BSR/ASHRAE Addendum c to
ANSI/ASHRAE Standard 140-2023

Second Public Review Draft

Proposed Addendum c to Standard 140-2023, Method of Test for Evaluating Building Performance Simulation Software

Second Public Review Draft (August 2026)
(Draft shows Proposed Changes to First Public Review Draft)

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Foreword to Addendum *c* ISC

This ISC updates the acceptance criteria ranges calculated with DOE-2.3 results received during the initial public review period replacing DOE-2.2 results.

[*Note to Reviewers:* This addendum makes proposed changes to the current standard. These changes are indicated in the text by underlining (for additions) and strikethrough (for deletions) except where the reviewer instructions specifically describe some other means of showing the changes. Only these changes to the current standard are open for review and comment at this time. Additional material is provided for context only and is not open for comment except as it relates to the proposed changes.]

[Note.to.Reviewers¿Revisions.proposed.for.this.addendum.begin.with.Normative.Annex.A9¡]

NORMATIVE ANNEX A3
SOFTWARE ACCEPTANCE CRITERIA

Table A3-1 Low Mass Building—Single-Value Ranges

	Annual Heating Load (MWh/yr)*		Annual Sensible Cooling Load (MWh/yr)*	
Range Case	**Lower Limit**	**Upper Limit**	**Lower Limit**	**Upper Limit**
Case 600	~~3.96~~ 4.1	~~4.85~~ 4.77	~~5.35~~ 5.32	~~6.52~~ 6.51
Case 610 – Case 600	~~-0.14~~ -0.15	0.30	~~-2.11~~ -2.17	~~-1.01~~ -0.89
Case 620 – Case 600	~~-0.05~~ -0.09	~~0.40~~ 0.46	~~-2.23~~ -2.21	~~-1.63~~ -1.62
Case 630 – Case 620	~~-0.05~~ 0.01	~~0.81~~ 0.74	~~-1.93~~ -1.88	~~-0.56~~ -0.64
Case 640 – Case 600	~~-2.04~~ -1.98	~~-1.4~~ -1.46	–0.56	0.03
Case 650 – Case 600	n/a	n/a	-1.51	~~-0.91~~ -0.92
Case 660 – Case 600	~~-1.08~~ -1.18	~~-0.25~~ -0.05	~~-3.11~~ -3.27	~~-2.38~~ -2.09
Case 670 – Case 600	0.77	2.48	0.13	0.84
Case 680 – Case 600	-2.44	-2.0	~~0.09~~ -0.12	~~0.82~~ 0.94
Case 685 – Case 600	0.33	0.77	~~2.72~~ 2.58	~~3.32~~ 3.55
Case 695 – Case 685	~~-2.38~~ -2.39	–1.94	~~-0.29~~ -0.55	~~0.46~~ 0.65

* For output specified in Section 7.3.1.1 and 7.3.1.2 for heating and cooling loads, respectively.

Table A3-4 High Mass Building—Single-Value Ranges

	Annual Heating Load (MWh/yr)*		Annual Sensible Cooling Load (MWh/yr)*	
Range Case	**Lower Limit**	**Upper Limit**	**Lower Limit**	**Upper Limit**
Case 900	~~1.2~~ 1.16	~~2.17~~ 2.27	~~2.23~~ 2.2	~~2.60~~ 2.67
Case 900 – Case 910	~~-0.42~~ -0.4	~~-0.14~~ -0.17	~~0.61~~ 0.76	~~1.49~~ 1.33
Case 920 – Case 900	~~1.45~~ 1.51	~~1.93~~ 1.92	~~0.04~~ 0.08	~~0.50~~ 0.48

