



BSR/ASHRAE Standard 229P

Public Review Draft **Protocols for Evaluating Ruleset** **Application in Building** **Performance Models**

Second Public Review (October 2025)
(Complete Draft for Full Review)

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1 Contents

Foreword.....	5
1 Purpose	6
2 Scope.....	6
3 Definitions, Abbreviations and Acronyms	6
3.1 General.....	6
3.2 Definitions.....	6
3.3 Abbreviations and Acronyms.....	7
4 Utilization.....	9
4.1 General.....	9
4.2 Project Checking Path	9
4.3 Building Performance Modeling Software Checking Path	10
4.3.1 Building Performance Modeling Software Requirements	10
4.3.2 Building Performance Modeling Software Testing Requirements	10
4.3.3 Building Performance Modeling Software Test Documentation	10
4.3.4 Software Reporting Capabilities	11
5 Ruleset Evaluation Schema	11
5.1 Format.....	11
5.2 Data Groups and Data Elements.....	12
5.3 Data Group Hierarchy (informative)	12
6 Ruleset Checking Specification Requirements.....	14
6.1 General.....	14
6.1.1 Scope.....	14
6.1.2 Required Content.....	14
6.2 Ruleset Specific Ruleset Evaluation Schema Data Groups, Data Elements, and Enumerations.....	15
6.3 Rule Requirements.....	15
6.3.1 Requirements for the Rules Included in Evaluation.....	15
6.3.2 Requirements for Rules Excluded from Evaluation	17
6.4 Rule Unit Tests	17
6.4.1 Required Rule Unit Tests.....	18
6.4.2 Rule Unit Test Specifications.....	18
6.5 Ruleset Project Description Generation Software Tests.....	19
7 Ruleset Project Description Generation Software Compliance	19
7.1 Scope.....	19
7.2 Compliance	20
7.3 Required Capabilities	20
7.4 Testing Requirements	21
7.4.1 Testing Procedure	21
7.5 Reporting Requirements.....	21
7.5.1 General Requirements	21
8 Ruleset Checking Tool Compliance	23
8.1 Scope.....	23
8.2 Compliance	23
8.3 Required Capabilities	23
8.4 Ruleset Checking Tool Testing Requirements.....	23
9 Normative References	24
Normative Appendix A: Ruleset Evaluation Schema Tables	25

Normative Appendix B: Ruleset Checking Tool Software Testing Report Schema	26
B.1 Format.....	26
B.2 Data Group Hierarchy (informative)	26
B.3 Data Groups and Data Elements.....	26
B.4 Data Group and Element Tables	26
Normative Appendix C: Ruleset Checking Tool Project Evaluation Report Schema.....	27
C.1 Format.....	27
C.2 Data Group Hierarchy (informative)	27
C.3 Data Groups and Data Elements.....	27
C.4 Log of Exception Messages	27
C.5. Data Group and Element Tables	28
Informative Appendix D: Project Checking Summary Report.....	29
Normative Appendix E: Ruleset Checking Specification	30
E1 Ruleset Checking Specification for ASHRAE Standard 90.1-2019	30
E1.1 Utilization	30
E1.2 Ruleset Model Types.....	30
E1.3. Ruleset Evaluation Schema	30
E1.4. Rules.....	31
E1.4.1 Rules Included in Evaluation	31
E1.4.2 Rules Excluded from Evaluation.....	31
E1.5 Rule Unit Tests	32
E1.6 Rule Evaluation Precision	32
E1.7. Ruleset Project Generation Software Testing.....	33
E1.7.1 General.....	33
E1.7.2 Base Ruleset Project Description Generation Software Test Description	33
E1.7.3 HVAC System Configuration Description	42
Informative Appendix F: Additional Ruleset Project Description Generation Software Tests	51
F1. Additional HVAC Test Case Variations	51
F3.2. Test Case 100: Packaged Terminal Air Conditioner (App G Baseline System 1)	55
F3.3. Test Case 110: Packaged Terminal Heat Pump (PTHP) (App G Baseline System 2)	56
F3.4. Test Case 120: Packaged Single Zone (PSZ) (App G Baseline System 3)	56
F3.5. Test Case 130: Packaged VAV with Hot Water Reheat (App G Baseline System 5)	57
F3.6. Test Case 140: Packaged VAV with Parallel Fan-Powered Boxes (App G Baseline System 6) ...	57
F3.7. Test Case 150: Chilled Water VAV with PFP Boxes (App G Baseline System 8)	58
F3.8. Test Case 160: Gas-Fired Heating and Ventilation (App G Baseline System 9).....	59
F3.9. Test Case 170: Electric Resistance Heating and Ventilation (App G Baseline System 10)	60
F3.10. Test Case 180: Single-Zone VAV (App G Baseline System 11).....	60
F3.11. Test Case 190: Single-Zone CV w/ CHW & HW Coils (App G Baseline System 12).....	61
F3.12. Test Case 200: Single-Zone CV w/ CHW & Electric Resistance (App G Baseline System 13) ...	61
F3.13. Test Case 210: Fan Coil Unit with Chilled Water/Hot Water	62
F3.14. Test Case 220: Fan Coil Unit with Purchased Chilled Water/Hot Water	62
F3.15. Test Case 230: Water-Source Heat Pump	63
F3.16. Test Case 240: Water-Source Heat Pump with Dedicated Outdoor Air System.....	63
Informative Appendix G	65
Normative Appendix H: Ruleset Project Description Generation Software Test Report Schema.....	66
H.1 Format	66
H.2 Data Group Hierarchy (informative).....	66
H.3 Data Groups and Data Elements	66

H.4. Data Group and Element Tables.....	67
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Foreword

This second full public review of Standard 229P provides two options for the evaluation of building energy modeling (BEM) based performance rulesets used by building energy codes and standards: the Project Checking Path and the Building Performance Modeling Software Testing Path. For the Project Checking Path, several schemata are defined in the draft standard as well as tests related to software that would use those schemata. The Building Performance Modeling Software Testing Path was added, and many other changes were made to resolve comments from the first public review. Some portions of the standard are available electronically and linked within the draft.

1 Purpose

This standard establishes tests and acceptance criteria for application of *rulesets* and related reporting in *building performance models*.

2 Scope

This standard applies to evaluation of the implementation of *rulesets* associated with new or existing buildings, their systems, controls, sites, and other aspects described by the *ruleset*. It establishes requirements for:

2.1 building performance modeling software

2.2 software that evaluates *building performance models* and associated information to check the application of a *ruleset*.

3 Definitions, Abbreviations, and Acronyms

3.1 General

Certain terms, abbreviations, and acronyms are defined in this section for the purposes of this standard. When the tense or plurality of the term is different than the defined term, the definition still applies. These definitions are applicable to all sections of this standard, wherever italicized. Terms that are not italicized shall have their ordinarily accepted meanings within the context in which they are used. Ordinarily accepted meanings shall be based on American standard English language usage as documented in an unabridged dictionary accepted by the adopting authority.

3.2 Definitions

building performance model: a computer representation of a building and how it functions including aspects of the building that impact energy use, water use, or occupant comfort.

calculation engine: the components of the software that performs the building performance simulation calculations.

data element: a named data item with an explicit data type.

data group: multiple data elements grouped together under a single, named data structure.

Compliance parameters: user inputs that are used by the *ruleset checking tool* but are not directly used by the *simulation engine*.

JSON: JavaScript Object Notation. A lightweight text-based data-interchange format. See JSON in normative references.

rule: A requirement for inputs or performance metric calculation of a protocol that uses modeling for assessing building performance.

Rule Evaluation: The process followed by the *ruleset checking tool* to determine whether the data elements in the RPD are consistent with the rule.

- **Applicability Evaluation:** Rule evaluation that is limited to determining whether the rule is relevant.

Informative Note: *Rules* might be only checked for applicability due to reasons such as the following:

- Data elements needed for verifying the *rule* are not included in the schema (e.g., *rules* related to minimum requirements for the building performance modeling software).
 - Data elements needed for verifying the *rule* are included in the schema but are unlikely to be populated by the building performance modeling software.
 - *Rule* evaluation logic is too complex.
 - *Rule* applies to a small fraction of projects (e.g., Standard 90.1-2019 Appendix G *rules* for projects that use district heating or cooling.)
- **Full Evaluation:** Rule *evaluation* that covers all possible rule evaluation outcomes as listed in Section 6.3.1.2

rule unit test: A procedure for verifying *ruleset checking tool's* capability to correctly evaluate a *rule*.

ruleset: A collection of rules for demonstrating adherence with a protocol that uses modeling for assessing building performance. Excludes *rulesets* used only for quality assurance.

ruleset checking specification: A set of requirements, specific to a *ruleset*, for documenting compliance of a *ruleset checking tool* and a *ruleset project description generation software* with the standard.

ruleset checking tool: a software tool that evaluates whether a *ruleset project description* is consistent with a *ruleset* and reports each *rule* evaluation outcome.

ruleset evaluation schema: schema that describes elements of *building performance models* or other compliance parameters that are relevant to *rulesets*.

ruleset model type: a *ruleset*-specific classification of *building performance models* for demonstrating compliance with a *ruleset*. Informative note: For example, Normative Appendix E1 defines user model, proposed model, and baseline model *ruleset model types* for Standard 90.1-2019 Appendix G.

ruleset project description: a file consistent with the *ruleset evaluation schema* representing a specific building project for the purpose of demonstrating compliance with a *ruleset*.

ruleset project description generation software: software that is either part of the building performance modeling software or a separate software tool used to create a *ruleset project description* based on one or more *building performance models*.

