



ASHRAE ADDENDA

2008 SUPPLEMENT

Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs

Approved by the ASHRAE Standards Committee on June 21, 2008; by the ASHRAE Board of Directors on June 25, 2008; and by the American National Standards Institute on June 26, 2008.

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**American Society of Heating, Refrigerating
and Air-Conditioning Engineers, Inc.**
1791 Tullie Circle NE, Atlanta, GA 30329
www.ashrae.org

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- b. participation in the next review of the Standard,
- c. offering constructive criticism for improving the Standard, or
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NOTE

When addenda, interpretations, or errata to this standard have been approved, they can be downloaded free of charge from the ASHRAE Web site at www.ashrae.org.

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FOREWORD

This addendum updates Annex A2 and references to this Annex for changes made to the modeling notes S140outNotes.TXT file. S140outNotes.TXT has been updated to match the content and format of the modeling notes TXT file used for posting Standard 140 results on the DOE Tools Directory Web site. This revised TXT file adds sections for software information and anomalous results. In addition, an example file, S140outNotes_Examples.TXT, is provided to illustrate how modeling notes information should be provided.

Specific changes made in this addendum are as follows:

Section 4.3.1—Adds two bullets to item “b” to describe the new software information and anomalous results sections of S140outNotes.TXT.

Section 4.4.4—Adds a new subsection regarding anomalous results.

Annex A2 Introduction—Revises the last paragraph in the introduction to reference the new Attachment sections and to note the intent that one modeling notes file should be provided for each section of tests.

Annex A2 Attachment A2.5—Replaces the current text in this attachment with the content of the new S140outNotes.TXT file.

Annex A2 Attachment A2.6—Deletes the current Attachments A2.6 through A2.9 and replaces them with a single Attachment section with the content of the new S140outNotes_Examples.TXT file. This TXT file provides example data for all types of modeling notes and therefore replaces the content that was originally in separate Attachments A2.6 through A2.9.

Addendum a to Standard 140-2007

[Informative Note: Additions are shown in this addendum by underlining and deletions are shown by ~~striking through~~ except when an informative note makes it clear that the entire material that follows is to be added or deleted as a whole.]

4.3 Reporting Results

4.3.1 Standard Output Reports. The standard output reports included on the accompanying CD shall be used. Instructions regarding these reports are included in Annex A2. Information required for this report includes

- a. software name and version number,
- b. modeling documentation using “S140outNotes.TXT” on the accompanying CD for:
 - Software identifying information and operating requirements.

- Modeling methods used when alternative methods are available in the software
- Equivalent modeling methods used when the software does not allow direct input of specified values
- Omitted test cases and results
- Changes to source code for the purpose of running the tests, where such changes are not available in publicly released versions of the software

• Anomalous results

- c. results for simulated cases using the following files on the accompanying CD:
 - Sec5-2out.XLS for the building thermal envelope and fabric load tests of Section 5.2
 - Sec5-3Aout.XLS for the space cooling equipment performance analytical verification tests of Sections 5.3.1 and 5.3.2
 - Sec5-3Bout.XLS for the space cooling equipment performance comparative tests of Sections 5.3.3 and 5.3.4
 - Sec5-4out.xls for the space heating equipment performance tests of Section 5.4.

Output quantities to be included in the results report are called out specifically for each case, as they appear in the appropriate subsections of Sections 5.2, 5.3 and 5.4.

If a program being tested omits a test case, the modeler shall provide an explanation using the modeler report template provided in Annex A2.

4.3.2 Simulation Input Files. All supporting data required for generating results with the tested software shall be saved, including:

- Input files
- Processed weather data
- Intermediate files containing calculations used for developing inputs
- A “Readme-software-name-yyymmdd.pdf” file that briefly describes the contents of the above files according to their file type (i.e., their “.xyz” file extension).

4.4 Comparing Output to Other Results. Annex B8 gives example simulation results for the building thermal envelope and fabric load tests. Annex B16 gives quasi-analytical solution results and example simulation results for the HVAC equipment performance tests. The user may choose to compare output with the example results provided in Annex B8 and Annex B16 or with other results that were generated using this standard method of test (including self-generated quasi-analytical solutions related to the HVAC equipment performance tests). Information about how the example results were produced is included in informational Annex B11 and Annex B17 for building thermal envelope and fabric load tests, and HVAC equipment performance tests, respectively. For the convenience to users who wish to plot or tabulate their results along with the example results, electronic versions of the example results have been included on the accompanying CD for Annex B8 with the file RESULTS5-2.XLS, and with the following files for Annex B16: RESULTS5-3A.XLS, RESULTS5-3B and RESULTS5-4.XLS. Documentation for

navigating these results files has been included on the accompanying CD, and is printed in Annex B10.

4.4.1 Criteria for Determining Agreement Between Results. There are no formal criteria for when results agree or disagree. Determination of when results agree or disagree is left to the user. In making this determination, the user should consider the following:

- magnitude of results for individual cases,
- magnitude of difference in results between certain cases (e.g., “Case 610 - Case 600”),
- same direction of sensitivity (positive or negative) for difference in results between certain cases (e.g., “Case 610 - Case 600”),
- if results are logically counterintuitive with respect to known or expected physical behavior,
- availability of analytical or quasi-analytical solution results (i.e., mathematical truth standard as described in informative Annex B16, Section B16.2),
- for the space-cooling and space-heating equipment performance tests of Section 5.3 and 5.4, the degree of disagreement that occurred for other simulation results in Annex B16 versus the analytical and quasi-analytical solution results.
- Example simulation results do not represent a truth standard.

4.4.2 Diagnostic Logic for Determining Causes of Differences Among Results. To help the user identify what algorithm in the tested program is causing specific differences between programs, diagnostic flow charts are provided as informational Annex B9.

4.4.3 Rules for Modifying Simulation Programs or Simulation Inputs. Modifications to simulation programs or simulation inputs shall have a mathematical, physical, or logical basis and shall be applied consistently across tests. Arbitrary modification of a simulation program’s input or internal code just for the purpose of more closely matching a given set of results shall not be allowed.