Case 930 – Case 920	~~0.22~~ 0.44	~~1.17~~ 1.0	~~-1.22~~ -1.40	~~-0.46~~ -0.34
Case 940 – Case 900	~~-0.87~~ -0.81	~~-0.29~~ -0.33	~~-0.18~~ -0.19	0.06
Case 950 – Case 900	n/a	n/a	~~-2.05~~ -2.06	~~-1.45~~ -1.47
Case 960 – Case 900	~~0.78~~ 0.60	~~1.3~~ 1.48	~~-1.79~~ -1.76	~~-1.29~~ -1.31
Case 980 – Case 900	~~-1.55~~ -1.64	~~-1.05~~ -1.01	~~0.67~~ 0.62	~~1.82~~ 1.86
Case 985 – Case 900	0.62	0.79	~~3.56~~ 3.46	~~4.06~~ 4.23
Case 995 – Case 985	~~-1.61~~ -1.76	~~-1.22~~ -1.14	~~0.48~~ 0.39	~~1.26~~ 1.31

* For output specified in Section 7.3.1.1 and 7.3.1.2 for heating and cooling loads, respectively.

Table A3-7 Cooling Equipment Single-Value Ranges

	Annual Total Cooling Energy Consumption (kWh/yr)*	
Range Case	**Lower Limit**	**Upper Limit**
CE300	33452	36973
CE310 – CE300	2706	6227
CE320 – CE300	2652	6173
CE330 – CE320	-733	2789
CE330 – CE300	3711	7232
CE340 – CE300	3277	6798
CE330 – CE340	~~-1429~~ -1390	~~2092~~ 2131
CE350 – CE300	-5293	-1771
CE360 – CE300	18094	21616
CE400 – CE300	-5711	-2190
CE410 – CE300	–5929	–371
CE420 – CE300	-3855	-334
CE430 – CE300	-4728	-1206
CE440 – CE300	-3611	-90

* For output specified in Section 9.3.2.1.1.1(a)

Table A3-8 Heating Equipment Single-Value Ranges

	Furnace Input Energy (GJ)*		Cumulative Fan Energy (kWh)*	
Range Case	**Lower Limit**	**Upper Limit**	**Lower Limit**	**Upper Limit**
HE210	~~49.84~~ 50.0	~~55.08~~ 55.26	278.67	308.0
HE220 – HE210	~~-5.48~~ -5.49	~~-0.24~~ -0.23	-30.14	-0.80
HE230 – HE220	~~-9.07~~ -9.12	~~-3.83~~ -3.86	~~186.99~~ 187.67	~~216.32~~ 217.01

* For output specified in Section 10.3.1.2 and 10.3.2.1 for furnace input energy and cumulative fan energy, respectively.

