiency requirements of the standard. Addendum 90.1al also repeated addendum 90.1t that advocated removal of the requirement to balance ducted air and water flows to within 10% of design rates; however this modification is discussed under addendum 90.1-99t.

No changes were made to the Definitions section of Standard 90.1-2001.

3.3 Administration and Enforcement Changes

Three addenda were identified that made changes to the Administration and Enforcement section. These are addenda 90.1-99af, 90.1-99am, and 90.1-01a.

Addendum 90.1-99af implemented several specific changes to the administration and enforcement sections 4.1.2.1, 4.1.2.2.1, 4.1.2.2.2, and 4.1.2.2.3 that deal with the application of the standard to alterations in existing buildings. These changes include:

HVAC alterations - **Addendum 90.1-99af** added a requirement that new cooling systems installed in previously un-cooled spaces shall comply with the requirements of the mechanical section (section 6) of the standard, that any alterations to existing cooling systems shall not decrease existing economizer capability unless the system complies with section 6.3.1., that and

new or replacement duct work and piping complies with the duct insulation, pipe insulation, and duct sealing requirements of section 6.2.4. In addition, piping for service water heating equipment must meet the pipe insulation requirements outlined in section 7.2.3 and Table 6.2.4.1.3. Exceptions were added to this section with regards to insulation for pipe and ducts located in spaces for which there is insufficient space or access to meet the requirements in section 6.2.4 or 7.2.3. The reference to specific requirements in the Standard 90.1-2001 mechanical section makes it clear how to apply the standard to mechanical or SWH systems The modifications take a common sense approach to application of the standard to existing systems and honor previous commitments to the Building Owners and Managers Association (BOMA) to provide an addenda to Standard 90.1-1999 which explicitly dealt with alterations in a manner that would provide exceptions for specific conditions where compliance with the precise wording of section 6 could be wildly non-cost effective (inaccessible ductwork for instance). In general, these likely represent a small loosening of the standard with regards to existing buildings. However, the addition of the requirement that new cooling systems installed in un-cooled spaces meet all the requirements of Section 6 is a strengthening of the standard with regards to existing buildings, however much of this equipment would likely fall under Federal manufacturing standards for efficiency anyway.

Envelope Alterations - **Addendum 90.1-99af** removed a requirement that the fenestration SHGC obtained after replacement of glazing window sash be equal to or lower than that in the original window. It also modified a second requirement that allowed replacement of less than 25% of the fenestration in the building as long as the U-factor and SHGC were both equal to or lower than the original fenestration. The modification removed the reference to SHGC in that requirement. Finally, Section 4 was modified to make clear that alterations to walls and floors that do not have preexisting framing cavities and for which the alteration will not create framing cavities are not required to meet the U-value requirements provided for in section 5. The envelope modifications above remove existing requirements to meet the same SHGC requirements as for new buildings shown in the prescriptive standard. This appears to be primarily based on aesthetic concern when only some windows are being replaced in the building. This also represents a loosening of the Standard as applied to existing buildings. Overall, Addendum 90.1-99af is essentially neutral in terms of energy efficiency.

Additions and Compliance Tradeoffs - **Addendum 90.1-99am** clarified the different treatments given to additions and alterations in existing buildings. Additions in Standard 90.1-1999 are generally subject to the identical set of requirements as new building construction, with the exception that existing systems and equipment that serve both the existing building and the new addition will not be subject to the requirements of the standard. A modification to section 4.1.2.1 was added saying that if compliance could not be achieved in the addition alone, tradeoffs would be allowed between the components and design of the addition and modification to one or more of the components of the existing building, the analysis to be done using the ECB methodology. The completed building design shall consume no more energy than the sum of the energy consumed by the existing building and the energy of the addition if made to comply with the standard. Note, the allowance for tradeoffs with the existing building could be construed to provide equivalent energy consumption for a specific permit. However, if these were alterations to the existing building would have been anyway, they would have to have been done to meet the

requirements of the Standard 90.1 and the additions would have to have met the requirements of Standard 90.1 alone. As such, it appears that the allowance for tradeoffs with the existing building is a weakening of the text of the standard.

Addendum 90.1-99am also addressed alterations to existing buildings by modifying section 4.1.2.2, Alterations to Existing Buildings. This modification appears mostly editorial. Section 4.1.2.2 was changed by removing the discussion of the two alternatives to show compliance to sections 5, 6, 7, 8, 9, and 10 of the standard. Those two methods were either to individually show that each replaced components by itself met the requirements of Standard 90.1-1999 as provided in subsections to 4.1.2.2 (the prescriptive approach), or that the annual energy use of the altered space would, after alteration, have no greater energy use than a "substantially" similar space meeting the requirements of Standard 90.1-1999 as provided in subsections to 4.1.2.2 and verified by a design professional (the performance approach). The modified wording treats the prescriptive approach as the default option, and provides the performance approach as an exception. The principle substantive change was that performance compliance calculation was still required to be verified by a design professional, but it was explicitly stated that it could be done using any calculation method acceptable to the authority having jurisdiction. Since the previous language did not specify the calculation methodology and the proposed language only requires that authority having jurisdiction approve the calculation methodology, it is not believed that these changes materially affect the energy stringency of the standard.

Addendum 90.1-01a deletes Section 4.4.7 Transformers from Standard 90.1-2001 entirely, thus removing a requirement that the energy efficiency levels of the transformer be identified on a permanent nameplate installed on the transformer by the manufacturer. This addendum was issued to clear up confusion over the "energy efficiency levels" of transformers when transformer requirements were removed entirely in the creation of Standard 90.1-1999. Since there are no transformer requirements in Standard 90.1-2001, the addenda only impacts labeling requirements and does not materially impact the efficiency of the standard.

3.4 Envelope Section Changes

A total of eleven addenda were identified that made changes to the envelope section. These include addenda 90.1-99a, 90.1-99b, 90.1-99d, 90.1-99e, 90.1-99f, 90.1-99g, 90.1-99ag, 90.1-99ak, 90.1-99ao, 90.1-01ah, and 90.1-01am.

Addendum 90.1-99a provides clarifying wording for the phrase substantial contact in section 5.5.1.2 by adding the phrase "per manufacturer's recommendations for the framing system used." The performance of different insulation materials and systems may be degraded by improper installation technique and poor installation quality. This clarification is intended to emphasize the importance of following the manufacturer's installation recommendations for the particular insulation and construction system. As such, it should be viewed as a positive with regards to efficiency, but proper installation is largely up to the installer and wording as such in the building design standard is unlikely to have significant impact.

Addendum 90.1-99b provides for the use of two new ASTM test procedures for determining

roof surface absorptivity and of two new ASTM test procedures for determining roof surface emissivity. These added test procedures are recognized test procedures and allowing the use of them is not expected to result in any change in standard stringency. Including additional ASTM test methods will provide for greater public access to absorptivity and emissivity data for a wider variety of materials and will facilitate the testing of existing roofs under a wider range of conditions. However, because surface absorptivity is implemented as a tradeoff for roof insulation in Section 5.3.1.1, wider use of low absorptivity roofs to meet code is not expected to provide a significant improvement in energy efficiency of the standard.

Addendum 90.1-99d clarified the allowed placements for horizontal slab insulation used in meeting the F-factors requirements for slab-on-grade floors. The addendum allows a combined vertical and horizontal placement of insulation to substitute for horizontal (under slab) insulation of same length and R-value. A given length of insulation placed in the vertical orientation along the edge of the slab and with the rest of the length running horizontally underneath the slab will typically provide the lower F- factor and thus reduce heat transfer more than the same length of insulation placed only horizontally underneath the slab. Since both options are allowed, there is no change in stringency per se, but some energy savings may result from persons using the combined vertical and horizontal placement.

Addendum 90.1-99e clarified that the calculation procedures in section A-9 can be used for determining the heat capacity of assemblies not covered in tables A6 and A7. Currently, Standard 90.1-1999 Section A-3 states that heat capacity for above grade walls shall be taken from Tables A6 or A7. Those tables only cover the heat capacities for concrete walls and floors and masonry walls. Some concrete or masonry wall assemblies may include other materials, like plaster or gypsum board finishes that contribute to the heat capacity of the assembly, or different thickness of materials may be used in the wall section. This change to the standard makes it clear that the calculation procedures in Section A-9 can also be used for determining heat capacity of assemblies not covered in Tables A6 or A7 as long as the unit weights and specific heat of any of the components used in the calculation for the assembly are the published values for the materials. It has no significant impact on the energy stringency of the standard.

Addendum 90.1-99f removed requirements for slab insulation for unheated slab-on-grade floor for residential spaces in climate bins 19 and 20, covering all buildings installed in climates with from 7201 to 9000 HDD65. This change covers most of the cities listed in the 90.1-2001 weather data for the states of New Hampshire, Maine, Minnesota, Montana, all of South Dakota and virtually all of Wyoming and Wisconsin. It is expected that the removal of unheated slab-on-grade floor insulation in these climates will result in increased heating energy usage for buildings in these climates. There may be a subsequent reduction in some building cooling energy use, however it is expected that the heating energy increase would be much more significant in these climates, particularly for small buildings.

Addendum 90.1-99g changes the heated slab-on-grade floor insulation requirement in climate bins 19-26 to R-10 insulation placed horizontally for 48 in. inward from the edge of the slab (or a combined vertical and horizontal length given Addendum 90.1d). Previously in ASHRAE 90.1-1999, R-10 insulation requirement was for continuous insulation underneath the entire slab. For large buildings, it is believe that the 90.1-1999 requirement would definitely not be cost-effective from an energy standpoint, since most of the slab heat transfer occurs near the perimeter of the slab (Although it is noted that in some northern climates, insulation underneath the entire heated slab may be desirable from the standpoint of preventing frost heave). The impact of this addenda will be to increase the building heating energy usage and energy cost for buildings with heated slabs in these climates (covering virtually all of the states of New Hampshire, Maine, Minnesota, Montana, South Dakota, North Dakota, Wyoming, Wisconsin, and Alaska as well as virtually all of Canada). However, it is recognized that this may be a substantial first cost savings over the 90.1-1999 requirements (note, that this change may reflect original intent of 90.1-1999 developers).

Addendum 90.1-99ag removed tables for default U-factor and SHGC requirements for glazed wall systems. When Standard 90.1-1999 was developed, an extensive default table was included for glazed wall systems (e.g. site-built curtain-wall construction) because NFRC was still developing the certification program for these products. NFRC now has a certification program in place for site-built fenestration. Consequently, compliance should be demonstrated based on the rating for a specific product. This is not believed to materially affect the efficiency of the standard since it does not affect the U-factor criteria and since the default table is believed to have generally represented the low end of U-factors for these glazed wall products.

Addendum 90.1-99ak corrected a mistake in the conversion of the opaque envelope U-factor requirements in the SI edition of 90.1-1999. The development of the envelope section of Standard 90.1-1999 was done using IP units, and the tables of requirements in the SI edition are simply SI equivalents for U-factors. In converting to SI units, an incorrect conversion factor was used. Addendum 90.1ak revises these SI values using the correct conversion factor. Given that the history of the development of requirements using IP units first, the conflicting values between the IP and SI editions, and the fact that very few buildings are expected to be designed to the SI requirements in the U.S., it is DOE's opinion that this change has no effect on the net efficiency of the standard.

Addendum 90.1-99ao provided a number of editorial changes to Standard 90.1-1999. None of these were deemed to impact the energy efficiency prescribed by the Standard. However, these changes may make the standard easier to use by moving some of the less commonly used requirements (e.g. envelope requirements for semi-heated spaces) to exceptions.

