ADDENDA

ANSI/ASHRAE Addendum h to
ANSI/ASHRAE Standard 55-2010

Thermal Environmental Conditions for Human Occupancy

Approved by the ASHRAE Standards Committee on January 26, 2013; by the ASHRAE Board of Directors on January 29, 2013; and by the American National Standards Institute on January 30, 2013.

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FOREWORD

This addendum clarifies the normative requirements for determining clothing insulation for representative occupants and moves these normative requirements to the body of the Standard. It adds a new informative appendix containing similar material that was in the previous Normative Appendix B, Clothing Insulation.

Note: *In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.*

Addendum h to Standard 55-2010

Add the following new Section 5.2.2 and relocate Tables B1, B2, and B3 from Normative Appendix B as shown.

5.2.2 Clothing Insulation

5.2.2.1 Insulation for Each Representative Occupant

5.2.2.1.1 For each representative occupant, determine the clothing insulation in clo (I_{cl}).

5.2.2.1.2 Insulation of several occupants with significantly different ensembles shall *not* be averaged to find a single, average insulation value.

Exception: Where individuals are free to adjust clothing to account for individual differences in response to the thermal environment, it is permitted to use a single representative occupant with an average clothing insulation value for multiple individuals.

5.2.2.2 Insulation Determination. Use one or a combination of the following methods to determine clothing insulation.

a. The data presented in Table 5.2.2.2A for the expected ensemble of each representative occupant.
b. Add or subtract the insulation (I_{clu}) of individual garments in Table 5.2.2.2B from the ensembles in Table 5.2.2.2A to determine the insulation of ensembles not listed.
c. Determine a complete clothing ensemble using the sum of the individual values listed for each item of clothing in the ensemble in Table 5.2.2.2B.
d. It is permitted, but not required, to adjust any of the above methods for seated occupants using Table 5.2.2.2C.
e. For moving occupants it is permitted, but not required, to adjust any of the above methods using the following formula:

$$I_{cl\text{-}active} = I_{cl} \times (0.6 + 0.4 / M)$$

$$1.2 \text{ met} < M < 2.0 \text{ met}$$

where M is the metabolic rate in met units and I_{cl} is the insulation without movement.

f. Interpolate between or extrapolate from the values given in Tables 5.2.2.2B and 5.2.2.2C.
g. Use measurement with thermal manikins or other approved engineering methods.

5.2.2.3 Limits of Applicability

5.2.2.3.1 High Insulation Value. This standard does not apply to occupants whose clothing insulation exceeds 1.5 clo.

5.2.2.3.2 Moisture-Impermeable Clothing. This standard does not apply to occupants whose clothing is highly impermeable to moisture transport (e.g., chemical protective clothing or rain gear).

5.2.2.3.3 Sleeping Occupants. This standard does not apply to occupants who are sleeping, reclining in contact with bedding, or able to adjust blankets or bedding.

TABLE ~~B1~~ 5.2.2.2A Clothing Insulation Values for Typical Ensembles[a]

Clothing Description	Garments Included[b*]	I_{cl} (clo)
Trousers	1) Trousers, short-sleeve shirt	0.57
	2) Trousers, long-sleeve shirt	0.61
	3) #2 plus suit jacket	0.96
	4) #2 plus suit jacket, vest, T-shirt	1.14
	5) #2 plus long-sleeve sweater, T-shirt	1.01
	6) #5 plus suit jacket, long underwear bottoms	1.30
Skirts/Dresses	7) Knee-length skirt, short-sleeve shirt (sandals)	0.54
	8) Knee-length skirt, long-sleeve shirt, full slip	0.67
	9) Knee-length skirt, long-sleeve shirt, half slip, long-sleeve sweater	1.10
	10) Knee-length skirt, long-sleeve shirt, half slip, suit jacket	1.04
	11) Ankle-length skirt, long-sleeve shirt, suit jacket	1.10
Shorts	12) Walking shorts, short-sleeve shirt	0.36
Overalls/Coveralls	13) Long-sleeve coveralls, T-shirt	0.72
	14) Overalls, long-sleeve shirt, T-shirt	0.89
	15) Insulated coveralls, long-sleeve thermal underwear tops and bottoms	1.37
Athletic	16) Sweat pants, long-sleeve sweatshirt	0.74
Sleepwear	17) Long-sleeve pajama tops, long pajama trousers, short 3/4 length robe (slippers, no socks)	0.96

~~a. Data are from Chapter 9 in the 2009 *ASHRAE Handbook—Fundamentals*.3~~

~~b~~* All clothing ensembles, except where otherwise indicated in parentheses, include shoes, socks, and briefs or panties. All skirt/dress clothing ensembles include panty hose and no additional socks.