3.3 Abbreviations and Acronyms.

ACM	alternative calculation method
AFUE	annual fuel utilization efficiency

AHJ	authority having jurisdiction
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
bhp	brake horsepower
Btu	British thermal unit
Btu/h	British thermal unit per hour
Btu/ft ² ·°F	British thermal unit per square foot per degree Fahrenheit
Btu/h·ft ²	British thermal unit per hour per square foot
Btu/h·ft·°F	British thermal unit per hour per linear foot per degree Fahrenheit
Btu/h·ft ² ·°F	British thermal unit per hour per square foot per degree Fahrenheit
cfm	cubic feet per minute
CHW	chilled water
CHWST	chilled-water supply temperature
COP	coefficient of performance
DCV	demand control ventilation
DOAS	dedicated outdoor air system
DX	direct expansion
E _c	combustion efficiency
EER/EER2	energy efficiency ratio
ERV	energy recovery ventilation
E _t	thermal efficiency
°F	Fahrenheit
HW	heating water
HWST	heating-water supply temperature
hp	horsepower
HSPF/HSPF2	heating seasonal performance factor
HVAC	heating, ventilating, and air conditioning
IEER	integrated energy efficiency ratio
IPLV.IP	integrated part-load value
kW	kilowatt

LPD	lighting power density
OAT	outdoor air temperature (dry-bulb unless wet-bulb is specified)
OA	outdoor air
PSZ-AC	packaged single-zone air conditioner
PSZ-HP	packaged single-zone heat pump
PTAC	packaged terminal air conditioner
PTHP	packaged terminal heat pump
RESNET	residential energy savings network
SHGC	solar heat gain coefficient
SZ	single zone
VAV	variable air volume
W	watt

4 Utilization

4.1 General

The section describes the pathways for utilizing the standard for verifying *ruleset* implementation in *building performance models*. Adopters of the standard shall identify the *ruleset checking specification* to be used. Software that facilitates application of *rulesets* that do not have a *ruleset checking specification* are excluded from requirements of this standard.

4.2 Project Checking Path

Project checking path verifies the implementation of *ruleset* requirements in *building performance models*. The project checking path requires the following:

- a. Project shall use a *ruleset project description generation software* that complies with the requirements specified in Section 7.
- *Ruleset project description* shall be checked using a *ruleset checking tool* that complies with the requirements in Section 8 and has been tested against a *ruleset checking specification*, compliant with the requirements specified in Section 6.
- b. The *ruleset project description* shall comply with the *ruleset evaluation schema*, defined in Section 5.

Informative Notes:

1. Sections 7 and 8 include references to a *ruleset checking specification*, which includes, for example, a list of *rules* that need to be evaluated by the *ruleset checking tool* and testing requirements for a *ruleset checking tool* and *ruleset project description generation software*. The required content of a *ruleset checking specification* are described in Section 6. Normative Appendix E1 provides a *ruleset checking specification* for Standard 90.1-2019, Appendix G, Performance Rating Method.

2. Project compliance with a *ruleset* may be determined based on review of reports generated by the *ruleset checking tool* and review of other aspects of the submittal which are not within the scope of the *ruleset checking tool* as defined by the *ruleset checking specification*. Informative Appendix D provides an example project checking summary report.

4.3 Building Performance Modeling Software Checking Path

Projects that use building performance modeling software complying with Section 4.3.1 shall meet the requirements of this section. Project documentation produced by the building performance modeling software as described in Section 4.3.4 and other reports required by the ruleset shall be provided to the authority having jurisdiction (AHJ).

4.3.1 Building Performance Modeling Software Requirements

Building performance modeling software shall meet the following requirements:

1. Automate the application of a *ruleset* by applying all or a subset of the *rules* defined in the *ruleset checking specification*.
2. Be tested as required in Section 4.3.2.
3. Post testing documentation on a publicly available website that meets requirements of Section 4.3.3.
4. Be capable of generating project reports as required in Section 4.3.4.

4.3.2 Building Performance Modeling Software Testing Requirements

1. Evaluate all or subset of the *rules* that are automated and that are required to have a *full evaluation* based on the published *ruleset checking specification* for the applicable *ruleset*.
2. For each evaluated *rule*, the test cases shall include all *rule unit tests* that have 'Pass' rule evaluation outcome in the published *ruleset checking specification* for the applicable *ruleset*.
3. Additional *rules* that are not included in the published *ruleset checking specification* for the applicable *ruleset* are permitted to be included in the testing.

4.3.3 Building Performance Modeling Software Test Documentation

The following documentation shall be provided for each test case:

1. The list of *rules* from the published *ruleset checking specification* covered by 4.3.2(a) and the rule tests covered in 4.3.2(b).
2. The list of additional rules from 4.3.2(c) being evaluated which are not included in the *ruleset checking specification*.
3. Description of differences in the *ruleset model types* using one of the following methods:
 - a. Software inputs that change between *ruleset model types* and the values for each input for each *ruleset model type*, or

- b. Project evaluation report as described in Section 8.3 #3 generated by a *ruleset checking tool* compliant with Section 8 for the *ruleset project description* created by a *ruleset project description generation software* compliant with Section 7.
4. Input and output files.

4.3.4 Software Reporting Capabilities

The building performance modeling software shall be capable of generating project reports that include the following:

1. Identification of the ruleset and the ruleset checking specification.
2. List of *rules* from the published *ruleset checking specification* that apply to the project but are not verified by the test cases across *ruleset model types*.
Informative Note: AHJs should manually review the models to ensure that these rules are implemented correctly.
3. Difference between the models representing each *ruleset model type* for the project, using one or more of the following methods:
 - a. Human-readable report showing the differences between models, or
 - b. Text files representing each model with similar ordering to be compared using common text comparison software.
4. Building performance modeling software that allows automatically generated models to be modified by the end-user shall provide one or more of the following:
 - a. The simulation results and compliance outcome from the automatically generated model along with the user modified model.
 - b. A report which identifies all such modifications.
 - c. A statement from the user describing the changes that have been made as compared to the automatically generated baseline.

Exception to 4.3.4: Building performance modeling software shall be permitted to not meet the requirements in Section 4.3.4 if all of the following conditions are met:

1. There is a *ruleset project description generation software* compliant with Section 7 capable of creating *ruleset project description* for energy models created in the building performance modeling software.
2. There is a *ruleset checking tool* compliant with Section 8 capable of generating a project evaluation report as described in Section 8.3 #3. The project evaluation report shall be permitted to include only the rules that were excluded from the test cases and the rules that were included in the test cases for which model inputs have been manually modified.

5 Ruleset Evaluation Schema

Building performance modeling software shall produce a *ruleset project description* consistent with the *ruleset evaluation schema* described in this section.

5.1 Format

The *ruleset evaluation schema* shall be in JSON format following the rules described in Standard 205 Sections 5 except 5.1, 5.7, and 5.8; Section 6 except 6.1, 6.2, 6.3, 6.7, and 6.8; and Section 7.

5.2 Data Groups and Data Elements

The *ruleset project description* shall contain the *data groups* and *data elements* as described at:

<https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/public%20review%20drafts/2025%20standard%20229/ashrae229.schema.json>

Additional schema documentation, presented in tabular form is available at

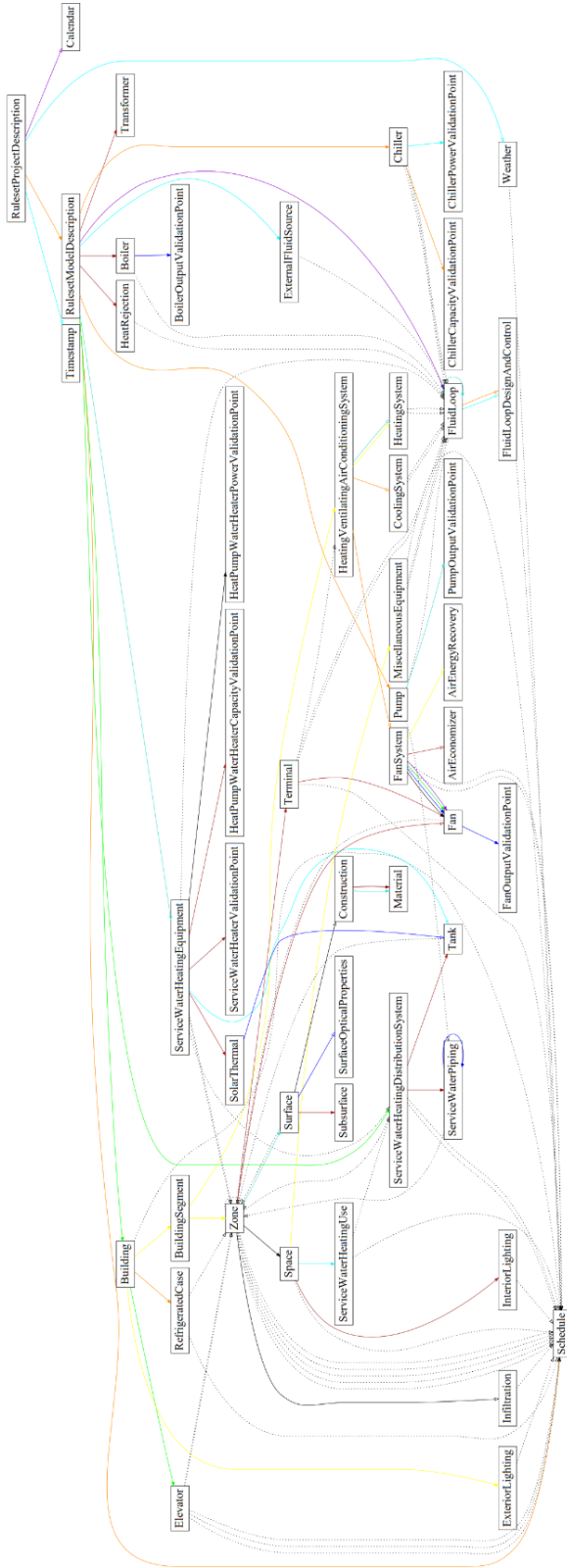
<https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/public%20review%20drafts/2025%20standard%20229/ashrae229.schema.pdf>

[Note for reviewers: This is a temporary page for publication public review. The content will be moved to <http://data.ashrae.org/> upon publication.]