Addendum 90.1-01ah adds weather data for eight new locations – the District of Columbia, six locations in other US territories, and Clark AFB in the Philippines. The addition of new weather data does not impact the energy efficiency of Standard 90.1, but does increase its usability in those locations.

Addendum 90.1-01am reduces the number of climate zones considered in the Standard from 26

to 8. While this sounds like a reasonable simple process, the addendum had to deal with every callout to those climate zones that falls within the envelope and HVAC sections of the standard plus Appendix B Building Envelope Climate Criteria. The intent of the addendum was to reduce the size and simplify compliance with the Standard. There was no specific intent to increase the stringency of Standard 90.1 during the development of this addendum, but given the process of mapping from 26 zones to 8, it was virtually certain that some building designs in some climates would be more energy efficient under the new version and some building designs in some climates would be less energy efficient under the new version.

The overall impact of all envelope addenda on energy efficiency of Standard 90.1 will be evaluated in the quantitative portion of this determination. However, we also compared the roof thermal transmittance, wall thermal transmittance, floor thermal transmittance, window and skylight thermal transmittance, and window and skylight solar heat gain coefficient for Standard 90.1-1999 and Standard 90.1-2004. The comparisons are shown in a series of tables that list the requirements of these two standards for each of the eleven cities used in the quantitative comparison. For each building element, requirements for all of the possible constructions are listed. This comparison is made much easier by the fact that Standard 90.1-1999 and Standard 90.1-2004 use the same format for building envelope requirements.

Table 3. Comparison of Roof U-Factor Criteria

City	Roof Type	99 Edition NonRes[1]	99 Edition Res[2]	99 Edition Semi[3]	2004 Edition NonRes[1]	2004 Edition Res[2]	2004 Edition Semi[3]
Denver	Insulation Entirely Above Deck	0.063	0.063	0.173	0.063	0.063	0.173
	Metal Building	0.065	0.065	0.097	0.065	0.065	0.097
	Attic and Other	0.034	0.027	0.053	0.034	0.027	0.053
Detroit	Insulation Entirely Above Deck	0.063	0.063	0.173	0.063	0.063	0.173
	Metal Building	0.065	0.065	0.097	0.065	0.065	0.097
	Attic and Other	0.034	0.027	0.053	0.034	0.027	0.053
Fresno	Insulation Entirely Above Deck	0.063	0.063	0.218	0.063	0.063	0.218
	Metal Building	0.065	0.065	0.167	0.065	0.065	0.097*
	Attic and Other	0.034	0.034	0.081	0.034	0.027*	0.081
Knoxville	Insulation Entirely Above Deck	0.063	0.063	0.218	0.063	0.063	0.218
	Metal Building	0.065	0.065	0.097	0.065	0.065	0.097
	Attic and Other	0.034	0.027	0.081	0.034	0.027	0.081
Los Angeles	Insulation Entirely Above Deck	0.093	0.063	0.218	0.063*	0.063	0.218
	Metal Building	0.072	0.065	0.167	0.065*	0.065	0.097
	Attic and Other	0.034	0.034	0.081	0.034	0.027*	0.081
Minneapolis	Insulation Entirely Above Deck	0.063	0.063	0.173	0.063	0.063	0.173
	Metal Building	0.065	0.065	0.097	0.065	0.065	0.097
	Attic and Other	0.027	0.027	0.053	0.027	0.027	0.053
Orlando	Insulation Entirely Above Deck	0.063	0.063	1.282	0.063	0.063	0.218*
	Metal Building	0.065	0.065	1.280	0.065	0.065	0.167*
	Attic and Other	0.034	0.027	0.614	0.034	0.027	0.081*
Phoenix	Insulation Entirely Above Deck	0.063	0.063	0.218	0.063	0.063	0.218
	Metal Building	0.065	0.065	0.167	0.065	0.065	0.167
	Attic and Other	0.034	0.027	0.081	0.034	0.027	0.081
Providence	Insulation Entirely Above Deck	0.063	0.063	0.173	0.063	0.063	0.173
	Metal Building	0.065	0.065	0.097	0.065	0.065	0.097
	Attic and Other	0.034	0.027	0.053	0.034	0.027	0.053
Seattle	Insulation Entirely Above Deck	0.063	0.063	0.218	0.063	0.063	0.218
	Metal Building	0.065	0.065	0.097	0.065	0.065	0.097
	Attic and Other	0.034	0.034	0.081	0.034	0.027*	0.081
Shreveport	Insulation Entirely Above Deck	0.063	0.063	0.218	0.063	0.063	0.218
	Metal Building	0.065	0.065	0.167	0.065	0.065	0.097*
	Attic and Other	0.034	0.027	0.081	0.034	0.027	0.081

[1] Nonresidential Requirements – applicable to all commercial buildings other than residential
[2] Residential Requirements – applicable to high-rise, multi-family residential buildings
[3] Semiheated Requirements – applicable to buildings or spaces that are not cooled and minimally heated
* 2004 edition requirements more stringent than 1999 edition requirements

Table 4. Comparison of Wall U-Factor Criteria

		1999 Edition			2004 Edition		
City	Roof Type	NonRes[1]	Res[2]	Semi[3]	NonRes[1]	Res[2]	Semi[3]
Denver	Mass	0.123	0.090	0.580	0.123	0.090	0.580
	Metal Building	0.113	0.057	0.123	0.113	0.057	0.123
	Steel Framed	0.084	0.064	0.124	0.084	0.064	0.124
	Wood Framed and Other	0.089	0.089	0.089	0.089	0.089	0.089
Detroit	Mass	0.123	0.090	0.580	0.123	0.090	0.580
	Metal Building	0.113	0.057	0.123	0.113	0.057	0.123
	Steel Framed	0.084	0.064	0.124	0.084	0.064	0.124
	Wood Framed and Other	0.089	0.089	0.089	0.089	0.089	0.089
Fresno	Mass	0.580	0.151	0.580	0.151*	0.123*	0.580
	Metal Building	0.113	0.113	0.184	0.113	0.113	0.184
	Steel Framed	0.124	0.124	0.352	0.124	0.084*	0.352
	Wood Framed and Other	0.089	0.089	0.089	0.089	0.089	0.089
Knoxville	Mass	0.151	0.104	0.580	0.151	0.104	0.580
	Metal Building	0.113	0.113	0.134	0.113	0.113	0.134
	Steel Framed	0.124	0.064	0.124	0.124	0.064	0.124
	Wood Framed and Other	0.089	0.089	0.089	0.089	0.089	0.089
Los Angeles	Mass	0.580	0.151	0.580	0.151*	0.123*	0.580
	Metal Building	0.113	0.113	0.184	0.113	0.113	0.184
	Steel Framed	0.124	0.124	0.352	0.124	0.084*	0.352
	Wood Framed and Other	0.089	0.089	0.292	0.089	0.089	0.089*
Minneapolis	Mass	0.104	0.090	0.580	0.104	0.090	0.580
	Metal Building	0.113	0.057	0.113	0.113	0.057	0.113
	Steel Framed	0.084	0.064	0.124	0.084	0.064	0.124
	Wood Framed and Other	0.089	0.064	0.089	0.089	0.064	0.089
Orlando	Mass	0.580	0.151	0.580	0.580	0.151	0.580
	Metal Building	0.113	0.113	1.180	0.113	0.113	0.184*
	Steel Framed	0.124	0.124	0.352	0.124	0.124	0.352
	Wood Framed and Other	0.089	0.089	0.292	0.089	0.089	0.292
Phoenix	Mass	0.580	0.151	0.580	0.580	0.151	0.580
	Metal Building	0.113	0.113	0.184	0.113	0.113	0.184
	Steel Framed	0.124	0.124	0.352	0.124	0.124	0.352
	Wood Framed and Other	0.089	0.089	0.292	0.089	0.089	0.292
Providence	Mass	0.123	0.090	0.580	0.123	0.090	0.580
	Metal Building	0.113	0.057	0.123	0.113	0.057	0.123
	Steel Framed	0.084	0.064	0.124	0.084	0.064	0.124
	Wood Framed and Other	0.089	0.089	0.089	0.089	0.089	0.089
Seattle	Mass	0.151	0.104	0.580	0.151	0.104	0.580
	Metal Building	0.113	0.113	0.134	0.113	0.113	0.134
	Steel Framed	0.124	0.084	0.124	0.124	0.064*	0.124
	Wood Framed and Other	0.089	0.089	0.089	0.089	0.089	0.089
Shreveport	Mass	0.580	0.123	0.580	0.151*	0.123	0.580
	Metal Building	0.113	0.113	0.184	0.113	0.113	0.184
	Steel Framed	0.124	0.084	0.352	0.124	0.084	0.352
	Wood Framed and Other	0.089	0.089	0.089	0.089	0.089	0.089

[1] Nonresidential Requirements – applicable to all commercial buildings other than residential
[2] Residential Requirements – applicable to high-rise, multi-family residential buildings
[3] Semiheated Requirements – applicable to buildings or spaces that are not cooled and minimally heated
* 2004 edition requirements more stringent than 1999 edition requirements

Table 5. Comparison of Floor U-factor Criteria

		1999 Edition			2004 Edition		
City	Floor Type	NonRes[1]	Res[2]	Semi[3]	NonRes[1]	Res[2]	Semi[3]
Denver	Mass	0.087	0.074	0.322	0.087	0.074	0.322
	Steel Joist	0.052	0.038	0.069	0.052	0.038	0.069
	Wood Frame and Other	0.033	0.033	0.066	0.033	0.033	0.066
Detroit	Mass	0.087	0.074	0.322	0.087	0.074	0.322
	Steel Joist	0.052	0.038	0.069	0.052	0.038	0.069
	Wood Frame and Other	0.033	0.033	0.066	0.033	0.033	0.066
Fresno	Mass	0.137	0.107	0.322	0.107*	0.087*	0.322
	Steel Joist	0.052	0.052	0.350	0.052	0.052	0.069*
	Wood Frame and Other	0.051	0.051	0.282	0.051	0.033*	0.282
Knoxville	Mass	0.107	0.087	0.322	0.107	0.087	0.322
	Steel Joist	0.052	0.038	0.069	0.052	0.038	0.069
	Wood Frame and Other	0.051	0.033	0.066	0.051	0.033	0.066
Los Angeles	Mass	0.137	0.137	0.322	0.107*	0.087*	0.322
	Steel Joist	0.052	0.052	0.350	0.052	0.052	0.069*
	Wood Frame and Other	0.066	0.051	0.282	0.051*	0.033*	0.282
Minneapolis	Mass	0.087	0.064	0.322	0.087	0.064	0.322
	Steel Joist	0.038	0.038	0.069	0.038	0.038	0.069
	Wood Frame and Other	0.033	0.033	0.066	0.033	0.033	0.066
Orlando	Mass	0.322	0.322	0.322	0.137*	0.107*	0.322
	Steel Joist	0.350	0.350	0.350	0.052*	0.052*	0.350
	Wood Frame and Other	0.282	0.282	0.282	0.051*	0.051*	0.282
Phoenix	Mass	0.137	0.107	0.322	0.137	0.107	0.322
	Steel Joist	0.052	0.052	0.350	0.052	0.052	0.350
	Wood Frame and Other	0.051	0.051	0.282	0.051	0.051	0.282
Providence	Mass	0.087	0.074	0.322	0.087	0.074	0.322
	Steel Joist	0.052	0.038	0.069	0.052	0.038	0.069
	Wood Frame and Other	0.033	0.033	0.066	0.033	0.033	0.066
Seattle	Mass	0.107	0.087	0.322	0.107	0.087	0.322
	Steel Joist	0.052	0.052	0.069	0.052	0.038*	0.069
	Wood Frame and Other	0.051	0.033	0.066	0.051	0.033	0.066
Shreveport	Mass	0.137	0.107	0.322	0.107*	0.087*	0.322
	Steel Joist	0.052	0.052	0.350	0.052	0.052	0.069*
	Wood Frame and Other	0.051	0.051	0.282	0.051	0.033*	0.282