If changes are made to the source code of the software for the purpose of performing tests, and these changes are not available in publicly released versions of the software, then the changes shall be documented in sufficient detail using the modeler report template provided in Annex A2, so that the implications of the changes can be assessed.

4.4.4 Discussion of Anomalous Results. At the option of the report author, anomalous test results may be explained using the modeler report template provided in Annex A2.

(This is a normative annex and is part of this standard.)

NORMATIVE ANNEX A2 STANDARD OUTPUT REPORTS

The standard output reports ~~consists~~ consist of five forms provided on the CD accompanying this standard:

- Output Results for Cases of Section 5.2 (Sec5-2out.XLS, spreadsheet file)

- Output Results for Cases of Sections 5.3.1 and 5.3.2 (Sec5-3Aout.XLS, spreadsheet file)
- Output Results for Cases of Sections 5.3.3 and 5.3.4 (Sec5-3Bout.XLS, spreadsheet file)
- Output Results for Cases of Section 5.4 (Sec5-4out.XLS, spreadsheet file)
- Modeling Notes (S140outNotes.TXT, text file reprinted as Attachment A2.5)

For entering output results into Sec5-2out.XLS, Sec5-3Aout.XLS, Sec5-3Bout.XLS, and Sec5-4out.XLS, follow the instructions provided at the top of the appropriate electronic spreadsheet file. These instructions are reprinted as Attachments A2.1, A2.2, A2.3, and A2.4 respectively, within this section.

For entering modeling notes into S140outNotes.TXT, use the format of the ~~following~~ examples given ~~as in~~ Attachments A2.6, ~~A2.7, A2.8, and A2.9~~ within this section. Note: The report author shall create one modeling notes TXT document for each section of tests, e.g.,

- S140outNotes 5-2.TXT for the building thermal envelope and fabric load tests of Section 5.2
- S140outNotes 5-3A.TXT for the space cooling equipment performance analytical verification tests of Sections 5.3.1 and 5.3.2
- S140outNotes 5-3B.TXT for the space cooling equipment performance comparative tests of Sections 5.3.3 and 5.3.4
- S140outNotes 5-4.TXT for the space heating equipment performance tests of Section 5.4.

[Informative Note: Original content of A2.5 is replaced with the new S140OutNotes.txt content. Replace previous version of S140OutNotes.txt with updated version in the following accompanying file folders: “Sec5-2Files”, “Sec5-3Afiles”, “Sec5-3Bfiles”, and “Sec5-4files”.]

Attachment A2.5 Standard 140 Output Form— Modeling Notes

~~STANDARD 140 OUTPUT FORM—MODELING NOTES~~

~~INSTRUCTIONS: See Annex A2.~~

~~SOFTWARE:~~

~~VERSION:~~

~~REPORT BLOCK FOR ALTERNATIVE MODELING
METHODS~~

~~DOCUMENT BELOW THE MODELING METHODS
USED IF ALTERNATIVE MODELING
METHODS OR ALGORITHMS ARE AVAILABLE IN THE
SOFTWARE BEING TESTED.~~

~~(See Annex A2 for examples.)~~

~~Describe the Effect Being Simulated Effect:~~

~~Optional Settings or Modeling Capabilities:~~

~~Setting or Capability Used:~~

~~Physical Meaning of Option Used:~~

~~(Include more alternative feature descriptions using this format if applicable to the test.)~~

~~REPORT BLOCK FOR EQUIVALENT MODELING METHODS~~

~~DOCUMENT BELOW THE EQUIVALENT INPUTS USED IF EQUIVALENT MODELING METHODS WERE USED (See Annex A2 for examples.)~~

~~Describe the Effect Being Simulated:~~

~~Section(s) of the Standard where Relevant Inputs are Specified:~~

~~Equivalent Input(s) Used:~~

~~Physical, Mathematical or Logical Justification of the Equivalent Input(s)~~

~~—provide supporting calculations, if relevant:~~

~~(Include more equivalent modeling method descriptions using this format, if applicable to the test.)~~

~~REPORT BLOCK FOR OMITTED TEST CASES AND RESULTS~~

~~DOCUMENT BELOW THE REASONS FOR OMITTING RESULTS (see Annex A2 for examples)~~

~~List the Case(s) where Results Were Omitted, and which Results Were Omitted for the Case(s):~~

~~Explanation for Omitting the Test Case(s) Results:~~

~~(Include explanations for omitting other test case results using this format, if applicable to the test.)~~

~~REPORT BLOCK FOR CHANGES TO SOURCE CODE FOR THE PURPOSE OF RUNNING THE TESTS, WHERE SUCH CHANGES ARE NOT AVAILABLE IN PUBLICLY RELEASED VERSIONS OF THE SOFTWARE~~

~~DOCUMENT BELOW THE REASONS FOR SPECIFIC CHANGES TO THE SOURCE CODE (See Annex A2 for examples.)~~

~~List the Change(s) to the source code:~~

~~List the Test Case(s) Relevant to the Change(s) in the Source Code:~~

~~Explanation of Why the Change Is Not Included in the Publicly Released Version of the Software:~~

~~(Include explanations for more changes to non-publicly released versions of the software using this format, if applicable to the test.)~~

MODELING NOTES FOR ASHRAE STANDARD 140-2007

INTRODUCTION

This document contains supplemental information about the ASHRAE Standard 140-2007 tests performed. One S140outNotes document is provided for each set of tests (e.g. one for the building thermal and fabric load tests of Section 5.2, one for the space cooling equipment analytical verification tests of Sections 5.3.1 and 5.3.2, etc.) Six types of information are provided in this document, each in a separate section:

- a. Software Information
- b. Alternative Modeling Methods
- c. Equivalent Modeling Methods
- d. Omitted Test Cases and Results
- e. Changes Made to Source Code for the Purpose of Running the Tests, where Such Changes are not Available in Publicly Released Versions of the Software
- f. Anomalous Results

Text at the start of each section describes the content of the section for the reader and provides instructions for supplying the content. Sample notes are provided in a separate document (S140outNotes_Examples.TXT).

Notes in this document are limited to the six topics shown above. Notes must be factual and objective and may only refer to the software being tested. Notes may not refer to any other software program.

