

MODELING NOTES FOR ASHRAE STANDARD 140

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INTRODUCTION
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This document shall include supplemental information about the ASHRAE Standard 140 tests performed. One S140outNotes document shall be provided for each set of tests (e.g., one for the building thermal and fabric load tests of Section 7.2; one for the space cooling equipment analytical verification tests of Sections 9.2; etc.) The types of information listed below shall be provided in this document, each in a separate section:

- a. Software information
- b. Alternative modeling methods
- c. Equivalent modeling methods
- d. Nonspecified inputs
- e. Omitted test cases and results
- f. 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
- g. Anomalous results.

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

INFORMATIVE NOTE: 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).

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A. SOFTWARE INFORMATION
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CONTENT: This section shall include reference information for the software - the vendor, name, and version of the software, plus operating system and computer hardware requirements.

INSTRUCTIONS: Information for items 1 through 7 below shall be provided. Information for Item 8 shall be permitted but is not required.

- 1. SOFTWARE VENDOR: Thermal Energy System Specialists, LLC and Transsolar Energietechnik GmbH
- 2. SOFTWARE NAME: TRNSYS
- 3. SOFTWARE VERSION (unique software version identifier): 18.06.0002
- 4. OPERATING SYSTEM REQUIREMENTS: Windows 10, Windows 11
- 5. APPROX HARD DISK SPACE REQUIRED FOR INSTALLATION: Maximum = 415 MB; Minimum (to run input files) = 51 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

INFORMATIVE NOTE: Item 8 can be used to supply additional relevant information.

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B. REPORT BLOCK FOR ALTERNATIVE MODELING METHODS

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CONTENT: If the software being tested provides alternative modeling methods or algorithms for performing the tests, this section shall describe modeling methods used for the tests.

INSTRUCTIONS: If alternative modeling methods are applicable, a separate note for each alternative modeling method or algorithm situation shall be provided. The standard format shown below and a separate number and title for each note shall be applied. If alternative modeling methods are not applicable, specify "NONE" in place of the information below.

NOTE 1 - Building Geometry

1.1 Describe the Effect Being Simulated:

1.2 Optional Settings or Modeling Capabilities:

- Manual
- Mixed
- 3D Data

1.2.1 Manual:

Physical Meaning: The manual geometry mode allows the user to manually enter the wall surface area. Thus, the user has to provide the necessary orientation information for the software's radiation processor.

1.2.2 Mixed:

Physical Meaning: The mixed geometry mode allows 3D data and manually entered wall surface area data.

1.2.3 3D Data

Physical Meaning: The 3D Data geometry mode requires the use of the plugin to create the building envelope. The advantage of using the 3D Data Geometry mode is that it allows the use of the automatic radiation processing for the different surface orientations of the building. It also allows for the ability to use the detailed beam, diffuse, and longwave radiation mode. Furthermore, the detailed radiation modes allow other capabilities including the implementation of emissivity in the longwave radiation mode.

1.3 Setting or Capability Used:

- 3D Data

NOTE 2 - Material specifications of opaque construction materials

2.1 Describe the Effect Being Simulated:

Material specifications of opaque construction materials

2.2 Optional Settings or Modeling Capabilities:

- "Massive layer"

"Massless layer"

2.2.1 Massive layer:

Physical Meaning: takes into account the thermal capacity of the material

2.2.2 Massless layer:

Physical Meaning: uses a resistive only conduction calculation for this layer.

2.3 Setting or Capability Used:

"Massive layer" for all materials except insulation of the floor and the high conductance wall / opaque window

"Massless layer" for insulation of the floor and the high conductance wall / opaque window

NOTE 3 - Window properties for double pane clear glass window

3.1 Describe the Effect Being Simulated:

Window properties for double pane clear glass window

3.2 Optional Settings or Modeling Capabilities:

Trnsys requires window properties for front and back window surface. The optical data depend on the incident angle

3.2.1

Physical Meaning: Description of the window properties for double pane clear glass window for determining solar and conductive heat gain.