[1] Nonresidential Requirements – applicable to all commercial buildings other than residential
[2] Residential Requirements – applicable to high-rise, multi-family residential buildings
[3] Semiheated Requirements – applicable to buildings or spaces that are not cooled and minimally heated
* 2004 edition requirements more stringent than 1999 edition requirements

Table 6. Comparison of Fenestration U-Factor Criteria

City	Fixed Window – Percent of Wall	1999 Edition NonRes[1]	Res[2]	Semi[3]	2004 Edition NonRes[1]	Res[2]	Semi[3]
Denver	0 to 10%	0.57	0.57	1.22	0.57	0.57	1.22
	10.1 to 20%	0.57	0.57	1.22	0.57	0.57	1.22
	20.1 to 30%	0.57	0.57	1.22	0.57	0.57	1.22
	30.1 to 40%	0.57	0.57	1.22	0.57	0.57	1.22
	40.1 to 50%	0.46	0.46	0.98	0.46	0.46	0.98
Detroit	0 to 10%	0.57	0.57	1.22	0.57	0.57	1.22
	10.1 to 20%	0.57	0.57	1.22	0.57	0.57	1.22
	20.1 to 30%	0.57	0.57	1.22	0.57	0.57	1.22
	30.1 to 40%	0.57	0.57	1.22	0.57	0.57	1.22
	40.1 to 50%	0.46	0.46	0.98	0.46	0.46	0.98
Fresno	0 to 10%	1.22	1.22	1.22	0.57*	0.57*	1.22
	10.1 to 20%	1.22	1.22	1.22	0.57*	0.57*	1.22
	20.1 to 30%	1.22	1.22	1.22	0.57*	0.57*	1.22
	30.1 to 40%	1.22	1.22	1.22	0.57*	0.57*	1.22
	40.1 to 50%	1.22	0.73	0.98	0.46*	0.46*	0.98
Knoxville	0 to 10%	0.57	0.57	1.22	0.57	0.57	1.22
	10.1 to 20%	0.57	0.57	1.22	0.57	0.57	1.22
	20.1 to 30%	0.57	0.57	1.22	0.57	0.57	1.22
	30.1 to 40%	0.57	0.57	1.22	0.57	0.57	1.22
	40.1 to 50%	0.46	0.46	0.98	0.46	0.46	0.98
Los Angeles	0 to 10%	1.22	1.22	1.22	0.57*	0.57*	1.22
	10.1 to 20%	1.22	1.22	1.22	0.57*	0.57*	1.22
	20.1 to 30%	1.22	1.22	1.22	0.57*	0.57*	1.22
	30.1 to 40%	1.22	1.22	1.22	0.57*	0.57*	1.22
	40.1 to 50%	1.22	1.22	0.98	0.46*	0.46*	0.98
Minneapolis	0 to 10%	0.57	0.57	1.22	0.57	0.57	1.22
	10.1 to 20%	0.57	0.57	1.22	0.57	0.57	1.22
	20.1 to 30%	0.57	0.57	1.22	0.57	0.57	1.22
	30.1 to 40%	0.57	0.57	1.22	0.57	0.57	1.22
	40.1 to 50%	0.46	0.46	0.98	0.46	0.46	0.98
Orlando	0 to 10%	1.22	1.22	1.22	1.22	1.22	1.22
	10.1 to 20%	1.22	1.22	1.22	1.22	1.22	1.22
	20.1 to 30%	1.22	1.22	1.22	1.22	1.22	1.22
	30.1 to 40%	1.22	1.22	1.22	1.22	1.22	1.22
	40.1 to 50%	1.22	1.22	0.98	1.22	1.22	0.98
Phoenix	0 to 10%	1.22	1.22	1.22	1.22	1.22	1.22
	10.1 to 20%	1.22	1.22	1.22	1.22	1.22	1.22
	20.1 to 30%	1.22	1.22	1.22	1.22	1.22	1.22
	30.1 to 40%	1.22	1.22	1.22	1.22	1.22	1.22
	40.1 to 50%	1.22	1.22	0.98	1.22	1.22	0.98
Providence	0 to 10%	0.57	0.57	1.22	0.57	0.57	1.22
	10.1 to 20%	0.57	0.57	1.22	0.57	0.57	1.22
	20.1 to 30%	0.57	0.57	1.22	0.57	0.57	1.22
	30.1 to 40%	0.57	0.57	1.22	0.57	0.57	1.22
	40.1 to 50%	0.46	0.46	0.98	0.46	0.46	0.98
Seattle	0 to 10%	0.57	0.57	1.22	0.57	0.57	1.22
	10.1 to 20%	0.57	0.57	1.22	0.57	0.57	1.22
	20.1 to 30%	0.57	0.57	1.22	0.57	0.57	1.22
	30.1 to 40%	0.57	0.57	1.22	0.57	0.57	1.22

	40.1 to 50%	0.46	0.46	0.98	0.46	0.46	0.98
Shreveport	0 to 10%	1.22	1.22	1.22	0.57*	0.57*	1.22
	10.1 to 20%	1.22	1.22	1.22	0.57*	0.57*	1.22
	20.1 to 30%	1.22	1.22	1.22	0.57*	0.57*	1.22
	30.1 to 40%	1.22	1.22	1.22	0.57*	0.57*	1.22
	40.1 to 50%	1.22	1.22	0.98	0.46*	0.46*	0.98

[1] Nonresidential Requirements – applicable to all commercial buildings other than residential
[2] Residential Requirements – applicable to high-rise, multi-family residential buildings
[3] Semiheated Requirements – applicable to buildings or spaces that are not cooled and minimally heated
* 2004 edition requirements more stringent than 1999 edition requirements

Table 7. Comparison of Fenestration SHGC Criteria

		1999 Edition			2004 Edition		
City	Fixed Window – Percent of Wall	NonRes[1]	Res[2]	Semi[3]	NonRes[1]	Res[2]	Semi[3]
Denver	0 to 10%	0.49	0.49	NR	0.49	0.49	NR
	10.1 to 20%	0.39	0.39	NR	0.39	0.39	NR
	20.1 to 30%	0.39	0.39	NR	0.39	0.39	NR
	30.1 to 40%	0.39	0.39	NR	0.39	0.39	NR
	40.1 to 50%	0.26	0.26	NR	0.26	0.26	NR
Detroit	0 to 10%	0.49	0.49	NR	0.49	0.49	NR
	10.1 to 20%	0.39	0.39	NR	0.39	0.39	NR
	20.1 to 30%	0.39	0.39	NR	0.39	0.39	NR
	30.1 to 40%	0.39	0.39	NR	0.39	0.39	NR
	40.1 to 50%	0.26	0.26	NR	0.26	0.26	NR
Fresno	0 to 10%	0.61	0.61	NR	0.39*	0.39*	NR
	10.1 to 20%	0.39	0.61	NR	0.25*	0.39*	NR
	20.1 to 30%	0.39	0.39	NR	0.25*	0.25*	NR
	30.1 to 40%	0.34	0.34	NR	0.25*	0.25*	NR
	40.1 to 50%	0.20	0.25	NR	0.19*	0.19*	NR
Knoxville	0 to 10%	0.39	0.39	NR	0.39	0.39	NR
	10.1 to 20%	0.39	0.39	NR	0.39	0.39	NR
	20.1 to 30%	0.39	0.39	NR	0.39	0.39	NR
	30.1 to 40%	0.39	0.39	NR	0.39	0.39	NR
	40.1 to 50%	0.25	0.25	NR	0.25	0.25	NR
Los Angeles	0 to 10%	0.61	0.61	NR	0.39*	0.39*	NR
	10.1 to 20%	0.61	0.61	NR	0.25*	0.39*	NR
	20.1 to 30%	0.44	0.61	NR	0.25*	0.25*	NR
	30.1 to 40%	0.44	0.44	NR	0.25*	0.25*	NR
	40.1 to 50%	0.31	0.31	NR	0.19*	0.19*	NR
Minneapolis	0 to 10%	0.49	0.49	NR	0.49	0.49	NR
	10.1 to 20%	0.39	0.39	NR	0.39	0.39	NR
	20.1 to 30%	0.39	0.39	NR	0.39	0.39	NR
	30.1 to 40%	0.39	0.39	NR	0.39	0.39	NR
	40.1 to 50%	0.26	0.26	NR	0.26	0.26	NR
Orlando	0 to 10%	0.25	0.39	NR	0.25	0.39	NR
	10.1 to 20%	0.25	0.25	NR	0.25	0.25	NR
	20.1 to 30%	0.25	0.25	NR	0.25	0.25	NR
	30.1 to 40%	0.25	0.25	NR	0.25	0.25	NR
	40.1 to 50%	0.17	0.17	NR	0.17	0.17	NR
Phoenix	0 to 10%	0.40	0.40	NR	0.25*	0.39*	NR
	10.1 to 20%	0.25	0.40	NR	0.25	0.25*	NR

	20.1 to 30%	0.25	0.40	NR	0.25	0.25*	NR
	30.1 to 40%	0.25	0.40	NR	0.25	0.25*	NR
	40.1 to 50%	0.19	0.31	NR	0.17*	0.17*	NR
Providence	0 to 10%	0.49	0.49	NR	0.49	0.49	NR
	10.1 to 20%	0.39	0.39	NR	0.39	0.39	NR
	20.1 to 30%	0.39	0.39	NR	0.39	0.39	NR
	30.1 to 40%	0.39	0.39	NR	0.39	0.39	NR
	40.1 to 50%	0.26	0.26	NR	0.26	0.26	NR
Seattle	0 to 10%	0.49	0.49	NR	0.39*	0.39*	NR
	10.1 to 20%	0.39	0.39	NR	0.39	0.39	NR
	20.1 to 30%	0.39	0.39	NR	0.39	0.39	NR
	30.1 to 40%	0.39	0.39	NR	0.39	0.39	NR
	40.1 to 50%	0.26	0.26	NR	0.25*	0.25*	NR
Shreveport	0 to 10%	0.39	0.39	NR	0.39	0.39	NR
	10.1 to 20%	0.25	0.39	NR	0.25	0.39	NR
	20.1 to 30%	0.25	0.25	NR	0.25	0.25	NR
	30.1 to 40%	0.25	0.25	NR	0.25	0.25	NR
	40.1 to 50%	0.15**	0.14**	NR	0.17	0.17	NR

[1] Nonresidential Requirements – applicable to all commercial buildings other than residential
[2] Residential Requirements – applicable to high-rise, multi-family residential buildings
[3] Semiheated Requirements – applicable to buildings or spaces that are not cooled and minimally heated
* 2004 edition requirements more stringent than 1999 edition requirements
** 1999 edition requirements more stringent than 2004 edition requirements