A. SOFTWARE INFORMATION

CONTENT: This section contains reference information for the software - the vendor, name and version of the software plus operating system and computer hardware requirements.

INSTRUCTIONS: Supply information for items 1 through 7 below. Item 8 is optional and can be used to supply additional, relevant information.

1. SOFTWARE VENDOR:
2. SOFTWARE NAME:
3. SOFTWARE VERSION (unique software version identifier):
4. OPERATING SYSTEM REQUIREMENTS:
5. APPROX HARD DISK SPACE REQUIRED FOR INSTALLATION:
6. MINIMUM RAM REQUIRED FOR SOFTWARE OPERATION:
7. MINIMUM DISPLAY MONITOR REQUIREMENTS:
8. OTHER HARDWARE OR SOFTWARE-RELATED REQUIREMENTS:

B. REPORT BLOCK FOR ALTERNATIVE MODELING METHODS

CONTENT: This section describes modeling methods used for tests if the software provides alternative modeling methods or algorithms that could be used to perform the test.

INSTRUCTIONS: If applicable, provide a separate note below for each alternative modeling method or algorithm situation. Use the standard format shown below and supply a separate number and title for each note. If not applicable, specify “NONE” in place of the information below.

NOTE 1 - <title>

1.1 Describe the Effect Being Simulated:

1.2 Optional Settings or Modeling Capabilities
(List setting or capability and its physical meaning):

1.2.1 <name>

Physical Meaning: <explanation>

1.2.2 <name>

Physical Meaning: <explanation>

1.2.n <name>

Physical Meaning: <explanation> etc...

1.3 Setting or Capability Used:

C. REPORT BLOCK FOR EQUIVALENT MODELING METHODS

CONTENT: This section describes equivalent modeling methods used to perform the tests. When the software cannot model an effect exactly as stated in the Standard or does not permit the input values required, equivalent modeling can be used to perform the test.

INSTRUCTIONS: If applicable, provide a separate note below for each instance of equivalent modeling. Use the standard format shown below and supply a separate number and title for each note. If not applicable, specify “NONE” in place of the information below.

NOTE 1 - <title>

1.1 Describe the Effect Being Simulated:

1.2 Section(s) of the Standard where Relevant Inputs are Specified:

1.3 Equivalent Input(s) Used:

1.4 Physical, Mathematical or Logical Justification of the Equivalent Input(s)
– provide supporting calculations, if relevant:

D. REPORT BLOCK FOR OMITTED TEST CASES AND RESULTS

CONTENT: This section describes test cases that were omitted and/or individual results of test cases that were omitted along with the reason for the omission.

INSTRUCTIONS: If applicable, provide a separate note below to describe each type of omission. Use the standard format shown below and supply a separate number and title for each note. If there are no omissions, specify “NONE” in place of the information below.

NOTE 1 - <title>

1.1 List the Case(s) where Results Were Omitted, and which Results Were Omitted for the Case(s):

1.2 Explanation for Omitting the Test Case(s) Results:

E. REPORT BLOCK FOR CHANGES TO SOURCE CODE FOR THE PURPOSE OF RUNNING THE TESTS, WHERE SUCH CHANGES ARE NOT AVAILABLE IN PUBLICLY RELEASED VERSIONS OF THE SOFTWARE

CONTENT: This section describes changes to software source code made to allow the software to run a test, where such changes are not available in a publicly released version of the software. In special situations a change to source code is necessary to activate a feature or permit inputs needed for a test, but these features are not available in the publicly released version of the software.

INSTRUCTIONS: If applicable, provide separate notes below to describe each source code modification. Use the standard format shown below and supply a separate number and title for each note. If not applicable, specify “NONE” in place of the information below.

NOTE 1 - <title>

1.1 List the Change(s) to the source code:

1.2 List the Test Case(s) Relevant to the Change(s) in the Source Code:

1.3. Explanation of Why the Change Is Not Included in the Publicly Released Version of the Software:

F. REPORT BLOCK FOR ANOMALOUS RESULTS

CONTENT: This section provides an opportunity to describe anomalous test results. Describing anomalous results is optional.

INSTRUCTIONS: If applicable, describe each type of anomalous result in a separate note. Use the standard format shown below and supply a separate number and title for each note item. If not applicable, specify “NONE” in place of the information below.

NOTE 1 - <title>

1.1 Test Case(s) and Specific Results from the Case(s) which are Anomalous:

1.2 Explanation of Reason for the Anomalous Results:

<END OF DOCUMENT>

[Informative Note: Replace Attachments A2.6, A2.7, A2.8, A2.9 with contents of the S140OutNotes_Examples.txt document. Modify title for the new Attachment A2.6. This document provides examples of the four types of modeling notes covered in the original A2.6 through A2.9 and examples of the new software information and anomalous results sections. Add new S140OutNotes_Examples.txt in the following accompanying file folders: “Sec5-2Files”, “Sec5-3Afiles”, “Sec5-3Bfiles”, and “Sec5-4files”.]

[Informative Note: For the next Continuous Maintenance Revision, renumber references 14, 15, and 16 that are deleted below; these are all cited later in the document.]

Attachment A2.6 Example of Modeling Notes, Report Block for Alternative Modeling Methods

~~STANDARD 140 OUTPUT FORM—MODELING NOTES~~

~~INSTRUCTIONS: See Annex A2.~~

~~SOFTWARE: BLAST 3.0⁵~~

~~VERSION: Level 193~~

~~REPORT BLOCK FOR ALTERNATIVE MODELING
METHODS~~

~~DOCUMENT BELOW THE MODELING METHODS
USED IF ALTERNATIVE MODELING METHODS OR
ALGORITHMS ARE AVAILABLE IN THE SOFTWARE
BEING TESTED.
(See Annex A2 for examples.)~~

~~Simulated Effect:~~

~~Convective heat transfer and radiative exchange related to
both interior and exterior surfaces~~

~~Optional Settings or Modeling Capabilities (from simplest to
most detailed):~~

~~HEAT BALANCE = 0; HEAT BALANCE = 1; HEAT
BALANCE = 2 Setting or Capability Used: HEAT BALANCE
= 2~~