3.3 Setting or Capability Used:

Gap	Thick	Cond	dCond	Vis	dVis	Dens	dDens	Pr	dPr		
1 Air	13.0	0.02407	7.760	1.722	4.940	1.292	-0.0046	0.720	-0002		
2	0	0	0	0	0	0	0	0	0		
3	0	0	0	0	0	0	0	0	0		
4	0	0	0	0	0	0	0	0	0		
5	0	0	0	0	0	0	0	0	0		
Angle	0	10	20	30	40	50	60	70	80	90	Hemis
Tsol	0.747	0.747	0.745	0.740	0.730	0.707	0.652	0.517	0.263	0.000	0.652
Abs1	0.064	0.065	0.066	0.068	0.071	0.075	0.080	0.086	0.094	0.000	0.080
Abs2	0.052	0.053	0.053	0.055	0.057	0.058	0.059	0.054	0.041	0.000	0.059
Abs3	0	0	0	0	0	0	0	0	0	0	0
Abs4	0	0	0	0	0	0	0	0	0	0	0
Abs5	0	0	0	0	0	0	0	0	0	0	0
Abs6	0	0	0	0	0	0	0	0	0	0	0
Rfsol	0.136	0.136	0.136	0.137	0.143	0.160	0.210	0.343	0.602	1.000	0.210
Rbsol	0.136	0.136	0.136	0.137	0.143	0.160	0.210	0.343	0.602	1.000	0.210
Tvis	0.747	0.747	0.745	0.740	0.730	0.707	0.652	0.517	0.263	0.000	0.652
Rfvis	0.136	0.136	0.136	0.137	0.143	0.160	0.210	0.343	0.602	1.000	0.210
Rbvis	0.136	0.136	0.136	0.137	0.143	0.160	0.210	0.343	0.602	1.000	0.210
SHGC	not used										
SC:	not used										

Layer ID#	9991	9991	0	0	0	0
Tir	0.000	0.000	0	0	0	0
Emis F	0.840	0.840	0	0	0	0
Emis B	0.840	0.840	0	0	0	0
Thickness (mm)	3.2	3.2	0	0	0	0
Cond (W/m2-K) 333.9	333.9	0	0	0	0

NOTE 4 - Surface Convective Heat Transfer Coefficients

4.1 Describe the Effect Being Simulated:
Convective Heat Transfer Coefficients

4.2 Optional Settings or Modeling Capabilities:
Userdefined
Internal Calculation

4.2.1 Userdefined

Physical Meaning: As a default, the software package has userdefined constant convective heat transfer coefficients for interior surfaces, 11 kJ / h m² K, and for exterior surfaces, 64 kJ / h m² K. The software also allows the user to make this value an input into the Type56 Multzone building component, so a transient value may be used from another component or an equation with a wind velocity correlation. For values less than 0.001 kJ / h m² K, the documentation exclaims the following from the software documentation, "05-MultizoneBuilding.pdf": "For wall types with a known boundary temperature, the convective heat transfer coefficient can be set to a very small value (less than 0.001 kJ/h m² K) to force the surface temperature of the wall to be equal to the boundary temperature. The use of a very small value can be confusing but was kept for backwards compatibility reasons."

4.2.2 Internal Calculation

Physical Meaning: It is possible to choose internal calculation for any surface within a zone if desired for the interior surface. The user has to select whether the wall is a floor a ceiling or vertical to fit the appropriate heat transfer mechanism.

4.3 Setting or Capability Used:

Internal calculation for interior surfaces
Userdefined for exterior surfaces: The convective surface coefficient is calculated by a second order polynomial in wind speed as described in INFORMATIVE ANNEX B4.
Usedefined for backside surface of the floor: constant value of 0.002 kJ / h m² K

NOTE 5 - Longwave radiation exchange inside

5.1 Describe the Effect Being Simulated:
Longwave radiation exchange inside

5.2 Optional Settings or Modeling Capabilities:

Simple
Standard
Detailed

5.2.1 Simple

Physical Meaning: In the combined mode, no longwave radiation model is applied. It is assumed that the defined value of the "convective" heat includes the longwave radiation heat transfer such that it represents a combined heat transfer factor or no longwave radiation heat transfer occurs.