Table 8. Comparison of Skylight Thermal Performance Criteria

		1999 Edition			2004 Edition		
City	Skylight Type–Percent of Roof	NonRes[1]	Res[2]	Semi[3]	NonRes[1]	Res[2]	Semi[3]
Denver	Glass with Curb, 0 to 2%	1.17	1.17	1.98	1.17	1.17	1.98
	Glass with Curb, 2.1 to 5%	1.17	1.17	1.98	1.17	1.17	1.98
	Plastic with Curb, 0 to 2%	1.10	1.10	1.90	1.10	1.10	1.90
	Plastic with Curb, 2.1 to 5%	1.10	1.10	1.90	1.10	1.10	1.90
	No curb, 0 to 2%	0.69	0.69	1.36	0.69	0.69	1.36
	No curb, 2.1 to 5%	0.69	0.69	1.36	0.69	0.69	1.36
Detroit	Glass with Curb, 0 to 2%	1.17	1.17	1.98	1.17	1.17	1.98
	Glass with Curb, 2.1 to 5%	1.17	1.17	1.98	1.17	1.17	1.98
	Plastic with Curb, 0 to 2%	1.10	1.10	1.90	1.10	1.10	1.90
	Plastic with Curb, 2.1 to 5%	1.10	1.10	1.90	1.10	1.10	1.90
	No curb, 0 to 2%	0.69	0.69	1.36	0.69	0.69	1.36
	No curb, 2.1 to 5%	0.69	0.69	1.36	0.69	0.69	1.36
Fresno	Glass with Curb, 0 to 2%	1.98	1.98	1.98	1.17*	1.17*	1.98
	Glass with Curb, 2.1 to 5%	1.98	1.98	1.98	1.17*	1.17*	1.98
	Plastic with Curb, 0 to 2%	1.90	1.90	1.90	1.30*	1.30*	1.90
	Plastic with Curb, 2.1 to 5%	1.90	1.90	1.90	1.30*	1.30*	1.90
	No curb, 0 to 2%	1.36	1.36	1.36	0.69*	0.69*	1.36
	No curb, 2.1 to 5%	1.36	1.36	1.36	0.69*	0.69*	1.36
Knoxville	Glass with Curb, 0 to 2%	1.17	0.98	1.98	1.17	0.98	1.98
	Glass with Curb, 2.1 to 5%	1.17	0.98	1.98	1.17	0.98	1.98
	Plastic with Curb, 0 to 2%	1.30	1.30	1.90	1.30	1.30	1.90
	Plastic with Curb, 2.1 to 5%	1.30	1.30	1.90	1.30	1.30	1.90
	No curb, 0 to 2%	0.69	0.58	1.36	0.69	0.58	1.36
	No curb, 2.1 to 5%	0.69	0.58	1.36	0.69	0.58	1.36

Los Angeles	Glass with Curb, 0 to 2%	1.98	1.98	1.98	1.17*	1.17*	1.98
	Glass with Curb, 2.1 to 5%	1.98	1.98	1.98	1.17*	1.17*	1.98
	Plastic with Curb, 0 to 2%	1.90	1.90	1.90	1.30*	1.30*	1.90
	Plastic with Curb, 2.1 to 5%	1.90	1.90	1.90	1.30*	1.30*	1.90
	No curb, 0 to 2%	1.36	1.36	1.36	0.69*	0.69*	1.36
	No curb, 2.1 to 5%	1.36	1.36	1.36	0.69*	0.69*	1.36
Minneapolis	Glass with Curb, 0 to 2%	1.17	0.98	1.98	1.17	0.98	1.98
	Glass with Curb, 2.1 to 5%	1.17	0.98	1.98	1.17	0.98	1.98
	Plastic with Curb, 0 to 2%	0.87	0.74	1.90	0.87	0.74	1.90
	Plastic with Curb, 2.1 to 5%	0.87	0.74	1.90	0.87	0.74	1.90
	No curb, 0 to 2%	0.69	0.58	1.36	0.69	0.58	1.36
	No curb, 2.1 to 5%	0.69	0.58	1.36	0.69	0.58	1.36
Orlando	Glass with Curb, 0 to 2%	1.98	1.98	1.98	1.98	1.98	1.98
	Glass with Curb, 2.1 to 5%	1.98	1.98	1.98	1.98	1.98	1.98
	Plastic with Curb, 0 to 2%	1.90	1.90	1.90	1.90	1.90	1.90
	Plastic with Curb, 2.1 to 5%	1.90	1.90	1.90	1.90	1.90	1.90
	No curb, 0 to 2%	1.36	1.36	1.36	1.36	1.36	1.36
	No curb, 2.1 to 5%	1.36	1.36	1.36	1.36	1.36	1.36
Phoenix	Glass with Curb, 0 to 2%	1.98	1.98	1.98	1.98	1.98	1.98
	Glass with Curb, 2.1 to 5%	1.98	1.98	1.98	1.98	1.98	1.98
	Plastic with Curb, 0 to 2%	1.90	1.90	1.90	1.90	1.90	1.90
	Plastic with Curb, 2.1 to 5%	1.90	1.90	1.90	1.90	1.90	1.90
	No curb, 0 to 2%	1.36	1.36	1.36	1.36	1.36	1.36
	No curb, 2.1 to 5%	1.36	1.36	1.36	1.36	1.36	1.36
Providence	Glass with Curb, 0 to 2%	1.17	1.17	1.98	1.17	1.17	1.98
	Glass with Curb, 2.1 to 5%	1.17	1.17	1.98	1.17	1.17	1.98
	Plastic with Curb, 0 to 2%	1.10	1.10	1.90	1.10	1.10	1.90
	Plastic with Curb, 2.1 to 5%	1.10	1.10	1.90	1.10	1.10	1.90
	No curb, 0 to 2%	0.69	0.69	1.36	0.69	0.69	1.36
	No curb, 2.1 to 5%	0.69	0.69	1.36	0.69	0.69	1.36
Seattle	Glass with Curb, 0 to 2%	1.17	1.17	1.98	1.17	0.98*	1.98
	Glass with Curb, 2.1 to 5%	1.17	1.17	1.98	1.17	0.98*	1.98
	Plastic with Curb, 0 to 2%	1.30	1.30	1.90	1.30	1.30	1.90
	Plastic with Curb, 2.1 to 5%	1.30	1.30	1.90	1.30	1.30	1.90
	No curb, 0 to 2%	0.69	0.69	1.36	0.69	0.58*	1.36
	No curb, 2.1 to 5%	0.69	0.69	1.36	0.69	0.58*	1.36
Shreveport	Glass with Curb, 0 to 2%	1.98	1.98	1.98	1.17*	1.17*	1.98
	Glass with Curb, 2.1 to 5%	1.98	1.98	1.98	1.17*	1.17*	1.98
	Plastic with Curb, 0 to 2%	1.90	1.90	1.90	1.30*	1.30*	1.90
	Plastic with Curb, 2.1 to 5%	1.90	1.90	1.90	1.30*	1.30*	1.90
	No curb, 0 to 2%	1.36	1.36	1.36	0.69*	0.69*	1.36
	No curb, 2.1 to 5%	1.36	1.36	1.36	0.69*	0.69*	1.36

[1] Nonresidential Requirements – applicable to all commercial buildings other than residential
[2] Residential Requirements – applicable to high-rise, multi-family residential buildings
[3] Semiheated Requirements – applicable to buildings or spaces that are not cooled and minimally heated
* 2004 edition requirements more stringent than 1999 edition requirements

Table 9. Comparison of Skylight SHGC Criteria

City	Skylight Type– Percent of Roof	1999 Edition NonRes[1]	1999 Edition Res[2]	1999 Edition Semi[3]	2004 Edition NonRes[1]	2004 Edition Res[2]	2004 Edition Semi[3]
Denver	Glass with Curb, 0 to 2%	0.49	0.49	NR	0.49	0.49	NR
	Glass with Curb, 2.1 to 5%	0.39	0.39	NR	0.39	0.39	NR
	Plastic with Curb, 0 to 2%	0.77	0.77	NR	0.77	0.77	NR
	Plastic with Curb, 2.1 to 5%	0.62	0.62	NR	0.62	0.62	NR
	No curb, 0 to 2%	0.49	0.49	NR	0.49	0.49	NR
	No curb, 2.1 to 5%	0.39	0.39	NR	0.39	0.39	NR
Detroit	Glass with Curb, 0 to 2%	0.49	0.49	NR	0.49	0.49	NR
	Glass with Curb, 2.1 to 5%	0.39	0.39	NR	0.39	0.39	NR
	Plastic with Curb, 0 to 2%	0.77	0.77	NR	0.77	0.77	NR
	Plastic with Curb, 2.1 to 5%	0.62	0.62	NR	0.62	0.62	NR
	No curb, 0 to 2%	0.49	0.49	NR	0.49	0.49	NR
	No curb, 2.1 to 5%	0.39	0.39	NR	0.39	0.39	NR
Fresno	Glass with Curb, 0 to 2%	0.61	0.39	NR	0.39*	0.36*	NR
	Glass with Curb, 2.1 to 5%	0.39	0.19	NR	0.19*	0.19	NR
	Plastic with Curb, 0 to 2%	0.65	0.65	NR	0.65	0.27*	NR
	Plastic with Curb, 2.1 to 5%	0.39	0.34	NR	0.34*	0.27*	NR
	No curb, 0 to 2%	0.61	0.39	NR	0.39*	0.36*	NR
	No curb, 2.1 to 5%	0.39	0.19	NR	0.19*	0.19	NR
Knoxville	Glass with Curb, 0 to 2%	0.49	0.36	NR	0.49	0.36	NR
	Glass with Curb, 2.1 to 5%	0.39	0.19	NR	0.39	0.19	NR
	Plastic with Curb, 0 to 2%	0.65	0.62	NR	0.65	0.62	NR
	Plastic with Curb, 2.1 to 5%	0.34	0.27	NR	0.34	0.27	NR
	No curb, 0 to 2%	0.49	0.36	NR	0.49	0.36	NR
	No curb, 2.1 to 5%	0.39	0.19	NR	0.39	0.19	NR
Los Angeles	Glass with Curb, 0 to 2%	0.61	0.39	NR	0.39*	0.36*	NR
	Glass with Curb, 2.1 to 5%	0.39	0.19	NR	0.19*	0.19	NR
	Plastic with Curb, 0 to 2%	0.65	0.65	NR	0.65	0.27*	NR
	Plastic with Curb, 2.1 to 5%	0.39	0.34	NR	0.34*	0.27*	NR
	No curb, 0 to 2%	0.61	0.39	NR	0.39*	0.36*	NR
	No curb, 2.1 to 5%	0.39	0.19	NR	0.19*	0.19	NR
Minneapolis	Glass with Curb, 0 to 2%	0.49	0.46	NR	0.49	0.46	NR
	Glass with Curb, 2.1 to 5%	0.49	0.36	NR	0.49	0.36	NR
	Plastic with Curb, 0 to 2%	0.71	0.65	NR	0.71	0.65	NR
	Plastic with Curb, 2.1 to 5%	0.58	0.55	NR	0.58	0.55	NR
	No curb, 0 to 2%	0.49	0.49	NR	0.49	0.49	NR
	No curb, 2.1 to 5%	0.49	0.39	NR	0.49	0.39	NR
Orlando	Glass with Curb, 0 to 2%	0.36	0.19	NR	0.36	0.19	NR
	Glass with Curb, 2.1 to 5%	0.19	0.19	NR	0.19	0.19	NR
	Plastic with Curb, 0 to 2%	0.39	0.27	NR	0.39	0.27	NR
	Plastic with Curb, 2.1 to 5%	0.34	0.27	NR	0.34	0.27	NR
	No curb, 0 to 2%	0.36	0.19	NR	0.36	0.19	NR
	No curb, 2.1 to 5%	0.19	0.19	NR	0.19	0.19	NR
Phoenix	Glass with Curb, 0 to 2%	0.36	0.19	NR	0.36	0.19	NR
	Glass with Curb, 2.1 to 5%	0.19	0.19	NR	0.19	0.19	NR
	Plastic with Curb, 0 to 2%	0.39	0.27	NR	0.39	0.27	NR
	Plastic with Curb, 2.1 to 5%	0.34	0.27	NR	0.34	0.27	NR
	No curb, 0 to 2%	0.36	0.19	NR	0.36	0.19	NR
	No curb, 2.1 to 5%	0.19	0.19	NR	0.19	0.19	NR
Providence	Glass with Curb, 0 to 2%	0.49	0.49	NR	0.49	0.49	NR