TABLE ~~B2~~ 5.2.2.2B Garment Insulation[a]

Garment Description[~~b~~a]	I_{clu}(clo)	Garment Description[~~b~~a]	I_{clu}(clo)
Underwear		**Dress and Skirts[~~e~~b]**	
Bra	0.01	Skirt (thin)	0.14
Panties	0.03	Skirt (thick)	0.23
Men's briefs	0.04	Sleeveless, scoop neck (thin)	0.23
T-shirt	0.08	Sleeveless, scoop neck (thick), i.e., jumper	0.27
Half-slip	0.14	Short-sleeve shirtdress (thin)	0.29
Long underwear bottoms	0.15	Long-sleeve shirtdress (thin)	0.33
Full slip	0.16	Long-sleeve shirtdress (thick)	0.47
Long underwear top	0.20	**Sweaters**	
Footwear		Sleeveless vest (thin)	0.13
Ankle-length athletic socks	0.02	Sleeveless vest (thick)	0.22
Panty hose/stockings	0.02	Long-sleeve (thin)	0.25
Sandals/thongs	0.02	Long-sleeve (thick)	0.36
Shoes	0.02	**Suit Jackets and Vests[~~d~~c]**	
Slippers (quilted, pile lined)	0.03	Sleeveless vest (thin)	0.10
Calf-length socks	0.03	Sleeveless vest (thick)	0.17
Knee socks (thick)	0.06	Single-breasted (thin)	0.36
Boots	0.10	Single-breasted (thick)	0.44
Shirts and Blouses		Double-breasted (thin)	0.42
Sleeveless/scoop-neck blouse	0.12	Double-breasted (thick)	0.48
Short-sleeve knit sport shirt	0.17	**Sleepwear and Robes**	
Short-sleeve dress shirt	0.19	Sleeveless short gown (thin)	0.18
Long-sleeve dress shirt	0.25	Sleeveless long gown (thin)	0.20
Long-sleeve flannel shirt	0.34	Short-sleeve hospital gown	0.31
Long-sleeve sweatshirt	0.34	Short-sleeve short robe (thin)	0.34
Trousers and Coveralls		Short-sleeve pajamas (thin)	0.42
Short shorts	0.06	Long-sleeve long gown (thick)	0.46
Walking shorts	0.08	Long-sleeve short wrap robe (thick)	0.48
Straight trousers (thin)	0.15	Long-sleeve pajamas (thick)	0.57
Straight trousers (thick)	0.24	Long-sleeve long wrap robe (thick)	0.69
Sweatpants	0.28		
Overalls	0.30		
Coveralls	0.49		

[a] ~~Data are from Chapter 9 in the 2009 *ASHRAE Handbook – Fundamentals*.3~~
[~~b~~a] "Thin" refers to garments made of lightweight, thin fabrics often worn in the summer; "thick" refers to garments made of heavyweight, thick fabrics often worn in the winter.
[~~e~~b] Knee-length dresses and skirts.
[~~d~~c] Lined vests.

TABLE ~~B3~~ 5.2.2.2C ~~Typical~~ Added Insulation when Sitting on a Chair
(~~Valid for~~ Applicable to Clothing Ensembles with Standing Insulation Values of 0.5 clo < I_{cl} < 1.2 clo)

Net chair[a]	0.00 clo
Metal chair	0.00 clo
Wooden side arm chair[b]	0.00 clo
Wooden stool	+0.01 clo
Standard office chair	+0.10 clo
Executive chair	+0.15 clo

[a] A chair constructed from thin, widely spaced cords that provide no thermal insulation.
[b] *Note:* this chair was used in most of the basic studies of thermal comfort that were used to establish the PMV-PPD index.

Delete the existing Normative Appendix B and add the following new Informative Appendix B.

(This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

INFORMATIVE APPENDIX B— CLOTHING INSULATION

The amount of thermal insulation worn by a person has a substantial impact on thermal comfort and is an important variable in applying this standard. Clothing insulation is expressed in a number of ways. In this standard, the clothing insulation of an ensemble expressed as a clo value (I_{cl}) is used. Users not familiar with clothing insulation terminology are referred to Chapter 9 of the 2009 *ASHRAE Handbook—Fundamentals*[3] for more information.

The insulation provided by clothing can be determined by a variety of means, and if accurate data are available from other sources, such as measurement with thermal manikins, these data are acceptable for use. When such information is not available, the tables in this standard may be used to estimate clothing insulation using one of the methods described below. Regardless of the source of the clothing insulation value, this standard is not intended for use with clothing ensembles with more than 1.5 clo of insulation. This standard is not intended for use when occupants wear clothing that is highly impermeable to moisture transport (e.g., chemical protective clothing or rain gear).