5.3 Data Group Hierarchy (informative)

The hierarchy of the data groups are shown in Figure 5.3

Figure 5.3 Data Group Hierarchy



6 Ruleset Checking Specification Requirements

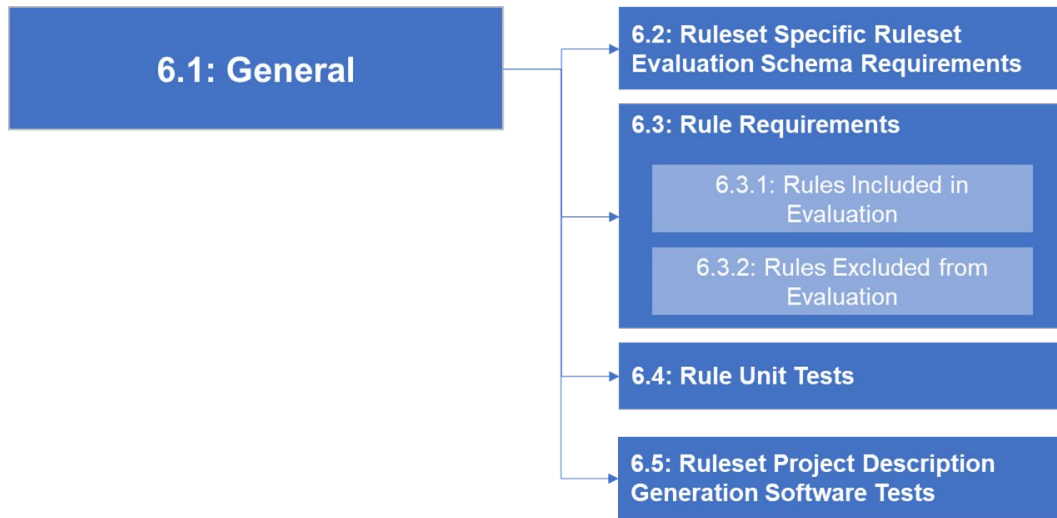


Figure 1: Flowchart for Ruleset Checking Specification Requirements

6.1 General

6.1.1 Scope

This section describes information that shall be included in the *ruleset checking specification* for a given *ruleset*, as shown in Figure 2.

Informative Note: The *ruleset checking specification* may be part of this standard or external to it. Normative Appendix E1 provides the *ruleset checking specification* for Standard 90.1-2019. *Ruleset checking specification* may include requirements in addition to those listed in this section.

6.1.2 Required Content

Ruleset checking specification shall include the following:

1. Definitions of applicable *ruleset model types*. **Informative Note:** For example, 90.1-2019 Appendix G *ruleset checking specification* in Appendix E of this standard defines user, proposed, and baseline *ruleset model types*.
2. Version of the *ruleset evaluation schema* used in the ruleset checking specification.
3. *Ruleset specific ruleset evaluation schema* data groups, data elements, or enumerations shall meet the requirements of Section 6.2.
4. The data groups or elements of the *ruleset evaluation schema* required for evaluating *rules*.
5. List of the *rules* within a *ruleset* that are required to be evaluated by the *ruleset checking tool* and *rules* that are excluded from evaluation following Section 6.3.1 and Section 6.3.2.
6. Applicable *rule* evaluation outcomes, if different from Section 6.3.1.2.
7. *Rule* evaluation precision, as described in Section 6.3.1.3.
8. *Rule unit tests*, as described in Section 6.4.
9. *Ruleset project description generation software* compliance requirements, as described in Section 6.5.

6.2 Ruleset Specific Ruleset Evaluation Schema Data Groups, Data Elements, and Enumerations

Section 5 describes the *ruleset evaluation schema* to be used by the *ruleset project description generation software* and by the *ruleset checking tool* for verifying *ruleset* implementation. Additional *ruleset specific ruleset evaluation schema* data groups, data elements, or enumerations, if applicable, shall be specified in the *ruleset checking specification* and may include one or more of the following:

1. *Ruleset specific enumerations*
2. *Ruleset specific output schema*

All *rulesets* shall use the schema as specified in Section 5. If additional data elements are needed for a specific *ruleset*, the same shall be added to the schema through the continuous maintenance process as an addendum. Examples of ruleset specific enumerations include but are not limited to lighting space types.

6.3 Rule Requirements

The *ruleset checking specification* shall identify the *rules* and sections of the document that describes a *ruleset* which are evaluated and the ones which are excluded from evaluation by the *ruleset checking tool*. The requirements for *rules* evaluated and excluded from evaluation are specified in Section 6.3.1 and Section 6.3.2.

6.3.1 Requirements for the Rules Included in Evaluation

6.3.1.1 Rule Information

Rules within a *ruleset* that shall be evaluated by the *ruleset checking tool* shall be identified and documented in the *ruleset checking specification*. For each *rule* being evaluated by the *ruleset checking tool*, the following information shall be provided in the *ruleset checking specification*:

1. *Rule ID*: A unique ID for the *rule* being evaluated.
2. *Ruleset Reference*: Reference to the section of the document containing the *ruleset* where the *rule* is defined.
3. *Ruleset model type* to which the *rule* applies (for example: the proposed model, the baseline model, or the user model).
4. *Rule* description summarizing the corresponding *ruleset* requirement.
5. Whether the *rule* is required to have a *full evaluation* or *applicability evaluation*.

Informative Note: It may be difficult or impractical to provide a *full evaluation* of a *rule* through the *ruleset checking tool*, but it may still be useful for the *ruleset checking tool* to determine whether the *rule* is relevant to the project being evaluated. This applicability information may be useful to, for example, an authority having jurisdiction (AHJ) by informing them that a manual review of a *rule's* implementation may be appropriate.

Informative Note: Informative Table 1 provides an example *rule*.

Informative Table 1: Example *Rule*

Rule ID	Ruleset Reference	Ruleset Model Type	Rule Description	Evaluation
ENV-1	Table G3.1(5) Baseline Building Performance (a)	Baseline Model	Baseline Performance is the average of 4 rotations if vertical fenestration area per each orientation differ by more than 5%	Full
ENV-2	Table G3.1(5) Baseline Building Performance (a)	Baseline Model	Baseline building must be modeled so that it doesn't shade itself	Applicability

6.3.1.2 Rule Evaluation Outcomes

Rule evaluation outcomes shall follow the four categories listed below. Additional subcategories for the defined rule evaluation outcomes are permitted.

1. Pass: the *ruleset checking tool* is capable of *full evaluation* of the *rule* and determines that the *ruleset project description* complies with the *rule*. The ‘pass’ outcome shall be provided when the data elements in the *ruleset project description* exactly matches the prescribed requirement, while accounting for any tolerance for numeric quantities specified in the *ruleset checking specification*.
2. Fail: the *ruleset checking tool* is capable of *full evaluation* of the *rule* and determines that the *ruleset project description* does not comply with the *rule*. A ‘fail’ outcome shall be provided when the data element in the *ruleset project description* does not match the requirement(s) prescribed in the *rule*. For numeric values, a ‘fail’ outcome shall be provided when the data element is outside of the tolerance specified in the *ruleset checking specification*.
3. Not Applicable: The *ruleset checking tool* software determined that the *rule* is not applicable to the *ruleset project description*. A ‘not applicable’ outcome shall be provided only when the *rule* is not applicable to the *ruleset project description*.
4. Undetermined: An ‘undetermined’ outcome shall be provided when the *ruleset checking tool* is not able to establish ‘pass’, ‘fail’ or ‘not applicable’ outcome. The scenarios resulting in an ‘undetermined’ outcome shall include the following.
 - a. The *ruleset checking tool* lacks the capability for *full evaluation* of the *rule*.
 - b. The *ruleset project description* is missing data elements required to evaluate a *rule* or to determine its applicability.
 - c. The complete set of necessary data elements do not exist in the *ruleset evaluation schema*. For a *rule* that applies to multiple components in a building (for example, a *rule* which defines the requirements for interior lighting power density for space types), the *rule* evaluation shall be provided by the *ruleset checking tool* for each applicable component. The AHJ shall decide the mechanism for aggregating *rule* evaluations at a component level, to the *rule* level.