	Glass with Curb, 2.1 to 5%	0.39	0.39	NR	0.39	0.39	NR
	Plastic with Curb, 0 to 2%	0.77	0.77	NR	0.77	0.77	NR
	Plastic with Curb, 2.1 to 5%	0.62	0.62	NR	0.62	0.62	NR
	No curb, 0 to 2%	0.49	0.49	NR	0.49	0.49	NR
	No curb, 2.1 to 5%	0.39	0.39	NR	0.39	0.39	NR
Seattle	Glass with Curb, 0 to 2%	0.49	0.49	NR	0.49	0.36*	NR
	Glass with Curb, 2.1 to 5%	0.39	0.39	NR	0.39	0.19*	NR
	Plastic with Curb, 0 to 2%	0.77	0.77	NR	0.65*	0.62*	NR
	Plastic with Curb, 2.1 to 5%	0.62	0.34	NR	0.34*	0.27*	NR
	No curb, 0 to 2%	0.49	0.49	NR	0.49	0.36*	NR
	No curb, 2.1 to 5%	0.39	0.39	NR	0.39	0.19	NR
Shreveport	Glass with Curb, 0 to 2%	0.39	0.36	NR	0.39	0.36	NR
	Glass with Curb, 2.1 to 5%	0.19	0.19	NR	0.19	0.19	NR
	Plastic with Curb, 0 to 2%	0.65	0.27	NR	0.65	0.27	NR
	Plastic with Curb, 2.1 to 5%	0.34	0.27	NR	0.34	0.27	NR
	No curb, 0 to 2%	0.39	0.36	NR	0.39	0.36	NR
	No curb, 2.1 to 5%	0.19	0.19	NR	0.19	0.19	NR

[1] Nonresidential Requirements – applicable to all commercial buildings other than residential
[2] Residential Requirements – applicable to high-rise, multi-family residential buildings
[3] Semiheated Requirements – applicable to buildings or spaces that are not cooled and minimally heated
* 2004 edition requirements more stringent than 1999 edition requirements

In summary, the overall change in building envelope requirements due primarily to addenda 90.1-01am may be expressed as follows:

Roof Thermal Transmittance – Of the 99 possible requirements listed in the standard for the 11 cities, 3 space conditioning types, and 3 roof types, 10 of the requirements are more stringent in Standard 90.1-2004 and 89 requirements are identical.

Wall Thermal Transmittance – Of the 132 possible requirements listed in the standard for the 11 cities, 3 space conditioning types, and 4 wall types, 10 are more stringent in Standard 90.1-2004 and 122 requirements are identical.

Floor Thermal Transmittance - Of the 99 possible requirements listed in the standard for the 11 cities, 3 space conditioning types, and 3 floor types, 20 are more stringent in Standard 90.1-2004 and 79 requirements are identical.

Window Thermal Transmittance - Of the 165 possible requirements listed in the standard for the 11 cities, 3 space conditioning types, and 5 values of window to wall ratio, 30 are more stringent in Standard 90.1-2004 and 135 requirements are identical.

Window Solar Heat Gain Coefficient - Of the 165 possible requirements listed in the standard for the 11 cities, 3 space conditioning types, and 5 window to wall ratios, 31 are more stringent in Standard 90.1-2004, 2 are less stringent in Standard 90.1-2004 and 132 requirements are identical.

Skylight Thermal Transmittance - Of the 198 possible requirements listed in the standard for the 11 cities, 3 space conditioning types, 2 values of roof to skylight ratio and 3 skylight to roof

ratios, 40 are more stringent in Standard 90.1-2004 and 158 requirements are identical.

Skylight Solar Heat Gain Coefficient - Of the 198 possible requirements listed in the standard for the 11 cities, 3 space conditioning types, 2 roof to skylight ratios and 3 skylight to roof ratios, 26 are more stringent in Standard 90.1-2004 and 172 requirements are identical.

Overall, the envelope requirements are more stringent in Standard 90.1-2004.

3.5 HVAC Equipment and System Changes

A total of 27 addenda were identified that made changes to the HVAC Equipment and System section. These include addenda 90.1-99j, 90.1-99k, 90.1-99m, 90.1-99n, 90.1-99o, 90.1-99q, 90.1-99r, 90.1-99s, 90.1-99t, 90.1-99u, 90.1-99ad, 90.1-01b, 90.1-01c, 90.1-01d, 90.1-01i, 90.1-01k, 90.1-01o, 90.1-01r, 90.1-01s, 90.1-01u, 90.1-01x, 90.1-01y, 90.1-01z, 90.1-01aa, 90.1-01ab, 90.1-01ak, and 90.1-01am.

Addendum 90.1-99j corrected a conflict between the minimum efficiency requirements for centrifugal chillers between 0 and 150 tons capacity shown in Table 6.2.1C and that shown in Table 6.2.1H of Standard 90.1-1999. During development of ASHRAE standard 90.1-1999, the nominal COP and IPLV requirements for these chillers was at 5.4 for a long period of time, however based on comments about product availability from ARI, was lowered to 5.0 prior to incorporation into Standard 90.1-1999. The principal rationale provided was that these small centrifugal chillers were a small volume product and the cost for manufacturers to reach a 5.4 COP and IPLV rating would make the chillers non-competitive in the market compared to positive displacement screw chillers, which were only required to meet a 4.45 COP and 4.50 IPLV. The change to a 5.0 COP was made in Table 6.2.1C, but was not made to the tables for Non-Standard Centrifugal Chillers 6.2.1H. The addendum corrects this.

Because 90.1-1999 and committee approved final working drafts of the standard both use a 5.4 COP in Table 6.2.1H, the change provided by **Addendum 90.1-99aj** is viewed by ASHRAE as a substantive change. However, the base 5.4 COP and subsequent COPs shown for other operating conditions in that table do not represent the intent of the ASHRAE committee.

Addendum 90.1-99j may be reviewed as a reduction in stringency for one compliance path of the standard; however, due to the small volume of product in this capacity range, the confusion about the standard versus non-standard nominal efficiency requirement, and the possibility that lower efficiency screw chillers that do meet the Standard might get used in place of centrifugal units, DOE does not believe that this change will impact the energy efficiency of buildings built to Standard 90.1. **Addendum 90.1-99j** also provides new Integrated Part Load Values (IPLVs) for all chillers, the result of changes in the chiller test procedures as well as adds Nonstandard Part Load Value “NPLV” requirements for non-standard centrifugal chillers. ASHRAE Standard 90.1-1999 referenced ARI Standards 550-92 and 590-92 for chillers. ARI recently revised these standards, and combined them into one volume, namely ARI-550/590-98. In the process of combining the standards, they were updated to incorporate certain revisions as described in

detail in a white paper available from ARI (Ref: http://www.ari.org/std/individual/550.590-98wp.pdf). ARI member companies, consisting of the major chiller manufacturers, did extensive correlation testing between the old and new standards to determine the effects of the revisions. The changed IPLVs reflect changes in the test procedures, but not changes in net product efficiency. As such, the incorporation of the new IPLV and NPLV numbers and the reference to ARI Standard 550/590-98 does not change the efficiency provided by Standard 90.1

Addendum 90.1-99k rewords the exceptions for to 6.2.3.1.1, Zone thermostatic controls, to provide greater clarity and consistency. Exception (a) has been combined with exception (b) to clarify the intent that a separate perimeter system be provided for significant expanses of exterior wall with similar orientation, but that minor offsets in a different orientation can be included in that same zone. Exception (c) has been reworded to be consistent with the rest of the standard by through use of the term "zone" and "thermostatic control" as used in other sections of the standard. These changes will have no expected impact on the efficiency of the standard.

Addendum 90.1-99m adds a climatic limitation to the low leakage requirement for motorized dampers and relaxes the leakage requirements. In Standard 90.1-1999, damper leakage was set to 3 cfm/ft^2 at 1.0 in. water gauge (w.g.) for motorized supply and exhaust dampers, and had no performance requirements for gravity dampers where allowed (basically in buildings less than 3 stories in height and all buildings located in climates less than 2700 heating degree days base 65 F.). Addendum 90.1m slightly relaxed the performance requirements for motorized dampers to 4 cfm/ft2 at 1.0 in. w.g. for cold (greater than 7200 hdd65) or very hot (greater than 7200 cdd50), and significantly relaxed the motorized damper performance requirements to 20 cfm/ft^2 at 1.0 in. w.g for a few very mild climates (e.g. Santa Barbara, CA) and to 10 cfm/ft^2 at 1.0 in. w.g for most of the rest of the U.S.. The addenda did add a performance requirement for gravity dampers of 20 cfm/ft^2 at 1.0 in w.g. The rationale for this relaxation was primarily based on the availability and cost of low leakage dampers. This modification represents a reduction in stringency of the standard.

Addendum 90.1-99n revises section 6.2.3.2.4, shutoff damper controls so that it allows for gravity dampers to be used on the outside air inlet and the exhaust in systems with outdoor air requirements of 300 cubic feet per minute (cfm) or less. The language in the 90.1-1999 standard section 6.2.3.2.4 requires that exhaust and inlet dampers on systems that are greater than 65,000 Btu/h in capacity and with fan horse power greater than 3/4 horse power be capable of being controlled so that are can be closed when the space is not in use by the system is on, with several exceptions. The exception in question was that if the system outside air intake or system exhaust was 300 cfm or less, dampers that open only when the system was energized would be allowable. The language in addendum 90.1n allows for gravity dampers in place of motor operated dampers. This similarly provides for open and closed dampers when the system is energized and blowing air, but with gravity dampers likely operating at poorer damper performance. The proposed wording is more consistent with what is currently allowed in the simplified approach option (Section 6.1.3) for exhaust systems (inlet dampers are not mentioned in section 6.1.3). However, section 6.1.3 is somewhat more stringent since it requires gravity dampers for all systems with 300 cfm of exhaust, not just those greater than 65,000 Btu/h and with fan power greater than 3/4 hp. Section 6.1.3 does not mention any damper requirements on

system intakes. It is expected that 90.1n will result in a minor reduction in system energy efficiency for standard 90.1-2001.

Addendum 90.1-99o clarifies that multiple control zones can be grouped into a single isolation area not exceeding 25,000 ft^2 in area nor occupying more than one floor. It also removes the explicit allowance for airflow into non-occupied isolation zones that was provided for in Standard 90.1-1999 under the premise that any explicit allowance was redundant to the requirement for "stable system and equipment operation". Given that some systems might require this level of airflow for stable system operation, but that many will not and would use other means to ensure stable operation, it is difficult to judge any net change in efficiency for the standard. It is likely that not providing an explicit allowance for airflow into non-occupied zones will encourage designers to see other, more energy efficient, devices to ensure stable system operation.

Addendum 90.1-99q deleted permissible and unenforceable language with regard to parking garage ventilation. The Standard 90.1-1999 language merely stated that garage fan ventilation controls shall be permitted by the code department. Standard 90.1-1999 It did not provide for either demand based ventilation controls, schedule based ventilation controls or manually operated ventilation controls. During discussion within the committee it was recognized that any code department could determine that these controls endanger public health and prohibit them if desired. Given that the section did not actually mandate any type of controls and that any jurisdiction concerned with the safety could choose to ignore a requirement that 90.1-1999 "permit" demand based ventilation controls, it was decided to eliminate the permissive language in its entirety. DOE believes that removal of this requirement will have no impact on the efficiency required under the standard.

Addendum 90.1-99r clarifies that only gas phase air cleaning systems are provided an exclusion from the economizer requirement. As it was originally written, exception b to section 6.3.1 could have been interpreted to mean that an economizer is not required on any system that has any type of filtration. This was not the committee's intent. The intent was for specific types of air cleaning that are expensive and have high pressure drops to be excluded from the economizer requirement. These gas phase air cleaning systems should be used to clean the ventilation air only and become cost prohibitive if sized for economizer airflow.