Three methods for estimating clothing insulation are presented. The methods are listed in order of accuracy. The tables used in the standard are derived from Chapter 9 of the 2009 *ASHRAE Handbook—Fundamentals.*[3]

- **Method 1:** Table 5.2.2.2A of this standard lists the insulation provided by a variety of common clothing ensembles. If the ensemble in question matches reasonably well with one of the ensembles in this table, then the indicated value of I_{cl} should be used.

- **Method 2:** Table 5.2.2.2B of this standard presents the thermal insulation of a variety of individual garments. It is acceptable to add or subtract these garments from the ensembles in Table 5.2.2.2A to estimate the insulation of ensembles that differ in garment composition from those in Table 5.2.2.2A. For example, if long underwear bottoms are added to Ensemble 5 in Table 5.2.2.2A, the insulation of the resulting ensemble is estimated as

$$I_{cl} = 1.01 + 0.15 = 1.16 \text{ clo}$$

- **Method 3:** It is acceptable to define a complete clothing ensemble using a combination of the garments listed in Table 5.2.2.2B of this standard. The insulation of the ensemble is estimated as the sum of the individual values listed in Table 5.2.2.2B. For example, the estimated insulation of an ensemble consisting of overalls worn with a flannel shirt, T-shirt, briefs, boots, and calf-length socks is

$$I_{cl} = 0.30 + 0.34 + 0.08 + 0.04 + 0.10 + 0.03 = 0.89 \text{ clo}$$

Tables 5.2.2.2A and 5.2.2.2B are for a standing person. A sitting posture results in a decreased thermal insulation due to compression of air layers in the clothing. This decrease can be offset by insulation provided by the chair. Table 5.2.2.2C shows the net effect on clothing insulation for typical indoor clothing ensembles that result from sitting in a chair. These data may be used to adjust clothing insulation calculated using any of the above methods. For example, the clothing insulation for a person wearing Ensemble 3 from Table 5.2.2.2A and sitting in an executive chair is 0.96 + 0.15 = 1.11 clo. For many chairs, the net effect of sitting is a minimal change in clothing insulation. For this reason, no adjustment to clothing insulation is needed if there is uncertainty as to the type of chair and/or if the activity for an individual includes both sitting and standing.

Tables 5.2.2.2A and 5.2.2.2B are for a person that is not moving. Body motion decreases the insulation of a clothing ensemble by pumping air through clothing openings and/or causing air motion within the clothing. This effect varies considerably depending on the nature of the motion (e.g., walking versus lifting) and the nature of the clothing (stretch-

able and snug fitting versus stiff and loose fitting). Because of this variability, accurate estimates of clothing insulation for an active person are not available unless measurements are made for the specific clothing under the conditions in question (e.g., with a walking manikin). An approximation of the clothing insulation for an active person is

$$I_{cl,\text{-}active} = I_{cl} \times (0.6 + 0.4 / M)$$

$$1.2 \text{ met} < M < 2.0 \text{ met}$$

where M is the metabolic rate in met units and I_{cl} is the insulation without activity. For metabolic rates less than or equal to 1.2 met, no adjustment for motion is required.

When a person is sleeping or resting in a reclining posture, the bed and bedding provide considerable thermal insulation. It is not possible to determine the thermal insulation for most sleeping or resting situations unless the individual is immobile. Individuals adjust bedding to suit individual preferences. Provided adequate bedding materials are available, the thermal environmental conditions desired for sleeping and resting vary considerably from person to person and cannot be determined by the methods included in this standard.

Clothing variability among occupants in a space is an important consideration in applying this standard. This variability takes two forms. In the first form, different individuals wear different clothing due to factors unrelated to the thermal conditions. Examples include different clothing style preferences for men and women and offices where managers are expected to wear suits while other staff members may work in shirtsleeves. In the second form, the variability results from adaptation to individual differences in response to the thermal environment. For example, some individuals wear sweaters while others wear short-sleeve shirts in the same environment if there are no constraints limiting what is worn. The first form of variability results in differences in the requirements for thermal comfort between the different occupants, and these differences should be addressed in applying this standard. In this situation, it is *not* correct to determine the average clothing insulation of various groups of occupants to determine the thermal environmental conditions needed for all occupants. Where the variability within a group of occupants is of the second form and is a result only of individuals freely making adjustments in clothing to suit their individual thermal preferences, it is correct to use a single representative average clothing insulation value for everyone in that group.

For near-sedentary activities where the metabolic rate is approximately 1.2 met, the effect of changing clothing insulation on the optimum operative temperature is approximately 6°C (11°F) per clo.

Example: Table 5.2.2.2B indicates that adding a thin, long-sleeve sweater to a clothing ensemble increases clothing insulation by approximately 0.25 clo. Adding this insulation would lower the optimum operative temperature by approximately 6°C/clo × 0.25 clo = 1.5°C (11°F/clo × 0.25 clo = 2.8°F).

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.