Table A3-9 Air-Side Equipment Single-Value Ranges

Range Case	Preheat-Coil Load (kWh/h)*		Heating-Coil Load (kWh/h)*		Cooling-Coil Total Load (kWh/h)*		Cooling-Coil Sensible Load (kWh/h)*		Zone 1 Reheat-Coil Load (kWh/h)*		Zone 2 Reheat-Coil Load (kWh/h)*	
	Lower Limit	Upper Limit	Lower Limit	Upper Limit	Lower Limit	Upper Limit	Lower Limit	Upper Limit	Lower Limit	Upper Limit	Lower Limit	Upper Limit
AE201	n/a	n/a	7.94	8.78	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
AE205	n/a	n/a	n/a	n/a	1.82	2.01	1.82	2.01	n/a	n/a	n/a	n/a
AE245 – AE205	n/a	n/a	n/a	n/a	0.20	0.39	0.20	0.39	n/a	n/a	n/a	n/a
AE206	n/a	n/a	n/a	n/a	2.54	2.81	1.62	1.79	n/a	n/a	n/a	n/a
AE226 – AE206	n/a	n/a	n/a	n/a	0.55	0.82	–0.23	–0.06	n/a	n/a	n/a	n/a
AE301	~~2.64~~ 1.86	~~4.52~~ 4.69	n/a	n/a	n/a	n/a	n/a	n/a	7.33	8.10	~~7.97~~ 7.77	8.81
AE301 – AE401	~~-8.21~~ -8.24	-5.85	n/a	n/a	n/a	n/a	n/a	n/a	~~2.68~~ 2.66	3.60	~~2.69~~ 2.77	~~4.03~~ 3.98
AE305	n/a	n/a	n/a	n/a	~~8.45~~ 8.88	~~9.94~~ 9.85	~~8.45~~ 8.88	~~9.94~~ 9.85	~~1.91~~ 2.07	~~2.47~~ 2.38	~~1.99~~ 2.21	~~2.75~~ 2.62
AE305 – AE405	n/a	n/a	n/a	n/a	~~4.35~~ 4.74	~~5.84~~ 5.75	~~4.35~~ 4.74	~~5.84~~ 5.75	n/a	n/a	n/a	n/a
AE345 – AE305	n/a	n/a	n/a	n/a	–0.15	0.79	–0.15	0.79	–0.11	0.11	–0.12	0.12
AE345 – AE445	n/a	n/a	n/a	n/a	~~4.59~~ 5.03	~~6.15~~ 6.01	~~4.59~~ 5.03	~~6.15~~ 6.01	n/a	n/a	n/a	n/a
AE306	n/a	n/a	n/a	n/a	13.65	15.08	~~8.16~~ 8.31	9.37	~~1.99~~ 2.1	~~2.43~~ 2.38	~~2.11~~ 2.27	~~2.69~~ 2.59
AE306 – AE406	n/a	n/a	n/a	n/a	5.42	6.86	~~4.62~~ 4.82	5.73	n/a	n/a	n/a	n/a
AE326 – AE306	n/a	n/a	n/a	n/a	5.68	7.12	–0.91	–0.01	–0.11	0.11	–0.12	0.12
AE326 – AE426	n/a	n/a	n/a	n/a	11.21	12.65	~~4.17~~ 4.11	~~5.31~~ 5.39	n/a	n/a	n/a	n/a
AE401	9.75	10.77	n/a	n/a	n/a	n/a	n/a	n/a	4.27	4.72	4.63	5.12
AE405	n/a	n/a	n/a	n/a	3.90	4.31	3.90	4.31	0.00	0.00	0.00	0.00
AE445 – AE405	n/a	n/a	n/a	n/a	–0.15	0.26	–0.15	0.26	n/a	n/a	n/a	n/a
AE406	n/a	n/a	n/a	n/a	7.78	8.85	3.45	3.82	0.00	0.00	0.00	0.00
AE426 – AE406	n/a	n/a	n/a	n/a	0.20	1.02	–0.22	0.14	n/a	n/a	n/a	n/a

For output specified in Sections as follows. Preheat coil, 11.3.3.2(a),11.3.4.2; heating coil, 11.3.1.2(a), 11.3.2.2; cooling coil total, 11.3.1.2(d), 11.3.2.2, 11.3.3.2(d), 11.3.4.2; cooling coil sensible load 11.3.1.2(b), 11.3.2.2, 11.3.3.2(b), 11.3.4.2; zone 1 reheat coil, 11.3.3.2(f), 11.3.4.2; zone 2 reheat coil, 11.3.3.2(g), 11.3.4.2.

INFORMATIVE ANNEX B12
DEVELOPMENT OF ACCEPTANCE CRITERIA

B12.1 Acceptance Criteria Bounds Calculations. The results from a reference set of software programs (see Section B12.1.2), also called "reference results" here, are used to calculate the upper and lower limits for the acceptance criteria.

B12.1.1 Equations for Setting Bound Limits. There are two different types of results included in the acceptance criteria: single-value results (e.g., annual totals) and time series results (e.g., hourly zone loads for a specific day). There are different calculation methodologies for each of these types of results.