Informative Notes:

- a. Informative Appendix D of the standard provides an example report which demonstrates a methodology for converting component level *rule* evaluations to a whole building level *rule* evaluation.
- b. A *rule* evaluation outcome may include an optional message explaining the outcome and identifying additional verification that might be done by the AHJ or additional input that could be provided by the modeler to enable evaluation of the *rule*.

6.3.1.3 Rule Evaluation Precision

The *ruleset checking specification* shall identify the number of significant digits and the maximum allowed deviation from the expected numeric values evaluated by a *rule* based on *ruleset* requirements. If the *ruleset* does not provide information on required precision, then the value needs to equal the expected numeric value when rounded to the appropriate number of significant digits shown in the document describing or associated with the *ruleset*.

6.3.2 Requirements for Rules Excluded from Evaluation

For *rules* and sections excluded from evaluation, the *ruleset checking specification* shall identify the following:

1. *Ruleset* Reference: Reference to the section within the *ruleset* where the *rule* is defined.
2. Description: Summary of the corresponding *ruleset* requirement.

Informative notes:

- a. A *ruleset checking specification* might choose to exclude certain *rules* from evaluation due to reasons including the fact that requirements related to a *rule* cannot be represented in a *building performance model* and hence be translated into the *ruleset evaluation schema*. A *ruleset checking specification* may also be limited to specific sections within a *ruleset* or limit the scope of *rules* being evaluated.
- b. An AHJ might require additional *rules* to be evaluated. However, adding *rules* would require updates to the *ruleset checking specification* with the corresponding *rule unit tests* and updates to the *ruleset evaluation schema*. The *ruleset checking tool* would need to demonstrate compliance with the updated *ruleset checking specification*.
- c. Informative Table 2 provides an example of a *rule* specification for a *rule* excluded from evaluation.

Informative Table 2: Example *Rule* Excluded from Evaluation

Ruleset Reference	Rule Description
Table G3.1 Section 14. Proposed Building Performance	The effect that structures and significant vegetation or topographical features on the amount of solar radiation being received by a structure shall be adequately reflected in the computer analysis. All elements whose effective height is greater than their distance from a proposed building and whose width facing the proposed building is greater than one-third that of the proposed building shall be accounted for in the analysis.
Table G3.1 Section 14. Proposed Building Performance	It is acceptable to use either an annual average ground temperature or monthly average ground temperatures for calculation of heat loss through below-grade walls.
Table G3.1 Section 14. Proposed Building Performance	Either an annual water main supply temperature or monthly average water main supply temperatures shall be used for calculating service water heating energy use. If annual or monthly water main supply temperatures are not available from the local water utility, annual average ground temperatures may be used.

6.4 Rule Unit Tests

Rule unit tests shall be included in the *ruleset checking specification* which verify the intended behavior of the *ruleset checking tool* for testing the implementation each *rule* included in evaluation.

Section 6.4.1 specifies the requirements for *rule unit tests*.

6.4.1 Required Rule Unit Tests

Rule unit tests facilitate evaluating *ruleset checking tool* implementation of a single *rule* within a *ruleset*. For each evaluated *rule*, the following *rule unit tests* shall be included in the *ruleset checking specification*.

1. For each *rule* which is required to have a *full evaluation*, the following *rule unit tests* shall be provided.
 - a. At least one *rule unit test* with 'Pass' *rule* evaluation outcome.
 - b. At least one *rule unit test* with 'Fail' *rule* evaluation outcome.
 - c. Where a *rule* includes data elements with multiple enumerations, like space types for lighting, space conditioning categories, and climate zones for envelope, *rule unit tests* shall be defined for a minimum of two enumerations for each such parameter with *Rule Unit Tests* specified to evaluate at least one 'pass' and one 'fail' outcome for each enumeration.
2. For each *rule* which is required to have an *applicability evaluation*, *rule unit tests* with at least one 'undetermined' and one 'not applicable' *rule* evaluation outcome shall be included.

6.4.2 Rule Unit Test Specifications

For each *rule unit test*, the following information shall be included in the *ruleset checking specification*.

1. *Rule Unit Test ID*.
 2. *Rule ID* for which the test case has been defined.
 3. The description of the project scenario represented by the test case.
Informative Note: For example, project is located in climate zone 5A, baseline model includes a residential zone served by a cooling and heating system of a given capacity and has an exterior wall of a certain U-factor.
 4. The *ruleset project description* files corresponding to the test case description and containing information required to determine the outcome of the *rule* being evaluated.
 5. Expected *rule unit test* evaluation outcome based on the options allowed in Section 6.3.2.2.
- Informative Table 3 provides examples of *rule unit tests*.

Informative Table 3: Example *Rule Unit Tests*

<i>Rule ID</i>	<i>Rule Unit Test ID</i>	<i>Test Case Description</i>	<i>Expected Rule Unit Test Outcome</i>	<i>Ruleset Project Description File</i>
LTG-2	LTG-2-a	The proposed building has one building segment with one zone and one space. The lighting space type is hotel/motel guest rooms, LPD is higher than the minimum value prescribed by Standard 90.1-2019 Table 9.6.1 Hotel/Motel Guest Room ≥ 0.41 W/sq.ft.	pass	Rule Test LTG-2
LTG-2	LTG-2-b	The proposed building has one building segment with one zone and one space. The lighting space type is hotel/motel guest rooms, LPD is lower than the minimum value prescribed by Standard 90.1-2019 Table 9.6.1.	fail	Rule Test LTG-2

6.5 Ruleset Project Description Generation Software Tests

The *ruleset checking specification* shall include the following content to supplement Section 7.3, Required Capabilities, Section 7.4 Testing Requirements, and Section 7.5 Reporting Requirements:

1. The *ruleset project description generation software* compliance requirements specific to the *ruleset* in addition to those in Section 7.3.
2. The following information for each *ruleset project description generation software* test following the requirements in Section 7.4:
 - a. Test ID.
 - b. Test description, including the building performance modeling software simulation inputs necessary to create the *ruleset project description* file for the test case.
 - c. The expected *ruleset project description* file containing the correct values of the data elements and correct relationships between the data groups.
3. A *ruleset project description generation software* testing report meeting requirements of Section 7.5 for each test case and including a tabulated list of the relevant data elements. The reporting template shall identify the evaluation criteria for all data elements being evaluated, including the following:
 - a. Data elements whose values are required to match the corresponding value in the test case specification shall have the evaluation criteria denoted as “value”.
 - b. Data elements that are required to be present, but whose values cannot be checked, shall have the evaluation criteria denoted as “present”.
 - c. Data elements whose values are required to match the name of the object that corresponds to the object that is named in the test case specification shall have the evaluation criteria denoted as “reference”.

Informative Note: The *ruleset evaluation schema* defines specific relationships between classes of components. For example, all surfaces must be in a list associated with a zone. These relationships are represented using "references", using the names of objects that appear in the model as values for certain data fields. For example, the requirement that all surfaces must be in a list that is associated with a zone is implemented using a list that contains names of surface objects. These relationships, shown in Section 5.3, and the values of data elements such as surface U-factor and area, must align in the *ruleset project descriptions* generated by the candidate *ruleset project description generation software* and the expected *ruleset project descriptions* included in the *ruleset checking specification*. A "value" data field is aligned if it matches the value of the corresponding data field in the test case specification directly. A "reference" data field is aligned if its value is the name of the object that corresponds to the object named by the field in the test case specification.

7 Ruleset Project Description Generation Software Compliance

7.1 Scope

The requirements of this section apply to *ruleset project description generation software*.

Informative Note: The procedures described in this section help verify that the *ruleset project description* is consistent with the building performance modeling software user inputs and simulation outputs.

7.2 Compliance

The *ruleset project description generation software* shall be permitted to comply with the standard for one or more building performance modeling software tools. Compliance shall be demonstrated separately for each building performance modeling software tool. The *ruleset project description generation software* shall meet the following requirements:

1. Comply with Section 7.3, “Required Capabilities”.
2. Comply with Section 7.4, “Testing Requirements”.
3. Comply with Section 7.5, “Reporting Requirements”.
4. Meet any additional *ruleset project description generation software* requirements in the *ruleset checking specification* for the applicable ruleset.

Informative Note: *Ruleset project description generation software* acceptance may be determined by an authority having jurisdiction (AHJ) based on review of reports and documentation provided in accordance with Section 7.5. The AHJ may also replicate tests using the building performance modeling software and use the *ruleset project description generation software* to ensure that independently produced building performance modeling inputs, building performance modeling outputs, and *ruleset project description* files are identical to those publicly posted as required by Section 7.5.

7.3 Required Capabilities

Ruleset project description generation software shall be capable of generating a *ruleset project description* that:

1. Conforms with the *ruleset evaluation schema* requirements in Section 5 and in the *ruleset checking specification* for the applicable *ruleset(s)*.
2. Reflects the simulation outputs and the inputs used by the building performance modeling software *calculation engine* that performs the building performance simulation calculations.

Informative Note: User input may differ from the inputs used by the *calculation engine*. For example, the building performance modeling software user interface may process the simplified user inputs before passing them to the *calculation engine*, or the *calculation engine* may override or prioritize certain user inputs over others.

Exceptions: The *ruleset project description generation software* shall be permitted to make the following adjustments to the simulation inputs and outputs to meet schema requirements in Section 5 and the *ruleset checking specification*:

- a. Perform unit conversions.