Addendum 90.1-99s provides clarification that economizers are allowed in systems that use reheat. The only time when normal economizer operation would consume more reheat energy than mechanical cooling is a control strategy where the economizer is used to supply lower air temperatures than the normal cooling operation, thus reducing fan energy. This is a clarification of the original intent of the standard and not expected to change the efficiency criteria demanded by the standard.

Addendum 90.1-99t removed a requirement that ducted air and water flow rates be measured and adjusted to deliver final flow rates within 10% of design rates. 90.1-1999 required that all air and water flow rates be adjusted to deliver flow rates within 10% of design flow rates. Variable speed, variable volume flow distribution systems were not required to be balanced

upstream of a pressure independent device. Commenters on the standard expressed the concern that balancing of any air and hydronic systems with variable flow controls may not be cost effective and therefore should not be required by the standard. In addition, the committee voted to remove the performance requirements for balancing to 10% of design flow rates. The removal of the exception and the performance requirements, leaving it up to the balancing personnel to determine the balancing procedure, reflects a compromise agreement of opposing commenters on this issue. DOE feels however, that removal of these performance requirements represents a relaxation of the standard.

Addendum 90.1-99u adopts ARI's industry-wide certification program for water-source, ground-water-source and ground-source heat pumps. ARI began using the ISO test procedure in the year 2000. Since the directory listings will be based on the ISO test procedure, ARI recommended that the Standard show the pre-October 29, 2001 requirements based on the ISO 13256-1 test procedure. This is expected to have no impact on the standard's efficiency.

Addendum 90.1-99ad modified many separate areas of the Heating Ventilating and Air Condition section of the standard. First, it incorporated into Table 6.2.1A and 6.2.1B the footnote at the bottom of the same tables in 90.1-1999 that provided for a 0.2 point EER deduction for unitary air cooled equipment >65,000 Btu/h for equipment with a non-electric resistance heating section. In addition, it clearly identified that the footnote should only apply to the EER requirements for equipment manufactured after 10/29/2001. The original addenda proposed to clarify that the footnote only applied to the 10/29/2001 column, however in the production of 90.1-2001, the column showing efficiency prior to 10/29/2001 was eliminated. After 10/29/2001, this change has only a minimal effect on the efficiency requirements of the standard. For large unitary equipment manufactured prior to 10/29/2001, and not covered my Federal manufacturing standards, Standard 90.1-2001 does not allow for a 0.2 point EER deduction in the pre 10/29/2001 efficiency levels for equipment with non-electric resistance heating systems. While this may technically be an improvement in efficiency, it is not clear that it represents the intent of the committee. Overall however, it is expected that any change in efficiency will be minor and will rapidly decrease in importance over time as stock of older equipment is depleted. **Addendum 90.1-99ad** also limited the use of low leakage dampers for closed circuit cooling towers used in water loop heat pump systems as an alternative to automatic bypass valves. In Standard 90.1-1999, low leakage dampers on cooling towers could be used as an alternative to automatic bypass valves in all climates. Addendum 90.1ad limited the use of low-leakage dampers as a viable alternative to warm climates (with less than 2700 hdd65). This is believed to be an increase in the stringency of the standard since dampers are likely to leak over time and that leakage will result in heat loss in the cooling tower during cold periods. 90.1-99ad also added requirements for buried duct insulation which were not included in Standard 90.1-1999. Since no such requirements existing previously, this is an increase in stringency of the standard.

Addendum 90.1-99ad also modified Section 6.3.2.1, Simultaneous Heating and Cooling Limitation, to remove the requirement that the minimum volume controller be certified by the manufacturer to maintain the minimum flow to within 10% of the minimum required by ASHRAE Standard 62, as well as removed the requirement that the fixed 0.4 cfm/ft2 per zone of

allowed reheated or re-cooled air be allowed only if the air temperature has been reset to within 12 F of the desired heating or cooling temperatures. It added an allowance that up to 30% of the design supply air volume be allowed to be reheated or re-cooled. These modifications were made on the basis that the requirements in Section 6.3.2.1 were unreasonably strict given the available products. However, DOE believes that the overall modifications to Section 6.3.2.1 represent a reduction in stringency of the Standard. **Addendum 90.1-99ad** also modified Section 6.3.3.2.2 Static Pressure Sensor Location to exempt systems with direct digital control of set point reset from requirements as to the location of the static pressure sensor in the ductwork. Since the static pressure control is reset by the zone requirements, there is no need to specify static pressure sensor location. This change does not impact the stringency of the Standard.

Addendum 90.1-99ad also made an explicit allowance that variable speed drives or vane axial fans with variable pitch blades are allowed for control of variable speed fans greater than 30 hp. Standard 90.1-1999 required all variable speed fans to meet a performance requirement. This modification allows these specific technologies in prescriptively since these technologies are believed to meet or exceed the performance requirements in virtually all cases. This is not believed to significantly impact the stringency of the standard, but in terms of the simplicity of allowing a prescriptive technology, may increase the use of variable volume designs in the field. Overall it is not judged to increase or decrease the efficiency prescribed by the standard. **Addendum 90.1-99ad** also explicitly allowed the use of residential system controllers that have only two (as opposed to seven) day types schedules. For residential occupancies, the requirement of seven day type schedules would seldom confer an advantage in energy efficiency given typical residential occupancy profiles. Controllers with only two day types, commonly found in residences, were deemed sufficient. This change is not believed to have a significant impact on the energy efficiency requirements of the standard.

Addendum 90.1-99ad also made editorial changes to the sections on Thermostatic Controls, Shutoff Damper Controls, Dampers, Zone Isolation, Hydronic System Design and Control, Hydronic Variable Flow Systems, Duct and Pipe Insulation, Completion Requirements, the Simplified Approach Option for HVAC Systems (Economizer Tradeoffs) , High Limit Shutoff, Static Pressure Sensor Location, and Heat Rejection Equipment. None of these changes are viewed as anything other than editorial clarification and they will not impact the stringency of the standard.

Addendum 90.1-01b clarifies the use of US Department of Energy certification requirements required by the Energy Policy Act of 1992 versus other certification programs. Equipment covered under the Energy Policy Act of 1992 is required to use DOE certification requirements. Other equipment may use other certification programs (if they exist) or, alternatively, the ratings may be verified by an independent laboratory test report. If no certification program exists for a particular product, the equipment efficiency ratings shall be supported by data furnished by the manufacturer. **Addendum 90.1-01b** also specifically requires that cooling towers (covered in Table 6.2.1G) shall have efficiency ratings supported by data furnished by the manufacturer. This clause was added to allow cooling tower to meet the same requirements as air-cooled equipment. Without the clause, cooling towers would be required to use an optional certification program in their industry, while air-cooled equipment has no optional certification program, and

would thus be exempt from certification requirements. This addendum provides clarification only and is not expected to have any material impact on the energy efficiency requirements of Standard 90.1.

Addendum 90.1-01c modifies the duct sealing requirements of Table 6.2.4.3B to allow the use pressure sensitive tape that has been certified to comply with UL-181A or UL-181B by an independent testing laboratory and the tape is used in accordance with that certification. Since UL-181A and UL-181B are specifically to certify the use of pressure-sensitive tape for rigid and flexible air ducts, a requirement to use those standards in accordance with that certification should not lead to any material impact on the energy efficiency requirements of Standard 90.1.

Addendum 90.1-01d sets minimum efficiency standards for single-package vertical units (SPVU) which consist of a separate encased or un-encased combination of cooling and optional heating components, factory assembled as a single package, and intended for exterior mounting on an outside wall. These units include both air-conditioners (SPVAC) and heat pumps (SPVHP). The products were originally covered under NAECA, but a DOE ruling on October 5, 2000 concluded that these were commercial products covered under EPAct. Accordingly, ASHRAE acted to add requirements for this product to ASHRAE Standard 90.1, adopting efficiency rating based on ARI Standard 390-2001, which use EER instead of the SEER used to rate these products under NAECA. Given that the only real change here is that existing products are now listed in Standard 90.1 and rated with an EER rather than an SEER, this change is not expected to lead to any material impact on the energy efficiency requirements of Standard 90.1.

Addendum 90.1-01i updates requirements for small electrically operated unitary air-conditioners and condensing units and electrically operated unitary and applied heat pumps less than 65,000 Btu/h. Requirements for most of these pieces of equipment are raised as of 1/23/2006, with some pieces of equipment also being raised as of 1/23/2010. The requirements in this addendum have been superseded by the results of a court case that raised the efficiency of much of this equipment even higher. This equipment can be thought of as the three-phase equivalent of the single-phase air-cooled air conditioners and heat pumps that are regulated under NAECA and that are commonly referred to as “residential” air conditioners.

Addendum 90.1-01k eliminates a prohibition on standard pneumatic controllers for either zone thermostatic or supply loop control. There is no evidence that this change will have any material impact on the energy efficiency requirements of Standard 90.1.

Addendum 90.1-01o clarifies the wording of the exception d to Section 6.3.1 Economizers to make it clear that the exception only applies to heat recovery systems required by Section 6.3.6.2. This change alleviates a concern that simply have condenser heat recovery to preheat water without regard to how much energy was being recovered would be enough to qualify for an exemption from an economizer. Since this addendum is only a clarification of the intent of the Standard, the addendum is not expected to have any impact on the requirements of this standard.

Addendum 90.1-01r clarifies that return duct requirements shown in Table 6.2.4.1.2A apply to

heating only, cooling only, and combined heating and cooling duct systems by adding the requirement for return ducts to Table 6.2.4.1.2B. This is a clarification only and should have no material impact on the energy efficiency of Standard 90.1.

Addendum 90.1-01s addresses a noted typographical error in Standard 90.1-2001. Exception (i) to Section 6.3.6.1 exempted only systems required dehumidification and that use series-style energy recovery coils wrapped around the cooling coils. Since series energy recovery can be accomplished by a number of technologies, the exception has been rewritten to include those other technologies. These may include run around loops, plates, heat pipes, and wheel. The modification is not expected to have a material impact on energy efficiency of Standard 90.1.

Addendum 90.1-01u adds a new allowable economizer control type – dew-point and dry-bulb temperature; and provides appropriate high-limit shutoff control settings for this type of control. Since this is simply one option among many economizer control options, the change is not expected to have a material impact on energy efficiency of Standard 90.1.

Addendum 90.1-01x broadens the requirement for off-hour HVAC controls in both the Simplified Approach Option and the Mandatory Provisions. The change requires off-hour controls for systems greater than 15,000 Btu/h as opposed to systems of 65,000 Btu/h as found in Standard 90.1. The addendum also adds a requirement that fans with motors greater than ¾ hp to have automatic shutoff control unless they run continuously. This addendum is expected to have a positive impact on energy efficiency of Standard 90.1 by requiring more systems to have off-hour controls.

Addendum 90.1-01y changes the limitation on VAV fan motor requirements from 30 hp to 15 hp, based on the fact that variable-frequency drive costs have decreased significantly in the last several years. This addendum is expected to have a positive impact on energy efficiency of Standard 90.1 by requiring more systems to have off-hour controls.

Addendum 90.1-01z clarifies the language of the exceptions to Section 6.2.1 Mechanical Equipment Efficiency to note that applications requiring secondary coolants such as glycol or brine are excluded from the standard. This addendum is not expected to have any impact on the energy efficiency of Standard 90.1.

Addenda 90.1-01aa updates normative references for test procedures in Tables 6.2.1A and 6.2.1B to new ARI Standard 210/240-2003. This addendum is not expected to have any impact on the energy efficiency of Standard 90.1.