~~Physical Meaning of Option Used:~~

~~Interior surface convection based on zone air and interior
surface delta T. Exterior surface heat transfer has separate
heat transfer coefficients for radiative exchange to sky and
ground and convection to ambient air~~

~~Simulated Effect:~~

~~Interior transmitted solar radiation distribution~~

~~Optional Settings or Modeling Capabilities (from simplest to
most detailed):~~

~~SOLAR DISTRIBUTION = 0; SOLAR DISTRIBUTION = 1
Setting or Capability Used: SOLAR DISTRIBUTION = 1~~

~~Physical Meaning of Option Used:~~

~~Beam radiation falling on each surface is calculated by ray
tracing. Beam radiation not initially absorbed is diffusely
reflected.~~

~~STANDARD 140 OUTPUT FORM—MODELING NOTES~~

~~INSTRUCTIONS: See Annex A2.~~

~~SOFTWARE: DOE 2.1E¹⁴~~

~~VERSION: W54~~

~~REPORT BLOCK FOR ALTERNATIVE MODELING
METHODS~~

~~DOCUMENT BELOW THE MODELING METHODS
USED IF ALTERNATIVE MODELING METHODS OR
ALGORITHMS ARE AVAILABLE IN THE SOFTWARE
BEING TESTED. (See Annex A2 for examples.)~~

~~Simulated Effect:~~

~~Thermal behavior of windows~~

~~Optional Settings or Modeling Capabilities:~~

- ~~1. “Shading Coefficient”~~
- ~~2. GLASS TYPE CODE ? 11~~
- ~~3. GLASS TYPE CODE ? 1000~~

~~3A. Existing window used from W4LIB.DAT 3B. Custom
window developed and added to W4LIB.DAT~~

~~Setting or Capability Used:~~

~~3B. GLASS TYPE CODE ? 1000 with custom window devel-
oped and added to W4LIB.DAT~~

~~Physical Meaning of Option Used:~~

~~Windows modeled using thermal and optical properties devel-
oped with WINDOW 4.0.¹⁵~~

~~STANDARD 140 OUTPUT FORM—MODELING NOTES~~

~~INSTRUCTIONS: See Annex A2.~~

~~SOFTWARE: ESP-r/HOT3000¹⁶~~

~~VERSION: bps3k version 1.1 and 1.7~~

~~REPORT BLOCK FOR ALTERNATIVE MODELING
METHODS~~

~~DOCUMENT BELOW THE MODELING METHODS
USED IF ALTERNATIVE MODELING METHODS OR
ALGORITHMS ARE AVAILABLE IN THE SOFTWARE
BEING TESTED.
(See Annex A2 for examples)~~

Simulated Effect:

Zone temperature controller

Optional Settings or Modeling Capabilities:

- Basic controller for heating/cooling
- Free float controller
- Basic pre-heat or pre-cool controller
- Fixed heat injection and extraction
- PID control action for heating/cooling
- Flux connection between zone & plant
- Multi-stage control with hysteresis
- Variable supply temp with constraints
- Heat pipe from outside to inside
- Separate flux ON & OFF set points
- Match sensed/recorded value (ideal)
- Match sensed/recorded value (on/off)
- Time proportioning (on/off) control
- Floating 'three position' control
- Optimum start control
- Optimum stop control
- Fuzzy Logic PI-PD control
- Null controller
- Multi-sensor heating/cooling
- Evaporative source (surface)
- Slave capacity controller

Setting or Capability Used:

ESP-r/H3K basic (ideal) controller used with heating capacity of 20 kW while the furnace capacity is set to 10 kW.

Physical Meaning of Option Used:-

In ESP-r, the controller has a defined capacity. When the load of the space is less than the capacity, the set point is maintained and the actual load is reported. If the load is greater than the capacity of the controller, ESP-r sets the load equal to the controller's capacity. In this case the actual load is not met and the set point is not satisfied.

A value greater than 10 kW is used for the ideal controller heating capacity to allow the load of the zone to exceed 10 kW if this is what the solution dictates. This way, the load on the furnace is not limited to a maximum of 10 kW and it is possible to predict the proper number of under-heating hours for the zone.

This is an issue only with test HE230.

Attachment A2.7 Examples of Modeling Notes, Report Block for Equivalent Modeling Methods

REPORT BLOCK FOR EQUIVALENT MODELING METHODS

DOCUMENT BELOW THE EQUIVALENT INPUTS USED IF EQUIVALENT MODELING METHODS WERE USED (See Annex A2 for examples.)

Describe the Effect Being Simulated:

Thermal decoupling of floor from ground.

Section(s) of the Standard where Relevant Inputs are Specified:

5.2.1.4, 5.2.1.5

Equivalent Input(s) Used:

Floor modeled as perfectly decoupled from ground.

Physical, Mathematical or Logical Justification of the Equivalent Input(s)-

—provide supporting calculations, if relevant:

Logical Justification: Section 5.2.1.5 states that "...the state of the art in ground modeling is not very good even in detailed building energy simulation programs. To reduce uncertainty regarding testing or other aspects of simulating the building envelope, the floor insulation has been made very thick to effectively decouple the floor thermally from the ground."

It is clear from this statement the intent is to eliminate floor to ground heat transfer to reduce the uncertainty in results that it will introduce. The prescribed method of doing this is to model a floor with very high R value ($R=25.374 \text{ sqm K/W}$ or $U=0.039 \text{ W/sqm K}$). This assumes that a software program cannot perfectly eliminate floor to ground heat transfer and therefore must minimize the error due to floor to ground heat transfer via use of a large floor R value.

The subject program cannot comply with the prescribed floor R value, however, the subject program can perfectly decouple the floor from the ground. Because perfect decoupling is interpreted as meeting the intent of section 5.2.1.5, perfect decoupling was used as an equivalent modeling approach.

Describe the Effect Being Simulated:

Thermostat control and equipment capacity.