Informative Note: Unit conversions in Standard 90.1-2019 Appendix G *ruleset checking specification* in the Normative Appendix E1 of this standard are based on the ASHRAE SI Guide for HVAC&R. Atlanta, Georgia: ASHRAE, 2013. <https://www.ashrae.org/technical-resources/ashrae-handbook/the-si-guide> and Python unit conversion library Pint version 0.18 <https://pint.readthedocs.io/en/0.18/>

- b. Allow users to specify *compliance parameters* that are not used in the simulation and do not impact simulation results.

Informative Note: Examples of accessory inputs include but are not limited to the ruleset-specific lighting space types and project climate zone.

- c. Perform other computations necessary to convert *building performance model* inputs and outputs to the *ruleset project description* data elements.

Informative Note: Examples of such computations include but are not limited to determining the overall surface U-factors written to the *ruleset project description* based on detailed description of materials making up the surface or the zone-level infiltration rate written to the *ruleset project description* based on the modeled space-level infiltration rate.

7.4 Testing Requirements

7.4.1 Testing Procedure

The *ruleset project description generation software* shall produce *ruleset project description* for the test cases specified in the *ruleset checking specification* for each applicable *ruleset*. The following steps shall be followed to demonstrate compliance:

1. Model each test case listed in the *ruleset checking specification* using the applicable building performance modeling software for which the *ruleset project description generation software* is demonstrating compliance. Building performance modeling software inputs for all test cases shall reflect the prescribed values.

Exceptions:

- a. The prescribed inputs that do not apply to the input structure of the building performance modeling software shall be disregarded.
 - b. Where the building performance modeling software does not allow direct input of the specified values, or where input of specified values causes instabilities in a program's calculations, equivalent inputs shall be used that match the intent of the test specification as nearly as the software being tested allows. Such equivalent inputs shall be developed based on the data provided in the test specification, have a mathematical, physical, or logical basis, and applied consistently throughout the test cases. The equivalent modeling inputs shall be documented.
 - c. Where the building performance modeling software does not support the prescribed input method, an alternative supported method shall be used. Differences in the inputs compared to the prescribed values shall be documented.
2. Use the qualifying *ruleset project description generation software* to create a *ruleset project description* for each test case.
 3. Compare the *ruleset project description* created by the qualifying *ruleset project description generation software* to the corresponding *ruleset project description* included in the *ruleset checking specification*.

7.5 Reporting Requirements

7.5.1 General Requirements

The *ruleset project description generation software* shall produce a software test report in *JSON* file format consistent with the *ruleset project description generation software* test report schema described in Normative Appendix H. The *ruleset project description* tests reporting documentation shall be posted on a publicly available website and shall include the following:

1. General Information
 - a. Posting date.
 - b. Name and version of the *ruleset project description generation software*.

- c. Name and version of the building performance modeling software that the *ruleset project description generation software* supports.
 - d. Version of the *ruleset evaluation schema* supported by the *ruleset project description generation software*.
 - e. Name of the *ruleset* for which compliance is demonstrated.
 - f. Name of *ruleset checking specification* for which compliance is demonstrated.
 2. A completed *ruleset project description* generation software testing report for each test case including the following.
 - a. Name of the *ruleset project description* file created by the *ruleset project description generation software*.
 - b. Names of all user and software created files utilized by the *ruleset project description generation software* to produce the values used in creating the associated *ruleset project description*.
 - c. Documentation when exceptions to Section 7.4.1 (1) were used.
 - d. Compliance outcome for each evaluated data element shall be recorded using one of the following strings:
 - i. “match” shall be used where the required type of alignment (value, present, or relationship) between the expected *ruleset project description* file and the *ruleset project description* file created by the candidate *ruleset project description generation software* is achieved.
 - ii. “differ” shall be used for the data elements where the required type of alignment is not achieved.
 - iii. “Not implemented” shall be used when the data element is not supported by the *ruleset project description generation software*.
- Informative Note:** Reasons for “not implemented” may include building performance modeling tool not supporting the relevant simulation inputs or the necessary functionality not implemented or not correctly implemented in *ruleset project description generation software*.
3. The following supporting documentation:
 - a. All user and software created files utilized by the submitted *ruleset project description generation software* to create the associated *ruleset project description* as listed in the *ruleset project description* reporting template.
 - b. Alternative equivalent simulation inputs used when the building performance modeling software does not allow direct input of the values specified in the test case description.
 - c. *Ruleset project descriptions* for all completed tests.
 - d. List of omitted test cases with explanation.
 - e. Explanation for each “differ” compliance outcome.

Informative Notes:

1. Examples when AHJ may allow “differ” compliance outcomes include the following:
 - a. Difference due to rounding of values introduced by unit conversion.
 - b. Difference due to workarounds used in the simulation. For example, if a test includes daylighting controls that cannot be explicitly modeled in the building performance modeling tool and such controls are simulated by reducing lighting runtime by adjusting the lighting schedule.

2. “Not implemented” compliance outcomes and omitted test cases may be allowed if AHJ deems acceptable to manually review the relevant aspect of the energy model.

8 Ruleset Checking Tool Compliance

8.1 Scope

The requirements of this section apply to *Ruleset Checking Tool* software for *rulesets* for which a *ruleset checking specification* is included in Appendix E.

Informative Note: The procedures described in this section help verify that a *ruleset checking tool* correctly evaluates whether a *ruleset project description* is consistent with a *ruleset* and reports each *rule* evaluation outcome.

8.2 Compliance

1. A *ruleset checking tool* shall comply with the standard for one or more *rulesets*. Compliance shall be demonstrated separately for each *ruleset*.
2. A *ruleset checking tool* shall meet the following requirements for each applicable *ruleset*:
 - a. Comply with the required capabilities for project checking in Section 8.3.
 - b. Comply with *ruleset checking tool* testing requirements in Section 8.4.

8.3 Required Capabilities

A *ruleset checking tool* shall have the following capabilities:

1. Accept the *ruleset project description* and verify its compliance with the *ruleset evaluation schema* requirements in Section 5.
2. Evaluate all *rules* defined in the *ruleset checking specification* as they apply to the *ruleset project description*.

Informative Note: If a *ruleset checking tool* evaluates *rules* or requirements in addition to those required to be evaluated in the *ruleset checking specification*, then it should identify those *rules* and their corresponding outcomes in the project evaluation report.

3. Generate a project evaluation report, as defined in Normative Appendix C, listing the outcomes for all evaluated *rules*.

Informative Note. The project evaluation report may include additional information such as warning messages and quality assurance flags.

8.4 Ruleset Checking Tool Testing Requirements

1. A *ruleset checking tool* shall be tested in accordance with a *ruleset checking specification* for the applicable *ruleset* and shall produce correct *rule* evaluation outcomes for all *rule unit tests*.
2. A *ruleset checking tool* shall produce a software testing report as described in Normative Appendix B.
3. A *ruleset checking tool* shall meet additional requirements in the *ruleset checking specification*.

Informative note: Normative Appendix E1 is a *ruleset checking specification* for ASHRAE Standard 90.1-2019 Appendix G.

9 Normative References

Reference		Section
ANSI/ASHRAE Standard 205-2023	Representation of Performance Data for HVAC&R and Other Facility Equipment	Sections 5 except 5.1, 5.7, and 5.8; Section 6 except 6.1, 6.2, 6.3, 6.7, and 6.8; Section 7.
ANSI/ASHRAE/IES Standard 90.1-2019	Energy Standard for Buildings Except Low-Rise Residential Buildings (IP Edition)	Normative Appendix G

JSON.org. Introducing JSON. 2018. URL: <http://www.json.org/>.

Normative Appendix A: Ruleset Evaluation Schema Tables

The *ruleset evaluation schema* is described at

<https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/public%20review%20drafts/2025%20standard%20229/ashrae229.schema.json>

Additional schema documentation, presented in tabular form is available at

<https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/public%20review%20drafts/2025%20standard%20229/ashrae229.schema.pdf>

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Normative Appendix B: Ruleset Checking Tool Software Testing Report Schema

The *ruleset checking tool* shall produce an output report in JSON file format consistent with the *ruleset checking tool* software testing output report schema described in this appendix. The report shall contain the detailed results for all the *rule unit tests* defined by the *ruleset checking specification* for the *ruleset*.

B.1 Format

The *ruleset checking tool* software testing report schema shall be in JSON format following the rules described in Standard 205 Sections 5 except 5.1, 5.7, and 5.8; Section 6 except 6.1, 6.2, 6.3, 6.7, and 6.8; and Section 7.

B.2 Data Group Hierarchy (informative)

The hierarchy of the data groups is shown in the figure below.



Figure 2: Hierarchy of Data Groups in *ruleset checking tool* software testing output report schema

B.3 Data Groups and Data Elements

The *ruleset checking tool* software testing report schema shall contain the *data groups* and *data elements* described at

<https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/public%20review%20drafts/2025%20standard%20229/ashrae229.schema.json>

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B.4 Data Group and Element Tables

[Note:

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https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/public%20review%20drafts/2025%20standard%20229/rct_software_output_test_report.schema.pdf]

Normative Appendix C: Ruleset Checking Tool Project Evaluation Report Schema

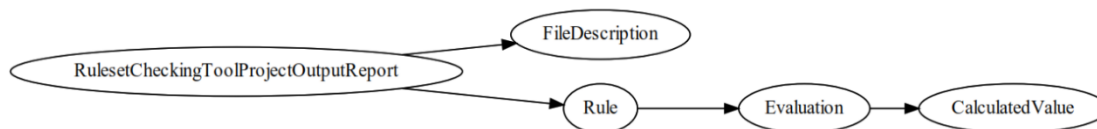
The *ruleset checking tool* shall produce a project evaluation report in JSON file format consistent with the *ruleset checking tool* project evaluation report schema described in this appendix. The report shall contain the detailed results for all *rule* evaluations conducted during an evaluation of a set of *ruleset project description* files.