Addenda 90.1-01ab modifies exceptions to 6.3.6.1(d) Exhaust Air Energy Recovery, related to commercial kitchen hoods. All this addenda does is change the wording from applying to only Type 1 hoods as classified by NFPA 96 to all commercial kitchen hoods used for collecting and removing grease vapors and smoke. This addendum does apply the exception to more commercial kitchen hoods, thus representing a lessening of energy efficiency of Standard 90.1.

Addendum 90.1-01am reduces the number of climate zones considered in the Standard from 26

to 8. While this sounds like a reasonable simple process, the addendum had to deal with every callout to those climate zones that fall within the envelope and HVAC sections of the standard. The intent of the addendum was to reduce the size and simplify compliance with the Standard. There was no specific intent to increase the stringency of Standard 90.1 during the development of this addendum, but given the process of mapping from 26 zones to 8, it was virtually certain that some building designs in some climates would be more energy efficient under the new version and some building designs in some climates would be less energy efficient under the new version. For the HVAC section of the Standard, the most significant impact is on economizer requirements. The changes are summarized in Table 10 below for the 11 climate cities used in the quantitative comparison in this determination.

Table 10. Comparison of Economizer Requirements

Table 10. Comparison of Economizer Requirements			
City	99 Edition	2004 Edition	
Denver	Required - Systems above 65k Btu/h	Required - Systems above 65k Btu/h	No difference
Detroit	Required - Systems above 135k Btu/h	Required - Systems above 135k Btu/h	No difference
Fresno	Required - Systems above 135k Btu/h	Required - Systems above 65k Btu/h	2004 more stringent
Knoxville	None required	None required	No difference
Los Angeles	Required - Systems above 65k Btu/h	Required - Systems above 65k Btu/h	No difference
Minneapolis	No requirement	Required - Systems above 135k Btu/h	2004 more stringent
Orlando	None required	None required	No difference
Phoenix	Required - Systems above 135k Btu/h	Required - Systems above 135k Btu/h	No difference
Providence	Required - Systems above 135k Btu/h	Required - Systems above 135k Btu/h	No difference
Seattle	Required - Systems above 65k Btu/h	Required - Systems above 65k Btu/h	No difference
Shreveport	None required	None required	No difference

For the eleven cities, there are only two differences in requirements are for Fresno and Minneapolis, with both cities have more stringent requirements in the 2004 edition. The overall impact of Addendum 90.1-01am for HVAC systems is therefore towards higher efficiency in the 2004 edition.

3.6 Service Water Heating Changes

Three addenda were identified that made changes to the service water heating section. These include 90.1-99ac, 90.1-01m, and 90.1-01n.

Addendum 90.1-99ac modified section 7.2.1, so that it was now titled Load Calculations, instead of Sizing of Systems, since the requirements of the section refer not to sizing requirements but rather to the method of calculating loads for the purpose of sizing systems. In addition, the 90.1-1999 language only allowed for the use of manufactures guidelines for the purpose of load calculations. 90.1-2001 now allows the use of any generally accepted engineering standards and handbooks. This is a clarification of the standard and the committees' intent and does not affect the efficiency of the standard.

Addendum 90.1-01m adds requirements for heat pump pool heaters. While the addition of performance requirements for equipment not previously regulated is a positive change, the impacts of this requirement are expected to be minimal.

Addendum 90.1-01n provides a more detailed explanation of control of supplemental heaters for heat pumps and provides an exception for NAECA-regulated equipment. The detailed explanation provides clarity but does not impact the requirements of this standard. The exception for NAECA-regulated equipment is justified by the fact that the heat pump and its controls are tested together as part of the HSPF ratings used under NAECA. This addendum is not expected to have any impact on the requirements of this standard.

3.7 Power Changes

One addendum was identified that made changes to the power section. This was addendum 90.1-99aa.

Addendum 90.1-99aa was a modification to sections 8.2.1.1 Feeders and 8.2.1.2 Branch Circuits which discuss voltage drop limitation electrical wiring design. 90.1-1999 had conductors sized to provide for a maximum 2% voltage drop at maximum connected load,. However "maximum connected load" was undefined and may not be the sizing method used in feeder or branch circuit design. 90.1-2001 refers instead to the design load instead. The impact of this change is unknown since maximum connected load has not been defined by the standard since much of the design plug loads are only estimated during building construction. If maximum connected load was construed as maximum power allowed by the breakers, this would be larger than the design load and providing for a limited voltage drop under these conditions would be more efficient than providing for the voltage drop limitation at design loads.

No changes were made to Section 8 Power in Standard 90.1-2001.

3.8 Lighting Changes

A total of 14 addenda were identified that made changes to the lighting section. These include addenda 90.1-99v, 90.1-99w, 90.1-99y, 90.1-99z, 90.1-99ab, 90.1-99ah, 90.1-99ai, 90.1-01g, 90.1-01j, 90.1-01q, 90.1-01t, 90.1-01ae, 90.1-01ag, and 90.1-01al.

Addendum 90.1-99v modified section 9.2.1.1 Automatic Lighting Shutoff clause (c) which referenced the use of occupant intervention. This was done to avoid confusion over what was meant by this section's requirements for automatic control. The intent of the 90.1 committee was to allow additional types of automatic lighting control (e.g. computer workstation system) in addition to time-of-day and occupancy sensors. This addendum is considered a clarification and does not change the efficiency requirements of the standard.

Addendum 90.1-99w clarifies the use of the space-by-space method of calculating additional interior lighting power in retail spaces by specifically allowing the increase in watts per square foot to apply only to the area of each specific display. This was original intent of the committee and is reflected in the requirement that the additional lighting power is only for the specified luminaires. This clarification has no anticipated impact on the stringency of the standard.

Addendum 90.1-99y clarifies the definitions of "General Low Bay and General High Bay" under the industrial buildings category shown in lighting power density table 9.3.1.2. While low and high bay are common terms, their use in a building code required the addition of a clear and measurable distinction between the two categories. Addendum 90.1y adds that distinction. This will make the standard clearer to use, although its energy impact is negligible.

Addendum 90.1-99z clarifies the original intent of the standard to reflect the committee's original requirements for exterior lighting building power in section 9.3.2. The 90.1-1999 wording allowed the exterior lighting budget for the building to count facade lighting, but only for the lit area of the building facade. Thus, it could allow very low power lighting for illumination of the building facade of the building, but allow credit to be taken so that higher lighting power could be used at the exits and entrances. By removing facade lighting from the lighting budget, the overall budget for the remaining exterior uses is tightened. This helps to clarify the original intent of Standard 90.1-1999 as was discussed in ASHRAE Interpretation IC 90.1-1999-1. Because it reflects the interpretation, the addendum does not have any impact on the efficiency of the standard.

Addendum 90.1-99ab clarifies the original intent of Standard 90.1-1999 that additional interior lighting power allowances may apply to any lighted area as long as there are lighting functions that meet the criteria outlined in Section 9.3.1.2.1 and when the additional lighting power is used only for luminaries serving the specific light functions outlined in that section. The checkmarks shown on the last column of table 9.3.1.2 and all references to these checkmarks were removed by the standard. This modification is a clarification of the intent of the Standard as provided in 90.1-1999 Interpretation Number 4. (Interpretations for Standard 90.1-1999 may be found at http://www.ashrae.org/publications/detail/14802.) Given that this change reflects the intent of the standard, there is no effective change in efficiency as required by the Standard.

Addendum 90.1-99ah allows the building area method to be used for buildings which are composed of multiple use types. The language in Standard 90.1-1999 did not work for construction of a building with multiple building area types since the building had to be defined as one predominant building area type. The proposed text is written to parallel that of the space-by-space method in Sections 9.3.1.2 so that if the building is composed of 80% office, 20% retail by floor space, the whole building lighting power density could be defined by weighting the lighting power densities for those building area types by their respective floor areas. This change does not represent an increase or decrease in the efficiency of the standard, since any such increase or decrease in the allowed whole building lighting power density depends on the building area types in question and the relative floor areas of those types in the building. In addition, the space-by-space methodology would allow for the development of similar, area weighted, lighting power density by looking at the individual space types within the building area types directly.

Addendum 90.1-99ai clarifies Table 9.3.1.1 with regard to building type by providing a footnote clearly indicating that for building area types for which a general and specific building area types are listed, the specific building area type shall be used in defining the allowed lighting power density for the building under the building area method. For example, a Religious Dormitory could be considered as a “Dormitory” or a “Religious Building”. The dormitory type would be considered the specific building area type for use in the determining whole building lighting power density. This footnote may help to clarify the requirements in 90.1-2001. However in many cases it would likely be the decision of most code personnel to go with the more defined and specific building area type when lighting power densities are available in the standard. This change does remove some ambiguity, but is expected to have little net impact on the efficiency requirements of the standard.

Addendum 90.1-01g completely revises the interior lighting power density requirements in Standard 90.1. As a general rule, lighting power allowances are reduced by about 30% across the board. This addendum was the result of a comprehensive review of both the building models and the inputs to those models used to develop the lighting power requirements. This addendum is without question the single most important change to occur between Standard 90.1-1999 and Standard 90.1-2004. A simplistic calculation says that 30% of commercial building site energy is lighting and this single addendum saves 30% of that, yielding a reduction of about 9% of commercial building energy usage. A more detailed consideration of the impacts of this addendum will be made in the companion quantitative assessment of energy savings of Standard

90.1-2004.

Addendum 90.1-01j clarifies the wording of Section 9.2.1.2 Space Control to ensure the requirements are applied to all time-of-day controls and not just time-of-day controls installed to meet the requirements of this standard and to differentiate between the need for accessibility of manual controls by occupants, but no necessarily for accessibility to occupancy sensors or other automatic controls. **Addendum 90.1-01j** also clarifies Section 9.3.1 Interior Lighting Power, item n to allow an exception for lighting for television broadcasting in sporting activity areas instead of an exemption for the entire athletic playing area. This change is not expected to have an impact on the efficiency requirements of the standard.

Addendum 90.1-01q provides a revision of the exterior lighting control requirements found in Section 9.2.1.3 and a major revision of the exterior building lighting power in Section 9.3.2 of Standard 90.1-2001. The revision to the control requirements is essentially a clarification of how automatic controls must provide the capability of shutoff when sufficient daylight is available or when lighting is not required during nighttime hours. The new requirements require an astronomical time switch for lighting that is not designated for dusk-to-dawn operation and either an astronomical time switch or photosensor for lighting that is designated for dusk-to-dawn operation. The requirement that any astronomical time switches be capable of retaining their programming for a period of 10 hours during loss of power was also added. The main impact is to disallow the use of photosensors for lighting that is not designated dusk-to-dawn and to add a requirement for 10 hour backup of programming for astronomical time clocks. This control requirement revision does not necessarily have an impact on the energy efficiency requirements of this standard. The revision to the exterior building lighting power in Addendum 90.1-01q is a more major revision and is expected to provide an increase in stringency to exterior lighting power requirements. The new requirements lower the lighting power density requirements found in Standard 90.1-2001 and add new lighting power density requirements for other types of exterior lighting, while retaining the existing limits on exterior building grounds lighting efficacy. This addendum is expected to increase the energy efficiency of buildings designed to Standard 90.1.

Addendum 90.1-01t revises and adds to the list of specific exceptions for automatic lighting shutoff in Section 9.2.1.1. The revision to Exception (a) is editorial in nature since the text removed is moved to the overall discussion of the exceptions. The new exception (c) provides an exemption for spaces where automatic shutoff would endanger the safety or security of the room or building occupants. This exception is really only a specific case of the blanket exemptions found both in the Scope of lighting section (Section 9.1.1 and exceptions) and Section 2.5 of the Scope of Standard 90.1. The new exception provides somewhat more flexibility to a code official to make a judgment call on the whether or not automatic shutoff would pose a safety or security risk, even if no formal health or life safety statutes, ordinances, regulations, or requirements were involved. This addendum is not expected to impact the energy efficiency of Standard 90.1.