Section(s) of the Standard where Relevant Inputs are Specified:

5.2.1.13.1

5.2.1.13.2

Equivalent Input(s) Used:

Heating Setpoint = 20 °C, Throttling Range = 0.1 K, Heating Capacity = 3.935 kW

Cooling Setpoint = 27 °C, Throttling Range = 0.1 K, Cooling Capacity = 3.935 kW

Physical, Mathematical or Logical Justification of the Equivalent Input(s)-

—provide supporting calculations, if relevant:

Logical Justification:

Together Sections 5.2.1.13.1 and 5.2.1.13.2 require use of a non proportional thermostat with which the heat extraction rate is effectively infinite when the zone air temperature exceeds 27°C, and the heat addition rate is effectively infinite when the zone air temperature falls below 20°C. The intent of these sections is to establish conditions for which equipment cooling or heating output exactly matches the zone load. This eliminates system effects and system dynamics that could obscure the focus of this test suite which is zone thermal loads, not system coil loads.

In the subject software program, use of the prescribed inputs constitutes an unstable control system. For example, the moment the zone air temperature exceeds 27°C, the system will provide 1000 kW of cooling to the zone. This quantity of cooling far exceeds the cooling demand, so the zone is overcooled, pushing the zone air temperature below 20°C. The moment this happens, the system provides 1000 kW of heating to the zone. This quantity of heating far exceeds the heating demand, so the zone is overheated, pushing the zone air temperature above 27°C. A system with this control will rapidly oscillate between cooling and heating. The system simulation algorithm in the subject program will not be able to converge on a solution state for any hour because of the unstable nature of this control.

To resolve this problem, a small throttling range was used with the prescribed setpoints, and the cooling and heating capacities were set to values close to the peak cooling and heating demands of the zone. These inputs were chosen empirically by tuning the inputs until thermostat control instability was eliminated and differences between the system cooling coil load and the zone cooling load, and between the system heating coil load and the zone heating load, were minimized as much as possible. This approach meets the intent of Sections 5.2.1.13.1 and 5.2.1.13.2.

Note: In the subject program the 3.935 kW capacity is not specified directly. Instead it is indirectly defined via supply airflow rate and supply temperature. The supply airflow was 565.6 L/s, the cooling supply air temperature was 20°C and the heating supply air temperature was 27°C. This yields the capacities as follows. The 0.994 factor is the standard 1.207 density x heat capacity x correction factor corrected for site altitude.

$$\text{Cooling Capacity} = 0.994 \times 565.6 \text{ L/s} \times (27^\circ\text{C} - 20^\circ\text{C}) = 3935 \text{ W} = 3.935 \text{ kW}$$

$$\text{Heating Capacity} = 0.994 \times 565.6 \text{ L/s} \times (20^\circ\text{C} - 27^\circ\text{C}) = 3935 \text{ W} = 3.935 \text{ kW}$$

Attachment A2.8 Examples of Modeling Notes, Report Block for Omitted Test Cases and Results

REPORT BLOCK FOR OMITTED TEST CASES AND RESULTS

DOCUMENT BELOW THE REASONS FOR OMITTING RESULTS

(see Annex A2 for examples)

List the Case(s) where Results Were Omitted, and which Results Were Omitted for the Case(s):

All results omitted for the following tabulated cases:

| | | | | |
|-----|-------|-----|-----|-----|
| 600 | 600FF | 230 | 300 | 420 |
| 610 | 650FF | 240 | 310 | 430 |
| 620 | 195 | 250 | 320 | 440 |
| 630 | 200 | 270 | 395 | |
| 640 | 210 | 280 | 400 | |
| 650 | 220 | 290 | 410 | |

Explanation for Omitting the Test Case(s) Results:

These test cases require modeling lightweight building construction (approx 12 lb/sqft floor area). This is residential weight construction. The subject software program is intended for modeling commercial buildings and consequently the minimum building construction weight is 30 lb/sqft floor area. Since the required building construction weight for these test cases is well outside the range of intended program operation, these test cases cannot be performed.

List the Case(s) where Results Were Omitted, and which Results Were Omitted for the Case(s):

Case 960—Sunspace, all results

Explanation for Omitting the Test Case(s) Results:

The required inputs to model this type of configuration are not available in this software program. Case 960 models a passive solar sun room using a modified Trombe wall. In order to model this configuration the associated algorithm would need to compute:

- a. The hourly proportion of solar radiation absorbed by the individual sunlit surfaces within the sunlit portion of the Trombe wall*
- b. The effect of introducing infiltration in the Trombe wall section*
- c. Adjacent space heat transfer between the Trombe wall and the interior room.*

Attachment A2.9 Example of Modeling Notes, Report Block for Changes to Source Code for the Purpose of Running the Tests, where such Changes Are Not Available in Publicly Released Versions of the Software

REPORT BLOCK FOR CHANGES TO SOURCE CODE FOR THE PURPOSE OF RUNNING THE TESTS, WHERE SUCH CHANGES ARE NOT AVAILABLE IN PUBLICLY RELEASED VERSIONS OF THE SOFTWARE

DOCUMENT BELOW THE REASONS FOR SPECIFIC CHANGES TO THE SOURCE CODE

List the Change(s) to the source code:

Include capability for hourly varying schedules, where such schedules may be varied for any day of the year, for sensible and latent internal gains, infiltration, outside air, and zone thermostat. Currently for the subject software's publicly released version, such hourly schedules may only be varied monthly, beginning on the first day of each month and continuing through the entire month

List the Test Case(s) Relevant to the Change(s) in the Source Code:

More flexible schedules are needed as follows:

Internal Gains: All cases of Sections 5.3.3 and 5.3.4 (i.e., Cases CE300 through CE545)

Infiltration and/or Outside Air: Cases CE320, CE330, and CE340 only

Thermostat: Case CE350 only.

Explanation of Why the Change Is Not Included in the Publicly Released Version of the Software:

Users of the subject software appear to be satisfied with hourly schedules limited to monthly variation. Changing the source code to accommodate the test cases of Sections 5.3.3 and 5.3.4 for the purpose of testing the calculation engine is justifiable. However, without known demand from users for additional scheduling flexibility, it is difficult to justify additional costs related to enhancing the user interface and revising software documentation.