C.1 Format

The *ruleset checking tool* project evaluation report schema shall be in JSON format following the rules described in Standard 205 Sections 5 except 5.1, 5.7, and 5.8; Section 6 except 6.1, 6.2, 6.3, 6.7, and 6.8; and Section 7.

C.2 Data Group Hierarchy (informative)

The hierarchy of the data groups is shown in the figure below.



C.3 Data Groups and Data Elements

The *ruleset checking tool* project evaluation report schema shall contain the *data groups* and *data elements* described at

https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/public%20review%20drafts/2025%20standard%20229/rct_project_output_test_report.schema.json

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C.4 Log of Exception Messages

A log shall be produced by the *ruleset checking tool* that shall include a log of exception messages and shall include a JSON object that identifies if the *ruleset checking tool* encountered an error. The *ruleset checking tool* shall generate a log file that identifies all *rules* that failed processing and the error that was encountered.

Informative Note: The developer of the *ruleset checking tool* should have a process for users to submit test files when errors occur including ways to submit log and other files.

C.5. Data Group and Element Tables

[Note: The text of this PDF will be added here:

https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/public%20review%20drafts/2025%20standard%20229/rct_project_output_test_report.schema.pdf]

Informative Appendix D: Project Checking Summary Report

The project checking summary report provides an example summary report which leverages the *Ruleset Checking Tool* Project Evaluation Test Report schema, as defined in Normative Appendix C, to generate a report which summarizes the rule evaluation outcomes to facilitate review by a jurisdiction.

An example summary report is available here:

https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/public%20review%20drafts/2025%20standard%20229/ashrae901_2019_summary_report.pdf

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Normative Appendix E: Ruleset Checking Specification

E1 Ruleset Checking Specification for ASHRAE Standard 90.1-2019

E1.1 Utilization

This *ruleset checking specification* has been developed for Standard 90.1 2019 Appendix G, Performance Rating Method, IP version, and applies to the project checking path, as described in Section 4.2.

E1.2 Ruleset Model Types

The *ruleset checking tool* shall be capable of evaluating the following *ruleset model types*: -

- **User model:** a *ruleset model type* that reflects specified or existing building systems, components, and controls and anticipated or actual operating conditions.
- **Proposed model:** *ruleset model type* of a hypothetical design obtained by transforming the user model as required by ASHRAE Standard 90.1 Performance Rating Method.
- **Baseline model:** a *ruleset model type* of a hypothetical design obtained by transforming the proposed model as required by ASHRAE Standard 90.1 Performance Rating Method. Four baseline *ruleset models*, one for each of the four orientations, are required by ASHRAE Standard 90.1 Performance Rating Method for most projects.

E1.3. Ruleset Evaluation Schema

Ruleset evaluation schema data elements, specific to Standard 90.1 2019 Appendix G, include the following:

- a. Standard 90.1-2019 enumerations described at
<https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/public%20review%20drafts/2025%20standard%20229/enumerations2019ashrae901.schema.json>
Additional schema documentation, presented in tabular form, is available at
<https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/public%20review%20drafts/2025%20standard%20229/enumerations2019ashrae901.schema.pdf>
- b. Standard 90.1-2019 output schema described at
<https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/public%20review%20drafts/2025%20standard%20229/output2019ashrae901.schema.json>
Additional schema documentation, presented in tabular form, is available at
<https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/public%20review%20drafts/2025%20standard%20229/output2019ashrae901.schema.pdf>
- c. Schema data elements required for evaluating *rules*, schema data elements required to be the same between the user model and proposed model and schema data elements required to be the same between proposed model and baseline model. The schema is described at
https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/public%20review%20drafts/2025%20standard%20229/ashrae229_extra.schema.json
Additional schema documentation, presented in tabular form, is available at
https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/public%20review%20drafts/2025%20standard%20229/ashrae229_extra.schema.pdf

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E1.4. Rules

This section identifies *rules* within the *ruleset* that are excluded from evaluation and the *rules* which are required to be evaluated by the *ruleset checking tool*.

E1.4.1 Rules Included in Evaluation

Rules required to be included in evaluation are identified through unique *rule* identifiers. *Rule* identifiers use a pre-fix determined by the Appendix G section they belong in.

The *ruleset checking tool* shall be capable of evaluating *rules* listed at

https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/public%20review%20drafts/2025%20standard%20229/rules_90.1-2019.xlsx

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Informative Note: Different *rules* might be grouped together if they apply to the same component. For example, Appendix G Section 1.2.1 identifies mandatory requirements and includes a rule which applies to lighting systems. That specific rule has been grouped under rule identifier 6, lighting.

Table E1.4.2: Rule Identifier Mapping to Ruleset

Rule Identifier Prefix	Ruleset Section Title	Ruleset Reference
CALC	Compliance calculations and Design Model	Section 4, Table G3.1(1)
SCH	Schedules and Setpoints	Table G3.1(4)
ENV	Building Envelope	Table G3.1(5)
LTG	Lighting	Table G3.1(6), G1.2.1(b)
SHW	Service Hot Water	Table G3.1(11)
REC	Receptables	Table G3.1(12)
ELEV	Elevators	Table G3.1(16)
HVAC-SYS	Baseline HVAC System Selection	Section G3.1.1
HVAC-GEN	General Baseline HVAC System Requirements	Section G3.1.2
HVAC-Airside	System-Specific Baseline HVAC System Requirements	Section G3.1.3 (Except the rules for hot water, chilled water and condenser water loop)
HVAC-HW	Baseline HVAC-Water Side Requirements: Hot Water	Section G3.1.3 (Rules for hot-water loop)
HVAC-CHW	Baseline HVAC-Water Side Requirements: Chilled Water	Section G3.1.3 (Rules for chilled water and condenser water loop)

E1.4.2 Rules Excluded from Evaluation

Rules excluded from evaluation are listed at:

https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/public%20review%20drafts/2025%20standard%20229/rules_90.1-2019.xlsx

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Informative Note: Table E1.4.2 includes additional requirements of Appendix G which are not *rules* according to the definition in the standard but which, for clarity, are noted here as also being excluded from evaluation.

Table E1.4.2 Requirements in Standard 90.1-2019 Excluded from Evaluation

Section Name	Standard 90.1-2019 Reference	Section Description
Performance Rating Method Scope	G1.1	This section describes the scope of the PRM approach as a pathway to demonstrate performance that exceeds the requirements of the standard.
Submittals	G1.3	This section specifies the submittal requirements for verifying compliance with the PRM approach.
Simulation General Requirements- Performance Calculations	G2.1	Section specifies the requirements related to the simulation program used for calculating the proposed and baseline building performance.
Simulation Program	G2.2	Section specifies the minimum required capabilities of the simulation program used for calculating the proposed and baseline building performance.
Climatic Data	G2.3	Section specifies requirements related to the climatic data used for the simulation.
Exceptional Calculation Methods	G2.5	Section specifies conditions in which an exceptional calculation method may be used and the documentation required to support the same.

E1.5 Rule Unit Tests

The *rule unit tests* for evaluating the *rules* included in evaluation are listed at

https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/public%20review%20drafts/2025%20standard%20229/RuleTests_90.1-2019.xlsx

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E1.6 Rule Evaluation Precision

For *rule* evaluations that check for an expected value, the *ruleset checking tool* shall round values to match the number of digits as the expected value is specified in the *ruleset*. The *ruleset checking tool* shall evaluate the *rule* for an exact match against the expected value.

Where the ruleset checking tool evaluates a threshold, the threshold value shall not be rounded.

Informative Note:

For example, in Standard 90.1 2019 Appendix G, the baseline is required to be modeled with a single boiler if the conditioned floor area is equal to or less than 15,000 ft² and with two boilers if the conditioned floor area is greater than 15,000 ft². In this scenario, where the evaluation is based on the threshold of conditioned floor area, the floor area would not be rounded.

E1.7. Ruleset Project Generation Software Testing

E1.7.1 General

Ruleset project description generation software shall be tested as required in Section 7. The *ruleset project description generation software* tests required for compliance with the *ruleset checking specification* for Standard 90.1-2019, are listed in Table E1.7.1.

Table E1.7.1: Tests for Ruleset Project Description Generation Software Compliance

Test ID	Test Description	File
E1	Base Test Description + HVAC Test Case 1 (Packaged Single Zone Heat Pump)	Test 1
E2	Base Test Description + HVAC Test Case 2 (Chilled Water VAV with Hot Water Reheat)	Test 2
E3	Base Test Description + HVAC Test Case 3 (Packaged VAV with Reheat and Baseboard Supplementary Heating)	Test 3

The base test case shall be as described in Section E1.7.2. The HVAC test cases shall be specified as described in Section E1.7.3.