B12.1.1.1 Equations for Single-Value Results. The upper and lower limits for each range case applied for acceptance criteria are set by selecting the lower minimum value and higher maximum value of the following: a. Statistical Bounds (SB):

$$\text{Minimum: MinSB} = \text{Median}_{case} - \text{MAD}_{3sigma} \quad \text{Minimum: MaxSB} = \text{Median}_{case} + \text{MAD}_{3sigma}$$

where

Median_{case} ≡ median value of reference results for a given case

MAD_{3sigma} ≡ median absolute deviation (MAD) with 99.73% (3 sigma) confidence interval for the reference results of a given case

and

$$\text{MAD}(X) = \text{Median}[|X - \text{Median}(X)|]$$

for a normal distribution, we can relate MAD to the standard deviation as

$$MAD = \sigma\Phi^{-1}\left(\frac{3}{4}\right) = \sigma\sqrt{2}erf^{-1}\left(\frac{1}{2}\right) \approx 0.6745\sigma$$

where

σ ≡ standard deviation

Φ ≡ quantile function

erf ≡ error function

The bounds of the confidence interval can be set in terms of ± standard deviation from the average or ± MAD from the median. In this case, a 99.73% confidence interval results from three standard deviations (or 3 sigma), which leads to a MAD multiplier (MAD_{3sigma}) of 4.64.

b. Nonstatistical Bounds (NSB):

1. Where no quasi-analytical solution results exist for an acceptance criteria test group:

$$\text{Minimum: MinNSB} = \text{Median}_{case} - \text{Median}_{BC} \times 0.05 \quad \text{Maximum: MaxNSB} = \text{Median}_{case} + \text{Median}_{BC} \times 0.05$$

where

Median_{BC} ≡ median value of reference results of base case (BC) for a given case

2. Where quasi-analytical solution results (QAS) exist for an acceptance criteria test group:

$$\text{Minimum: MinNSB} = \text{QAS}_{case} - \text{QAS}_{BC} \times 0.05 \quad \text{Maximum: MaxNSB} = \text{QAS}_{case} + \text{QAS}_{BC} \times 0.05$$

where

QAS_{case} ≡ QAS value for a given case

QAS_{BC} ≡ QAS value of the base case (BC) for a given case

B12.1.2 Reference Software for Setting Bound Limits. The reference set of software for setting the bound limits is selected based on the following criteria:

- A single set of results per calculation engine is included (multiple user interfaces for the same calculation engine are not included).
- Results are submitted by the calculation engine copyright holder(s) or by a modeler designated by the calculation engine copyright holder(s), applying a user interface specified by the calculation engine copyright holder(s) if appropriate.
- The set of selected software should represent a diversity of modeling methods, such as control-based and load-based.
- The calculation engine should be actively, reasonably, and widely used and actively maintained.
- Software satisfies the following:
  - Able to run at a time step of an hour or less
  - Able to include hourly variations in occupancy, lighting power, miscellaneous equipment power, thermostat set points, and HVAC system operation
  - Include thermal mass effects
- If a software did not participate in the simulation trials for the initial development of a test suite, then prior to the submittal, its results are reviewed and undergo iterative rounds of review and revisions as determined during the submission review process. The reviewer comments and submitter responses are documented from each round, with a logical basis for corrections to programs or inputs included in the documentation. This review process only applies to the initial submittal of a software and not subsequent submittals of that software for version updates.

The results from a reference software

- include justification via Normative Annex A2, Attachment A2.8, Item G (“Report Block for Anomalous Results”) if they fall outside of the established bounds and
- pass the minimum number of tests indicated for each test group in Table A3.2-1 for which a given reference software provided results.

The results from a reference software may be updated for each new public release of the calculation engine. For future continuous maintenance revisions of Standard 140, SSPC 140 may

- include any additional software in the acceptance criteria-bounds reference set that apply and meet the criteria for inclusion;
- remove any software from the reference set that no longer meet the criteria for inclusion; and
- update the acceptance criteria with the most recent results from the reference set of software.

The current reference set of software used to determine the acceptance criteria are (in alphabetical order): CSE, DeST, ~~DOE-2.2~~ DOE-2.3, EnergyPlus, ESP-r, IDA ICE, IES-VE, Modelica Buildings Library, TAS, and TRNSYS. Not all software are applied for all test groups.