5.2.2 Standard

Physical Meaning: In the standard mode the longwave radiation exchange is modelled by a star node model which assumes an inside emissivity of 0.9 for opaque surfaces.

5.2.3 Detailed

Physical Meaning: In the detailed mode for each surface Gebhart factors are applied for the longwave radiation exchange which take into account the geometry of the surfaces as well as emissivity.

5.3 Setting or Capability Used:

Standard for all cases with an inside surface emissivity of 0.9.
Detailed for cases 195, 200, 210

NOTE 6 - Longwave radiation exchange outside

6.1 Describe the Effect Being Simulated:

Longwave radiation exchange outside

6.2 Optional Settings or Modeling Capabilities:

Internally Calculated

6.2.1 Internally Calculated

Physical Meaning: The internal model is based on the Stefan-Boltzmann law and considers a weighting factor f_{sky} between the sky temperature and the ground surface temperature as well as the surface infrared emittance. The sky temperature is calculated based on the Martin-Berdahl (1984). The ground surface temperature is set equal to the ambient air temperature.

6.3 Setting or Capability Used:

Internally Calculated

NOTE 7 - Ground Coupling

7.1 Describe the Effect Being Simulated:

Ground Coupling

7.2 Optional Settings or Modeling Capabilities:

Userdefined Constant Temperature
Input Temperature

7.2.1 Userdefined Constant Temperature

The user can define a constant value for the back side temperature for the back side of the floor temperature (ground temperature).

7.2.2 Input Temperature

Physical Meaning: An input temperature may also be implemented for the back side temperature of the floor (ground temperature). As an input to the TRNSYS Building component, another component's ground temperature output can provide the input to this ground temperature. There is a simple ground temperature component in the TRNSYS standard library, but that still will not provide enough accuracy with for the building to earth heat transfer. There is also a slab on grade component in TRNSYS that will calculate the ground temperature based on the work that was completed for the IEA Annex 34/43 as well as additional ground coupling components in the add-on TESS Component Libraries.

7.3 Setting or Capability Used:

Input temperature: Since the floor is decoupled thermally from the ground a constant temperature equal to the given deep ground temperature of 10 °C is used.

NOTE 8 - Solar radiation model - Tilted surface mode

8.1 Describe the Effect Being Simulated:

Solar radiation model - Tilted surface mode

8.2 Optional Settings or Modeling Capabilities:

Isotropic Sky Model
Hay and Davies Model
Reindl Model
Perez 1988 Model
Perez 1999 Model

8.2.1 Isotropic Sky Model

Physical Meaning: The isotropic sky model assumes that the diffuse radiation is uniformly distributed over the complete sky dome.

8.2.2 Hay and Davies Model

Physical Meaning: The Hay and Davies model accounts for both circumsolar and isotropic diffuse radiation. Under clear sky conditions, there is an increased intensity of diffuse radiation in the area around the sun (circumsolar diffuse). Hay and Davies weight the amount of circumsolar diffuse by using an anisotropy index.

8.2.3 Reindl Model

Physical Meaning: This model adds a horizon brightening diffuse term to the Hay and Davies model. The horizon brightening is lumped with the isotropic diffuse term and its magnitude is controlled by a modulating factor, f .

8.2.4 Perez 1988 Model

Physical Meaning: This model accounts for circumsolar, horizon brightening, and isotropic diffuse radiation by empirically derived "reduced brightness coefficients". The reduced brightness coefficients are functions of sky clearness and sky brightness parameters.

8.2.4 Perez 1999 Model

Physical Meaning: The Perez 1999 model is identical in formulation to the Perez 1988 model. It differs only in the curve fit coefficients.

8.3 Setting or Capability Used:

Perez 1999 Model

NOTE 9 - Solar radiation shading

9.1 Describe the Effect Being Simulated:

Solar radiation shading

9.2 Optional Settings or Modeling Capabilities:

User defined external shading factor
Type 34 - Overhang and wing wall shading
Shading matrix - medium resolution
Shading matrix - high resolution

9.2.1 User defined external shading factor

Physical Meaning: The user can define an external shading factor which is applied for direct and diffuse radiation as a constant value, a schedule or an input.