[Note for reviewers: The test cases are hosted on a temporary page for publication public review. The content will be moved to <http://data.ashrae.org/> upon publication.]

Informative Note: The test cases do not represent models compliant with ASHRAE Standard 90.1. The intent is to cover various input methods that may be used to capture building design and exercise the *Ruleset Project Description Generation Software*.

E1.7.2 Base Ruleset Project Description Generation Software Test Description

The base test case shall be as defined in this section. Building characteristics defined in this section shall be used for all *ruleset project description generation software* tests. The *ruleset project description generation software* shall meet the following requirements while defining the *ruleset project description generation software* tests:

1. Where a system, device, or parameter is not described, it shall not exist in the *ruleset project description*.
2. *Ruleset evaluation schema* data elements specific to 90.1 Appendix G *ruleset* are described in Section E1.3 and shall be used by the *ruleset project description generation software*.
3. SurfaceConstructionOptions: LAYERS shall be used if at least one material making up a construction is specified using detailed properties.

Informative Note:

To reduce the number of tests and simplify the testing process, the base test case defined in this section covers a variety of systems and components, a range of component properties, and various simulation input methods. For example, the base test case includes exterior walls with different construction types and U-factors and multiple methods of modeling infiltration (such as constant flow or weather dependent algorithms) for different zones. HVAC system configurations to be tested are defined in Section E1.7.3.

E1.7.2.1 Site and Weather

Table 1: Site and Weather Summary

Parameter Description	Specification – SI Units (IP Units)
-----------------------	-------------------------------------

Weather file type	TMY3
Location	Denver, CO
Climate zone	5B
Elevation	1,609 m (5,280 ft)
Altitude adjustment	N/A (airflows are normalized to sea level)
Simulation year	2021
Holidays	None
Daylight savings	None
Ground temperature schedule	Constant, 10°C (50°F)
Cooling design day type	1.0% annual cumulative frequency of occurrence
Heating design day type	99.0% annual cumulative frequency of occurrence

E1.7.2.2 Building Geometry

- a. The building's geometry shall be as specified in Figures 1 through 3 and Table 2.

Informative Note:

The dimensions presented in IP units represent the original absolute values. SI values have been converted and rounded. Due to this rounding, performing arithmetic operations with the presented SI values may result in slight discrepancies when compared to calculations from IP values which have been converted to SI. For precise calculations, it is recommended that the original IP values be used, then unit conversions be made to the result if needed.

- b. If the *building performance modeling* software includes surface thickness in a three-dimensional definition of the building geometry, then wall, roof, and floor thicknesses shall be defined such that the interior air volume of the building model remains as specified. The thicknesses shall extend exterior to the currently defined internal volume.

Figure 1: Building Floor Plan

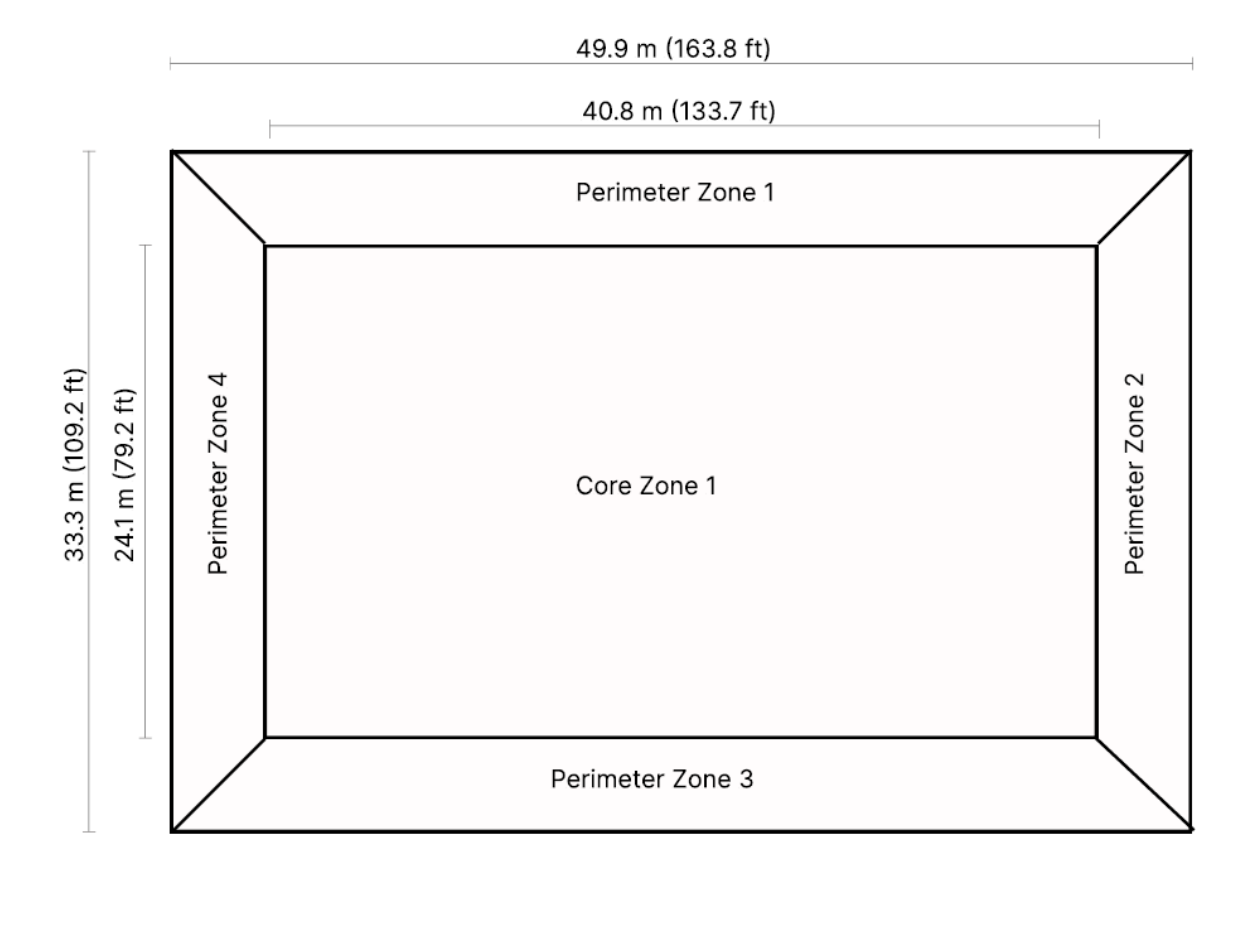


Figure 2: North/South Building Elevations

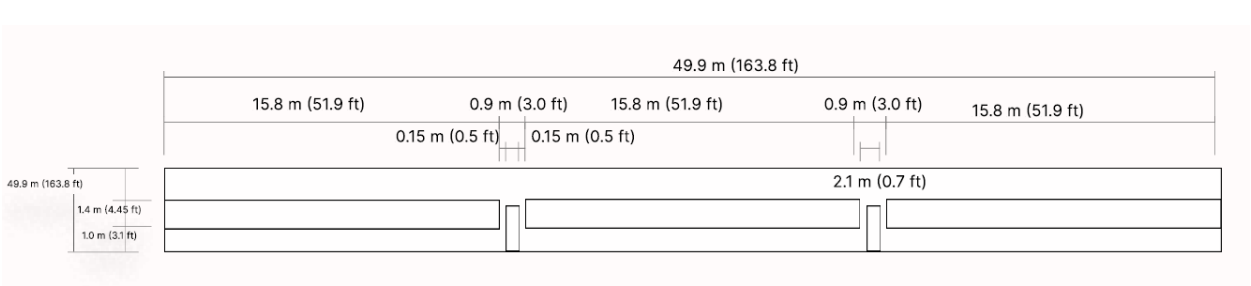


Figure 3: East/West Building Elevations

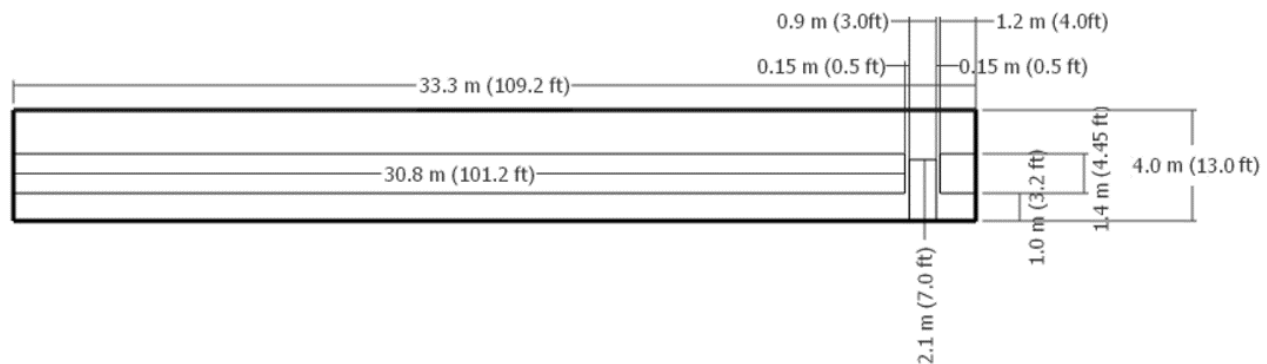


Table 2: Building Geometry Summary

Parameter Description	Specification – SI Units (IP Units)
Total Floor Area	1,660.7 m ² (17,876 ft ²)
Dimensions	49.9 m x 33.3 m (163.7 ft x 109.2 ft)
Aspect Ratio	1.5
Number of Floors	1
Window and Door Locations	See Figures 2&3 for detailed dimensions
Window Dimensions	See Figures 2&3 for detailed dimensions
Shading	None
Azimuth	Long axis along East/West
Thermal Zoning	The building has four perimeter zones and one core zone. Perimeter zone depth: 4.57 m (15 ft)
Building height	3.96 m (13 ft)
Floor-to-ceiling height	3.96 m (13 ft)
Door dimensions	0.91 m x 2.13 m (3 ft x 7 ft) See Figures 2&3 for quantities
Foundation	Slab-on-grade