Addendum 90.1-01ae adds a requirement for occupancy sensors in specific buildings spaces, including college classrooms (not including shop or laboratory class rooms), conference/meeting rooms, and employee lunch and break rooms. The addendum also makes minor editorial changes to Section 9.2.1.2 Space Control. The requirement of occupancy sensors beyond the requirement for automatic shutoff control will increase the energy efficiency of Standard 90.1. While the amount of space in any one building required having occupancy sensors may be small (with the exception of college classroom buildings), the cumulative effect over all lunch rooms, meeting rooms, and college class rooms should be significantly positive. .

Addendum 90.1-01ag corrects the retail sales area lighting power density number that was previously published in **addendum 90.1-01g**. The value is changed from 2.1 watts per foot squared to 1.7 watts per foot squared. Given the amount of floorspace impacted by this change and the difference in allowable watts, this addendum will definitely have a positive impact on the energy efficiency of Standard 90.1.

Addendum 90.1-01al requires that exit signs have a maximum wattage of 5 watts per face, as opposed to the original requirement that any signs using more than 20 watts have a minimum efficacy of 35 lumen/watts. This requirement may be achieved by using LED, electroluminescent and cold cathode technologies. The foreword of **addendum 90.1-01al** estimates savings of 394 kWh per year compared to standard incandescent exit signs and 131 kWh per year compared to compact fluorescent exit signs. This addendum will definitely have a positive impact on the energy efficiency of Standard 90.1.

3.9 Energy Cost Budget Method Changes

A total of 5 addenda were identified that made changes to the Energy Cost Budget method. These include addenda 90.1-99an, 90.1-99ap, 90.1-01e, 90.1-01p, and 90.1-01ac.

Addendum 90.1-99an modified the Energy Cost Budget Section 11.4.2, Building Envelope, so that it better matched with the language in the Administration and Enforcement sections 4.1.2.1 and 4.1.2.2, and more specifically, highlighting the different treatments of new buildings, additions, and alterations. In particular, it added specific text to make it clear that trade-offs between an addition and an existing building are allowed, and that when such tradeoffs are done, the envelope assumptions for the existing building in the budget building design shall reflect existing conditions prior to any revisions that are part of this permit. This modification only clarifies the intent of the standard and makes provision for the updates to section 4.1.2.2. As such it does not impact the efficiency by itself.

Addendum 90.1-99ap modifies Section 11.4.3. HVAC systems part e and f to combine them into one section and in the process clarified that the budget building shall use either air or water economizers based on what is specified in the proposed design, but whether or not economizers exist in the budget building depends on what is required in the prescriptive section of the standard in section 6.3.1. The addendum also provided that the control for the economizer be that outlined in the prescriptive section of the standard. Previously, 90.1-1999 determined the choice of air or water economizer based on the budget system choice for the building. By

making the economizer choice the same in the budget and proposed design, the choice of economizer can be tailored to each individual system design and more importantly to appropriate climates. This is not believed to have any impact on the criteria established by the standard or the energy efficiency of buildings complying using the ECB methodology.

Addenda 90.1-01e adds a new Informative Appendix G, Performance Rating Method, to Standard 90.1. This method, modeled on the Energy Cost Budget Method in Section 11 of Standard 90.1, was developed to provide a more usable way for developing above-standard ratings, such as those required in the USGBC LEED program. The Performance Rating Method provides much greater flexibility than the Energy Cost Budget method for achieving and documenting whole building energy savings. While this new method is very useful and appropriate for programs such as LEED, this appendix is informative only in Standard 90.1 and is not expected to have any impact on the energy efficiency of buildings built to Standard 90.1.

Addendum 90.1-01p adds a requirement that simulation programs used in the Energy Cost Budget method be tested in accordance with ANSI/ASHRAE Standard 140, *Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs.* The main impact of this addendum is to ensure that simulation programs used with the ECB method provide reasonable answers and are properly maintained by their developers. This addendum does not materially impact the energy efficiency requirements of Standard 90.1.

Addendum 90.1-01ac provides clarification and specificity to a number of sections in the Energy Cost Budget Method. The changes include:

- an explicit clarification that "manually operated fenestration shading devices shall not be modeled" (Exception (d) to 11.3.6);
- "lighting system power shall include all lighting system components shown or provided for on plans (11.3.8d);
- replacement of an allowance for modeling of motor and other systems with a requirement that receptacle, motor, and process be modeled (Section 11.3.9);
- a much more explicit description of the budget heating type to be considered for a water-source heat pump system (Table 11.4.3A (Note 7));
- a requirement that the budget system for proposed designs with ground-source or ground-water source heat pumps be a water-source heat pump system (Section 11.4.3k(1));
- a requirement that fixtures not included in the lighting power density calculation (such as second lighting systems, safety and security lighting) be modeled identically in the proposed and budget building.

While these changes add clarification and may increase the stringency of tradeoffs using the ECB method, these changes do not alter the mandatory or prescriptive requirements of Standard 90.1 and are therefore not likely to have an impact on the stringency of Standard 90.1.

3.10 Normative and Informative Reference Changes

A total of 7 addenda were identified that made changes to the normative and informative reference section. Normative references were changed in addenda 90.1-01c, 90.1-01d, 90.1-01h, 90.1-01p, and 90.1-01aa. Informative references were editorially updated for Standard 90.1-2001 and changed in addendum 90.1-01al.

Editorial Updates: The reference years for the ASHRAE Handbook of Fundamentals, the MICA Insulation Standards, the NEBB Procedural Standards, and the AABC procedures were updated for Standard 90.1-2001. The reference to WYEC data was changed to WYEC2 data to reflect the newer data set. Since these are all informative references, there is no change to the stringency of the standard.

Addendum 90.1-01c adds UL-181A and UL-181B to Section 12, Normative References. This change is not expected to materially impact the energy efficiency of buildings designed to Standard 90.1.

Addendum 90.1-01d adds ARI Standard 390-2001 to Section 12, Normative References. This change is not expected to materially impact the energy efficiency of buildings designed to Standard 90.1.

Addendum 90.1-01h updates a number of existing references, deletes two references, and adds a number of new references to Section 12, Normative References. The reference updates were all to newer versions of existing ASTM and NFRC standards. The references added and removed were also ASTM and NFRC standards. All of these changes were related to determination of building material thermal properties (R-values and thermal conductivities) and assembly U-factors of Sections A9.3.1 and A9.3.2 of Standard 90.1-2001. These changes are not expected to materially impact the energy efficiency of buildings designed to Standard 90.1.

Addendum 90.1-01p adds ANSI/ASHRAE Standard 140 to Section 12, Normative References. This change is not expected to materially impact the energy efficiency of buildings designed to Standard 90.1.

Addendum 90.1-01aa updates, adds, and removes a number of normative references. None of the references are expected to have any impact and thus the entire addendum is not expected to impact the energy efficiency of Standard 90.1.

Addendum 90.1-01al modifies Informative Appendix E, Informative References by modifying references for BLAST and DOE-2, and adding references for TMY2, WYEC2, and IWEC data, as well as modifying the section numbers where these references are called out. As this entire appendix is informative, this addendum will not impact the energy efficiency of Standard 90.1.

4 Overall Comparison between Standard 90.1-1999 and Standard 90.1-2004

This review identifies by addenda very specific changes to Standard 90.1-1999 that resulted in Standard 90.1-2004. Some of these changes were deemed to affect the stringency and efficiency of the building standard. Most of the changes were not deemed to materially impact the efficiency of the Standard included published interpretations. A summary of the changes that affect the stringency of the standard are as follows.

Reductions in stringency

Standard 90.1-1999 to Standard 90.1-2001

1. Reduction of slab on grade insulation requirements for northern U.S. and Alaska
2. Relaxation of heated slab on grade insulation requirement in northern U.S. and Alaska.
3. Reduction of motorized damper leakage requirements for most of the continental U.S.
4. Removal of requirements for motorized dampers on small-medium system HVAC systems.
5. Removal of performance requirements for balancing to 10% of design flow rates
6. Relaxed requirements limiting volume of air reheated or re-cooled in supply air systems

Standard 90.1-2001 to Standard 90.1-2004

7. Expansion of Exhaust Air Energy Recovery requirement to additional commercial kitchen hoods

Increases in stringency

Standard 90.1-1999 to Standard 90.1-2001

1. Removed explicit allowance for supply air into non-occupied isolation areas
2. Limits the use of dampers in closed circuit cooling towers in place of water bypass valves and piping
3. Adds insulation requirements for buried ductwork

Standard 90.1-2001 to Standard 90.1-2004

4. Mapping of envelope requirements to new climate zones
5. Mapping of economizer requirements to new climate zones
6. Addition of requirements for ventilation fan controls
7. Lowered size range for part-load fan power limitation
8. Addition of requirements for heat pump pool heaters
9. Complete replacement of interior lighting power density allowances
10. Revised exterior lighting power density allowances
11. Addition of occupancy sensor requirements for classrooms, meeting, and lunch rooms
12. Lower retail sales lighting power allowance
13. New exit sign wattage requirement

Other Changes

Standard 90.1-1999 to Standard 90.1-2001

- Numerous other changes were made that clarify the requirements of the Standard, correct editorial mistakes in the Standard, or to rearrange the standard to make it more readable and usable. In general, all of these changes should be viewed as improvements in the standard with regard to usability by designers and code-officials.

Standard 90.1-2001 to Standard 90.1-2004

- Numerous other changes were made that clarify the requirements of the Standard, correct editorial mistakes in the Standard, or to rearrange the standard to make it more readable and usable. In general, all of these changes should be viewed as improvements in the standard with regard to usability by designers and code-officials. Changing deserving special mention here were the entire reformat of Standard 90.1 (made as editorial changes only outside of the addenda process) and the major overhaul of all climate related parameters to rely on eight climate zones rather than 26.

From a strict text comparison standpoint, there were 6 negative and 3 positive changes made from Standard 90.1-1999 to Standard 90.1-2001, resulting in a net negative change in energy efficiency. There was 1 negative and 9 positive changes made from Standard 90.1-2001 to Standard 90.1-2004, resulting in a net positive change in energy efficiency. Overall, there were 7 negative and 12 positive changes made from Standard 90.1-1999 to Standard 90.1-2004, resulting in a net positive change to energy efficiency. Coupling this net positive result with the editorial improvements in clarity made to both Standard 90.1-2001 and Standard 90.1-2004 indicates that Standard 90.1-2004 can be considered to represent a net improvement in energy efficiency. The magnitude of that improvement will be determined in the quantitative assessment portion of this determination.

Assessment of Stringency Change by Section of Standard
The changes made to Standard 90.1 were evaluated in ten categories as shown below.

Section of Standard	Number of Changes	Number of Positive Changes	Number of Negative Changes	Overall Net Change
Title, Purpose, and Scope	0	0	0	0
Definitions	2	0	0	0
Administration and Enforcement	3	0	0	0
Envelope	11	1	2	-1[1]
HVAC Equipment and Systems	27	7	4	+3
Service Water Heating	3	0	0	0
Power	1	0	0	0
Lighting	14	5	0	+5
Energy Cost Budget	5	0	0	0
Normative and Informative References	7	0	0	0
Overall	73[2]	13	6	+7

[1] The impact of the single positive envelope change greatly outweighs the impact of the two negative envelope changes.
[2] The overall number of changes is more than the total number of addenda due to the fact that some addenda covered more than one section of the standard.