Attachment A2.6 Examples of Modeling Notes

MODELING NOTES FOR ASHRAE STANDARD 140-2007—EXAMPLES

OVERVIEW

This document contains examples of modeling notes entered in the S140outNotes_Sec5-x.TXT file. Examples are provided to guide in filling out the S140outNotes_Sec5-x.TXT file.

Note that in this file sample notes refer to different sections of Standard 140-2007. In an actual S140outNotes_Sec5-x.TXT file the notes would only address one set of tests within Standard 140 (e.g., Section 5.2).

INTRODUCTION

This document contains supplemental information about the ASHRAE Standard 140-2007 tests performed. One S140outNotes document is provided for each set of tests (e.g., one for the building thermal and fabric load tests of Section 5.2, one for the space cooling equipment analytical verification tests of Sections 5.3.1 and 5.3.2, etc.) Six types of information are provided in this document, each in a separate section:

- a. Software Information
- b. Alternative Modeling Methods
- c. Equivalent Modeling Methods
- d. Omitted Test Cases and Results
- e. Changes Made to Source Code for the Purpose of Running the Tests, where Such Changes are not Available in Publicly Released Versions of the Software
- f. Anomalous Results

Text at the start of each section describes the content of the section for the reader and provides instructions to the vendor for supplying the content. Sample notes are provided in a separate document (S140outNotes_Examples.TXT).

Notes in this document are limited to the six topics shown above. Notes must be factual and objective and may only refer to the software being tested. Notes may not refer to any other software program.

A. SOFTWARE INFORMATION

CONTENT: This section contains reference information for the software—the vendor, name and version of the software plus operating system and computer hardware requirements.

INSTRUCTIONS: Supply information for items 1 through 7 below. Item 8 is optional and can be used to supply additional, relevant information.

1. SOFTWARE VENDOR: Dummy Software Solutions
2. SOFTWARE NAME: Building Energy Simulation
3. SOFTWARE VERSION (unique software version identifier): 1.00.039
4. OPERATING SYSTEM REQUIREMENTS:
Windows 98,
Windows NT (Service Pack 4 or later),
Windows 2000 (Service Pack 2 or later), or
Windows XP (Service Pack 2 or later)
5. APPROX HARD DISK SPACE REQUIRED FOR INSTALLATION:
Maximum = 45 MB
Typical = 15 to 17 MB
6. MINIMUM RAM REQUIRED FOR SOFTWARE OPERATION:
128 MB
7. MINIMUM DISPLAY MONITOR REQUIREMENTS:
VGA with 600x800 resolution and 256 colors
8. OTHER HARDWARE OR SOFTWARE-RELATED REQUIREMENTS:
(none)

B. REPORT BLOCK FOR ALTERNATIVE MODELING METHODS

CONTENT: This section describes modeling methods used for tests if the software provides alternative modeling methods or algorithms that could be used to perform the test.

INSTRUCTIONS: If applicable, provide a separate note below for each alternative modeling method or algorithm situation. Use the standard format shown below and supply a separate number and title for each note. If not applicable, specify “NONE” in place of the information below.

NOTE 1 - Convective Heat Transfer and Radiative Exchange Related to Both Interior and Exterior Surfaces
(Section 5-2)

1.1 Describe the Effect Being Simulated:

Convective heat transfer and radiative exchange related to both interior and exterior surfaces.

1.2 Optional Settings or Modeling Capabilities:

1.2.1 HEAT BALANCE = 0;

Physical Meaning: Interior surface heat transfer calculated using ASHRAE values for combined convective and radiative coefficient with the radiation component subtracted out; interior radiative exchange is determined using the balanced mean radiant temperature method. Exterior surface heat transfer calculated using combined coefficients for convective and radiative exchange.

1.2.2 HEAT BALANCE = 1;

Physical Meaning: Same as Heat Balance = 0, except interior surface convection is calculated based on zone air and interior surface temperature difference.

1.2.3 HEAT BALANCE = 2

Physical Meaning: Same as Heat Balance = 1, except exterior surface heat transfer is calculated using separate heat transfer coefficients for radiative exchange to sky and ground and for convection to ambient air.

1.3 Setting or Capability Used:

HEAT BALANCE = 2

NOTE 2 - Interior Transmitted Solar Radiation Distribution
(Section 5-2)

2.1 Describe the Effect Being Simulated:

Interior transmitted solar radiation distribution.

2.2 Optional Settings or Modeling Capabilities:

2.2.1 SOLAR DISTRIBUTION = 0

All radiation initially hits the floor. Radiation not initially absorbed by the floor is diffusely reflected and absorbed by all surfaces in proportion to their area-absorptance products.

2.2.2 SOLAR DISTRIBUTION = 1

Beam radiation falling on each surface is calculated by ray tracing. Beam radiation not initially absorbed is diffusely reflected and absorbed by all surfaces in proportion to their area-absorptance products.

2.3 Setting or Capability Used:

SOLAR DISTRIBUTION = 1

NOTE 3 - Thermal Behavior of Windows
(Section 5-2)

3.1 Describe the Effect Being Simulated:

Thermal behavior of windows.

3.2 Optional Settings or Modeling Capabilities:

3.2.1 “Shading Coefficient”

Applies the ASHRAE shading coefficient technique to calculate solar heat gain (e.g., see 1989 ASHRAE Handbook of Fundamentals, Chp. 27).

3.2.2 GLASS-TYPE-CODE =< 11

Applies pre-calculated transmittance and absorptance coefficients based on specified glass-type-code; the coefficients are used to calculate solar gain as a function of incidence angle.

3.2.3 GLASS-TYPE-CODE => 1000

Window used from the library W4LIB.DAT, where windows are modeled using thermal and optical properties developed with WINDOW 4.0. [Window 4.0 (March 1992) LBL-32091 UC-350, Berkeley, CA, Lawrence Berkeley Laboratory]

3.2.3.1 Existing window used from W4LIB.DAT

3.2.3.2 Custom window developed using Window 4.0 and added to W4LIB.DAT

3.3 Setting or Capability Used:

Custom window developed and added to W4LIB.DAT; see 3.2.3.2 above.