9.2.2 Type 34 - Overhang and wing wall shading

Physical Meaning: Since Type34 requires assumes an isotropic sky model and the chosen sky model is anisotropic it can't be applied

9.2.2 Shading matrix - medium resolution

Physical Meaning: The hemisphere of the sky is divided into 577 patches according to a Tregenzia division. For the center point of each patch the sunlit fraction of each window is determined. In addition the integrated value for the hemisphere is determined. For each time step in the simulation direct radiation shading as well as anisotropic diffuse shading is calculated.

9.2.1 Shading matrix - high resolution

Physical Meaning: Instead of 577 patches the hemisphere of the sky is divided into 2305 patches according to a Tregenzia division.

9.3 Setting or Capability Used:

Shading matrix - high resolution

NOTE 10 - Solar distribution - direct radiation

10.1 Describe the Effect Being Simulated:
Solar distribution - direct radiation

10.2 Optional Settings or Modeling Capabilities:
Standard
Detailed

10.2.1 Standard

Physical Meaning: The direct solar radiation is distributed according to distribution coefficients (GEOSURF) which are defined by the user as constant value, schedule and input values in the building description.

10.2.2 Detailed

Physical Meaning: Direct radiation entering a zone through an external window is distributed to inside surfaces according to an insolation distribution matrix. The insolation matrix takes into account the external shading effects provided by a shading matrix. For each time step the current sunlit fraction of inside surfaces are determined by a bilinear interpolation of the four nearest center points of insolation matrix with respect to the sun's actual position.

10.3 Setting or Capability Used:
Detailed

NOTE 11 - Solar distribution - diffuse radiation

11.1 Describe the Effect Being Simulated:
Solar distribution - diffuse radiation

11.2 Optional Settings or Modeling Capabilities:
Standard
Detailed

11.2.1 Standard

Physical Meaning: The diffuse solar radiation within a zone is distributed to the surfaces of a zone according to transmission-absorption weighted area factors. The primary distribution is improved such that diffuse radiation entering a zone through an external window is distributed to all other surfaces except the window itself.

11.2.2 Detailed

Physical Meaning: Diffuse radiation entering a zone is distributed by Gebhart factors which take into account the geometry of the surfaces as well as reflection, transmission and absorptance.

11.3 Setting or Capability Used:
Detailed

NOTE 12 - Ground Reflectance

12.1 Describe the Effect Being Simulated:

Ground Reflectance

12.2 Optional Settings or Modeling Capabilities:

userdefined constant value (0..1)

12.2.1 userdefined constant value

Physical Meaning: Proportion of the incident solar radiation that is reflected by the ground.

12.3 Setting or Capability Used:

Ground Reflectance = 0.2

NOTE 13 - Simulation time step

13.1 Describe the Effect Being Simulated:

Simulation time step

13.2 Optional Settings or Modeling Capabilities:

userdefined constant value

13.2.1 userdefined constant value

Physical Meaning: Simulation time step

13.3 Setting or Capability Used:

The simulation time step is 15 minutes: Time step = 0.25

NOTE 14 - Simulation convergence tolerances

14.1 Describe the Effect Being Simulated:

Convergence tolerances

14.2 Optional Settings or Modeling Capabilities:

Absolute Tolerances

Relative Tolerances

14.2.1 Absolute tolerances

Physical Meaning: Specifying an absolute tolerance indicates that TRNSYS should not converge until all connected outputs are changing by a value of TolA and all integration outputs are changing by a value of TolD

14.2.1 Relative tolerances

Physical Meaning: Specifying a relative tolerance indicates that TRNSYS should not move on to the next time step until all connected outputs are changing by less than (100 TolA) percent of their absolute value and all integrated outputs are changing by (100 TolD) percent of their absolute value.

14.3 Setting or Capability Used:

Relative Tolerances: 0.001 0.001

NOTE 15 - Integration

15.1 Describe the Effect Being Simulated:
Integration

15.2 Optional Settings or Modeling Capabilities:
Type24 Integrator Component
Type46 "Printegrator" Component

15.2.1 Type24 Integrator Component

Physical Meaning: Since TRNSYS simulates dynamically with inputs and outputs (i.e. mass flow rates, energy rates, etc.), and integrator component is required to quantify the rate over a specified time value. The TRNSYS Type24 Integrator Component integrates any specified output over any period of simulation time (i.e. a timestep, 1 hour, 1 month, or 1 year). The integrated values such as the load are necessary for the other values the simulation (such as part load ratio); therefore, the Type24 integrator component was used in the simulations.

15.2.2 Type 46 "Printegrator" Component

Physical Meaning: The TRNSYS Type46 "Printegrator" Component not only integrates any components' output over a user defined timeperiod, but it also "prints" the integrated value to a text output file.

15.3 Setting or Capability Used:
Type 24 Integrator Component

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C. REPORT BLOCK FOR EQUIVALENT MODELING METHODS
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CONTENT: This section shall describe equivalent modeling methods used to perform the tests. When the software does not model an effect exactly as stated in the standard or does not permit the input values required, equivalent modeling methods shall be permitted to perform the test.

INSTRUCTIONS: If equivalent modeling methods are applied, a separate note for each instance of equivalent modeling shall be provided. The standard format shown below and a separate number and title for each note shall be applied. If equivalent modeling methods are not applicable, specify "NONE" in place of the information below.

NONE

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D. REPORT BLOCK FOR USE OF NON-SPECIFIED INPUTS
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CONTENT: This section shall describe nonspecified inputs used to perform the tests. Use of nonspecified inputs shall be permitted only for the following specified sections relating to the following topics:

- * Alternative constant exterior surface coefficients in Sections 5.2.1.9.3, 5.2.3.1.4.3, 5.2.3.3.2, and 5.3.1.8
- * Alternative constant interior surface coefficients in Sections 5.2.1.10.3, 5.2.3.1.4.4, 5.2.3.2.2, and 5.3.1.9
- * Alternative constant interior solar distribution fractions in Sections 5.2.1.12, 5.2.2.1.2.2, 5.2.2.1.6.2, 5.2.2.1.7.2, 5.2.2.2.7.4, 5.2.3.9.3, 5.2.3.10.2, and 5.2.3.12.2
- * Air density given at specific altitudes for the space-cooling and space- heating equipment cases in Sections 5.3.1.4.3, 5.3.3.4.3, and 5.4.1.4.3.

INSTRUCTIONS: If nonspecified inputs are applied, a separate note for each use of nonspecified inputs shall be provided. The standard format shown below and a separate number and title for each note shall be applied. If nonspecified inputs are not applied, specify "NONE" in place of the information below.

NONE

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E. REPORT BLOCK FOR OMITTED TEST CASES AND RESULTS
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CONTENT: This section shall describe test cases that were omitted and/or individual results of test cases that were omitted along with the reason for the omission.

INSTRUCTIONS: If test cases were omitted, a separate note to describe each type of omission shall be provided. The standard format shown below and a separate number and title for each note shall be applied. If there are no omitted test cases, specify "NONE" in place of the information below.

NONE

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F. 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
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CONTENT: This section shall describe 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.

INFORMATIVE NOTE: This section addresses special situations where a change to source code is necessary to activate a feature or to permit inputs needed for a test when these features are not available in the publicly released version of the software.

INSTRUCTIONS: If changes to the source code for the purpose of running a test are applied, separate notes to describe each source code

modification shall be provided. The standard format shown below and a separate number and title for each note shall be applied. If changes to source code are not applied, specify "NONE" in place of the information below.

NONE

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G. REPORT BLOCK FOR ANOMALOUS RESULTS
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CONTENT: Describing anomalous results shall be permitted but is not required. If anomalous test results are described, this section shall be used.

INSTRUCTIONS: If anomalous test results are described, each type of anomalous result shall be described in a separate note. The standard format shown below and a separate number and title for each note item shall be applied. If anomalous results are not discussed, it shall be permitted to specify "NONE" in place of the information below.

NONE