C. REPORT BLOCK FOR
EQUIVALENT MODELING METHODS

CONTENT: This section describes equivalent modeling methods used to perform the tests. When the software cannot model an effect exactly as stated in the Standard or does not permit the input values required, equivalent modeling can be used to perform the test.

INSTRUCTIONS: If applicable, provide a separate note below for each instance of equivalent modeling. Use the standard format shown below and supply a separate number and title for each note. If not applicable, specify “NONE” in place of the information below.

NOTE 1 - Thermal Decoupling of Floor From Ground
(Section 5-2)

1.1 Describe the Effect Being Simulated:

Thermal decoupling of floor from ground.

1.2 Section(s) of the Standard where Relevant Inputs are Specified:

5.2.1.4 and 5.2.1.5.

1.3 Equivalent Input(s) Used:

Floor modeled as perfectly decoupled from ground.

1.4 Physical, Mathematical or Logical Justification of the Equivalent Input(s)

– provide supporting calculations, if relevant:

Logical Justification: Section 5.2.1.5 states that “...the state-of-the-art in ground modeling is not very good even in detailed building energy simulation programs. To reduce uncertainty regarding testing or other aspects of simulating the building envelope, the floor insulation has been made very thick to effectively decouple the floor thermally from the ground.”

It is clear from this statement the intent is to eliminate floor-to-ground heat transfer to reduce the uncertainty in results that it will introduce. The prescribed method of doing this is to model a floor with very high R-value ($R=25.374 \text{ sqm-K/W}$ or $U=0.039 \text{ W/sqm-K}$). This assumes that a software program cannot perfectly eliminate floor-to-ground heat transfer and therefore must minimize the error due to floor-to-ground heat transfer via use of a large floor R-Value.

The subject program cannot comply with the prescribed floor R-value; however, the subject program can perfectly decouple the floor from the ground. Because perfect decoupling is interpreted as meeting the intent of section 5.2.1.5, perfect decoupling was used as an equivalent modeling approach.

NOTE 2 - Thermostat Control and Equipment Capacity (Section 5-2)

2.1 Describe the Effect Being Simulated:

Thermostat control and equipment capacity

2.2 Section(s) of the Standard where Relevant Inputs are Specified:

Sections 5.2.1.13.1 and 5.2.1.13.2

2.3 Equivalent Input(s) Used:

Heating Setpoint = 20°C, Throttling Range = 0.1°K,
Heating Capacity =
3.935 kW

Cooling Setpoint = 27°C, Throttling Range = 0.1°K,
Cooling Capacity =
3.935 kW

2.4 Physical, Mathematical or Logical Justification of the Equivalent Input(s)

– provide supporting calculations, if relevant:

Logical Justification: Together sections 5.2.1.13.1 and 5.2.1.13.2 require use of a non-proportional thermostat with which the heat extraction rate is effectively infinite when the zone air temperature exceeds 27°C and the heat addition rate is effectively infinite when the zone air temperature falls below 20°C. The intent of these sections is to establish conditions for which equipment cooling or heating output exactly matches the zone load. This eliminates system effects and system dynamics that could obscure the focus of this test suite, which is zone thermal loads, not system coil loads.

In the subject software program, use of the prescribed inputs constitutes an unstable control system. For example, the moment the zone air temperature exceeds 27°C, the system will provide 1000 kW of cooling to the zone. This quantity of cooling far exceeds the cooling demand, so the zone is over-cooled pushing the zone air temperature below 20°C. The moment that happens, the system provides 1000 kW of heating to the zone. This quantity of heating far exceeds the heating demand, so the zone is overheated, pushing the zone air temperature above 27°C. A system with this control will rapidly oscillate between cooling and heating. The system simulation algorithm in the subject program will not be able to converge on a solution state for any hour because of the unstable nature of this control.

To resolve this problem, a small throttling range was used with the prescribed setpoints, and the cooling and heating capacities were set to values close to the peak cooling and heating demands of the zone. These inputs were chosen empirically by tuning the inputs until thermostat control instability was eliminated and differences between the system cooling coil load and the zone cooling load and between the system heating coil load and the zone heating load were minimized as much as possible. This approach meets the intent of sections 5.2.1.13.1 and 5.2.1.13.2.

Note: In the subject program the 3.935 kW capacity is not specified directly. Instead it is indirectly defined via supply airflow rate and supply temperature. The supply airflow was 565.6 L/s, the cooling supply air temperature was 20°C and the heating supply air temperature was 27°C. This yields the capacities as follows. The 0.994 factor is the standard 1.207 density x heat capacity x correction factor corrected for site altitude.

Cooling Capacity = $0.994 \times 565.6 \text{ L/s} \times (27^\circ\text{C} - 20^\circ\text{C}) = 3935 \text{ W} = 3.935 \text{ kW}$

Heating Capacity = $0.994 \times 565.6 \text{ L/s} \times (20^\circ\text{C} - 27^\circ\text{C}) = 3935 \text{ W} = 3.935 \text{ kW}$

D. REPORT BLOCK FOR OMITTED TEST CASES AND RESULTS

CONTENT: This section describes test cases that were omitted and/or individual results of test cases that were omitted along with the reason for the omission.

INSTRUCTIONS: If applicable, provide a separate note below to describe each type of omission. Use the standard format shown below and supply a separate number and title for each note. If there are no omissions, specify “NONE” in place of the information below.

NOTE 1 - Light Weight Test Cases (Section 5-2)

1.1 List the Case(s) where Results Were Omitted, and which Results Were Omitted for the Case(s):

| | | | | |
|------------|--------------|------------|------------|------------|
| <u>600</u> | <u>600FF</u> | <u>230</u> | <u>300</u> | <u>420</u> |
| <u>610</u> | <u>650FF</u> | <u>240</u> | <u>310</u> | <u>430</u> |
| <u>620</u> | <u>195</u> | <u>250</u> | <u>320</u> | <u>440</u> |
| <u>630</u> | <u>200</u> | <u>270</u> | <u>395</u> | |
| <u>640</u> | <u>210</u> | <u>280</u> | <u>400</u> | |
| <u>650</u> | <u>220</u> | <u>290</u> | <u>410</u> | |

1.2 Explanation for Omitting the Test Case(s) Results:

These test cases require modeling lightweight building construction (approx 12 lb/sqft floor area). This is residential weight construction. The subject software program is intended for modeling commercial buildings and consequently the minimum building construction weight is 30 lb/sqft floor area. Since the required building construction weight for these test cases is well outside the range of intended program operation, these test cases cannot be performed.

NOTE 2 - Case 960- Sunspace, All Results
(Section 5-2)

2.1 List the Case(s) where Results Were Omitted, and which Results Were Omitted for the Case(s):

Case 960 - Sunspace, all results.

2.2 Explanation for Omitting the Test Case(s) Results:

The required inputs to model this type of configuration are not available in this software program. Case 960 models a passive solar sun room using a thermal storage wall. In order to model this configuration, the associated algorithm would need to compute:

- The hourly proportion of solar radiation absorbed by the individual sunlit surfaces within the sunlit portion of the thermal storage wall.
- The effect of introducing infiltration in the thermal storage wall section.
- Adjacent space heat transfer between the thermal storage wall and the interior room.

E. REPORT BLOCK FOR CHANGES TO SOURCE CODE FOR THE PURPOSE OF RUNNING THE TESTS, WHERE SUCH CHANGES ARE NOT AVAILABLE IN PUBLICLY RELEASED VERSIONS OF THE SOFTWARE

CONTENT: This section describes changes to software source code made to allow the software to run a test, where such changes are not available in a publicly released version of the software. In special situations a change to source code is necessary to activate a feature or permit inputs needed for a test, but these features are not available in the publicly released version of the software.

INSTRUCTIONS: If applicable, provide separate notes below to describe each source code modification. Use the standard format shown below and supply a separate number and title for each note. If not applicable, specify "NONE" in place of the information below.

NOTE 1 - Modification of Scheduling Capabilities (Sections 5.3.3, 5.3.4)

1.1 List the Change(s) to the source code:

Include capability for hourly varying schedules, where such schedules may be varied for any day of the year, for sensible and latent internal gains, infiltration, outside air and zone thermostat. Currently for the subject software's publicly released version such hourly schedules may only be varied monthly, beginning on the first day of each month and continuing through the entire month.

1.2 List the Test Case(s) Relevant to the Change(s) in the Source Code:

More flexible schedules are needed as follows:

- Internal Gains: All cases of Sections 5.3.3 and 5.3.4 (i.e., Cases CE300 through CE545).
- Infiltration and/or Outside Air: Cases CE320, CE330, and CE340 only.
- Thermostat: Case CE350 only.

1.3 Explanation of Why the Change Is Not Included in the Publicly Released Version of the Software:

Users of the subject software appear to be satisfied with hourly schedules limited to monthly variation. Changing the source code to accommodate the test cases of Sections 5.3.3 and 5.3.4 for the purpose of testing the calculation engine is justifiable. However, without known demand from users for additional scheduling flexibility, it is difficult to justify additional costs related to enhancing the user interface and revising software documentation.

F. REPORT BLOCK FOR ANOMALOUS RESULTS

CONTENT: This section provides an opportunity to describe anomalous test results. Describing anomalous results is optional.

INSTRUCTIONS: If applicable, describe each type of anomalous result in a separate note. Use the standard format shown below and supply a separate number and title for each note item. If not applicable, specify "NONE" in place of the information below.

NOTE 1 - Zone Air Temperature Variations in Test Cases HE210, HE220, HE230 (Section 5.4)

1.1 Test Case(s) and Specific Results from the Case(s) which are Anomalous:

Large differences in minimum/maximum zone air temperatures for test cases HE210, HE220 and HE230 versus reference results.

1.2 Explanation of Reason for the Anomalous Results:

The default settings in the subject simulation program use a 50%/50% mix of explicit and implicit solution schemes for

solving for the unknown zone air temperature of the next time step.

The explicit solution of a building simulation case tends to become unstable if the conduction through the walls is relatively large compared to the thermal storage capacity of the zone. For simulated houses with little or no thermal mass, solving the energy balance to obtain the required furnace output may therefore result in oscillating solutions when the default simulation settings are used.

The implicit solution however is stable and its zone air temperatures perfectly follow the thermostat settings.

When a 50%/50% mix of explicit and implicit solutions is used, the zone air temperature is sometimes too high and sometimes too low due to the effect of the explicit solution.

If the fully implicit solution scheme is used, the total furnace loads will only differ slightly from furnace loads predicted using the default 50%/50% mix of explicit and implicit solutions. Because HE210, HE220 and HE230 focus on total furnace load rather than on calculated zone temperatures, it was felt the results using default simulation settings are valid in spite of the anomaly in zone air temperature results.

<END OF DOCUMENT>

(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.)

APPENDIX
18-MONTH SUPPLEMENT
ADDENDA TO ANSI/ASHRAE STANDARD 140-2007

This supplement includes Addendum a to ANSI/ASHRAE Standard 140-2007. The following table lists each addendum and describes the way in which the standard is affected by the change. It also lists the ASHRAE and ANSI approval dates for each addendum.

| Addendum | Section(s) Affected | Description of Changes * | ASHRAE Standards Committee Approval | ASHRAE BOD Approval | ANSI Approval |
|----------|----------------------------------|--|--|------------------------|------------------|
| a | 4.3.1 4.4.4 A2 in Annex A. | This addendum updates Annex A2 and references to this Annex for changes made to the modeling notes S140outNotes.TXT file. S140outNotes.TXT is being updated to match the content and format of the modeling notes TXT file used for posting Standard 140 results on the DOE Tools Directory web site. This revised TXT file adds sections for software information and anomalous results. In addition, an examples file, S140outNotes_Examples.TXT, is provided to illustrate how modeling notes information should be provided. | 6/21/08 | 6/25/08 | 6/26/08 |

* These descriptions may not be complete and are provided for information only.

NOTE

When addenda, interpretations, or errata to this standard have been approved, they can be downloaded free of charge from the ASHRAE Web site at <http://www.ashrae.org>.

**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.