E1.7.2.3 Envelope Properties

E1.7.2.3.1. Envelope Opaque Surfaces

- Envelope shall be modeled with surface constructions specified in Tables 3 through Table 5. Materials specified for constructions exposed to exterior are shown in the tables, ordered from outside to inside.
- The interior air film resistance shall be as shown in Table 6.
- Surface-to-surface thermal resistance (excluding air-films) of interior wall assembly shall be 0.35 m²·K/W (SI) / 1.99 h·ft²·°F/Btu (IP).
- The exterior air-film resistance for roof and exterior walls shall be 0.03 m²·K/W (SI) / 0.17 h·ft²·°F/Btu (IP). Where the exterior air-film resistance is not a user input and is determined during the hourly simulation, the overall roof and exterior wall assembly air-to-air u-factors reported in the *ruleset project description* shall be based on the exterior air film resistance of 0.03 m²·K/W (SI) / 0.17 h·ft²·°F/Btu (IP).

- e. The solar (visible and ultraviolet wavelengths) absorptances and infrared emittances of the opaque surfaces shall be as specified in Table 7.
- f. The surface-to-surface thermal conductivity (excluding air-films) of opaque doors shall be $2.100 \text{ W/m}^2\cdot\text{K}$ / $0.37 \text{ Btu/h}\cdot\text{ft}^2\cdot^\circ\text{F}$ (IP).

Informative Note: The specified opaque envelope model inputs test the following aspects of the *ruleset project description* generation:

- i. Identifying the applicable `Construction.surface_construction_input_option`
- ii. Determining the `Construction.u_factor` based on detailed properties of individual materials
- iii. Populating `Material.thickness`, `Material.thermal_conductivity`, `Material.density`, `Material.specific_heat`, `Material.r_value`
- iv. Populating `SurfaceOpticalProperties`

Table 3: Roof Construction Summary

Roof Type 1: Construction assembly is described layer-by-layer where detailed properties are provided for built-up roofing, continuous insulation, and metal roof deck layers. Assigned to: Core Zone 1, Perimeter Zone 1, Perimeter Zone 2		
Layer Description	Parameter Description	Specification – SI Units (IP Units)
Built-up roofing	Thickness	0.0095 m (0.031 ft)
	Conductivity	$0.16 \text{ W/m}\cdot\text{K}$ ($0.092 \text{ Btu}/[\text{h}\cdot\text{ft}\cdot^\circ\text{F}]$)
	Density	$1,120 \text{ kg/m}^3$ (69.92 lb/ft^3)
	Specific Heat	$1,460 \text{ J/kg}\cdot\text{K}$ ($0.349 \text{ Btu}/[\text{lb}\cdot^\circ\text{F}]$)
Continuous Insulation	Thickness	0.0527 m (0.173 ft)
	Conductivity	$0.020 \text{ W/m}\cdot\text{K}$ ($0.012 \text{ Btu}/[\text{h}\cdot\text{ft}\cdot^\circ\text{F}]$)
	Density	32.000 kg/m^3 (2.00 lb/ft^3)
	Specific Heat	$922 \text{ J/kg}\cdot\text{K}$ ($0.220 \text{ Btu}/[\text{lb}\cdot^\circ\text{F}]$)
Metal Deck	Thickness	0.0008 m (0.003 ft)
	Conductivity	$45.28 \text{ W/m}\cdot\text{K}$ ($26.162 \text{ Btu}/[\text{h}\cdot\text{ft}\cdot^\circ\text{F}]$)
	Density	$7,824 \text{ kg/m}^3$ (488.44 lb/ft^3)
	Specific Heat	$500 \text{ J/kg}\cdot\text{K}$ ($0.119 \text{ Btu}/[\text{lb}\cdot^\circ\text{F}]$)
Roof Type 2: Assembly is described layer-by-layer identically to Roof Type 1, except as specified below where the thickness of continuous insulation is increased and overall thermal resistance is provided for built-up-roofing. Assigned to: Perimeter Zone 3		
Layer Description	Parameter Description	Specification – SI Units (IP Units)
Continuous Insulation	Thickness	0.106 m (0.346 ft)
Built-up roofing	Total Thermal Resistance	$0.059 \text{ m}^2\cdot\text{K/W}$ ($0.337 \text{ h}\cdot\text{ft}^2\cdot^\circ\text{F/Btu}$)
Roof Type 3: Assembly is described as a total surface-to-surface thermal resistance without thermal mass Assigned to: Perimeter Zone 4		
Simplified Input Description		Specification – SI Units (IP Units)
Total surface-to-surface thermal resistance (excluding air-films)		$2.66 \text{ m}^2\cdot\text{K/W}$ ($15.09 \text{ h}\cdot\text{ft}^2\cdot^\circ\text{F/Btu}$)

Table 4: Exterior Wall Construction Summary

Exterior Wall Type 1: Assembly is described layer-by-layer from exterior to interior with detailed properties provided for each layer Assigned to: Perimeter Zone 1		
Layer Description	Parameter Description	Specification – SI Units (IP Units)
Gypsum Board	Thickness	0.0159 m (0.052 ft)
	Conductivity	0.16 W/[m·K] (0.092 Btu/[h·ft·°F])
	Density	800 kg/m ³ (50 lb/ft ³)
	Specific Heat	1,090 J/kg·K (0.26 Btu/[lb·°F])
Insulation	Thickness	0.062 m (0.204 ft)
	Conductivity	0.037 W/[m·K] (0.021 Btu/[h·ft·°F])
	Density	9.600 kg/m ³ (0.600 lb/ft ³)
	Specific Heat	838 J/kg·K (0.200 Btu/[lb·°F])
Gypsum Board	Thickness	0.0159 m (0.052 ft)
	Conductivity	0.16 W/[m·K] (0.092 Btu/[h·ft·°F])
	Density	800 kg/m ³ (50 lb/ft ³)
	Specific Heat	1090 J/kg·K (0.26 Btu/[lb·°F])
Stucco	Thickness	0.0254 m (0.083 ft)
	Conductivity	0.72 W/[m·K] (0.416 Btu/[h·ft·°F])
	Density	1,856 kg/m ³ (116 lb/ft ³)
	Specific Heat	840 J/kg·K (0.201 Btu/[lb·°F])
Exterior Wall Type 2: Assembly is the same as Exterior Wall Type 1 except as specified below. Assigned to: Perimeter Zone 2		
Layer Description	Parameter Description	Specification – SI Units (IP Units)
Insulation	Thickness	0.179 m (0.588 ft)
Gypsum Board	Overall Thermal Resistance	0.099 m ² ·K/W (0.565 h·ft ² ·°F/Btu)
Exterior Wall Type 3: Assembly is described as an overall thermal resistance without thermal mass Assigned to: Perimeter Zone 3 & 4		
Simplified Input Description		Specification – SI Units (IP Units)
Total surface-to-surface thermal resistance (excluding air-films)		1.95 m ² ·K/W (11.05 h·ft ² ·°F/Btu)

Table 5: Floor Construction Summary

Slab-on-grade Type 1: Assembly is described with detailed properties Assigned to: Core Zone 1, Perimeter Zone 1 & 2		
Layer Description	Parameter Description	Specification – SI Units (IP Units)
Concrete	Thickness	0.1016 m (0.333 ft)
	Conductivity	2.31 W/[m·K] (1.335 Btu/[h·ft·°F])
	Density	2,322 kg/m ³ (145.125 lb/ft ³)
	Specific Heat	832 J/kg·K (0.199 Btu/[lb·°F])
Slab-on-grade Type 2: Assembly is the same as Slab-on-grade Type 1 except with additional insulation as described below		

Assigned to: Perimeter Zone 3 & 4		
Layer Description	Parameter Description	Specification – SI Units (IP Units)
Insulation (Note 1)	Thickness	0.1143 m (0.375 ft)
	Conductivity	0.04 W/[m·K] (0.025 Btu/[h·ft ² ·°F])
	Density	91.31 kg/m ³ (5.700 lb/ft ³)
	Specific Heat	838 J/[kg·K] (0.200 Btu/[lb·°F])

Note 1: Insulation placement shall be as shown in Figure 4.

Table 6: Interior Air Film Resistance Summary

Construction	Specification – SI Units (IP Units)
Roof	0.11 m ² ·K/W (0.61 h·ft ² ·°F/Btu)
Wall	0.12 m ² ·K/W (0.68 h·ft ² ·°F/Btu)
Floor	0.16 m ² ·K/W (0.92 h·ft ² ·°F/Btu)

Figure 4: Slab Insulation for Ground Floor Perimeter Zone 3 & 4 Slab

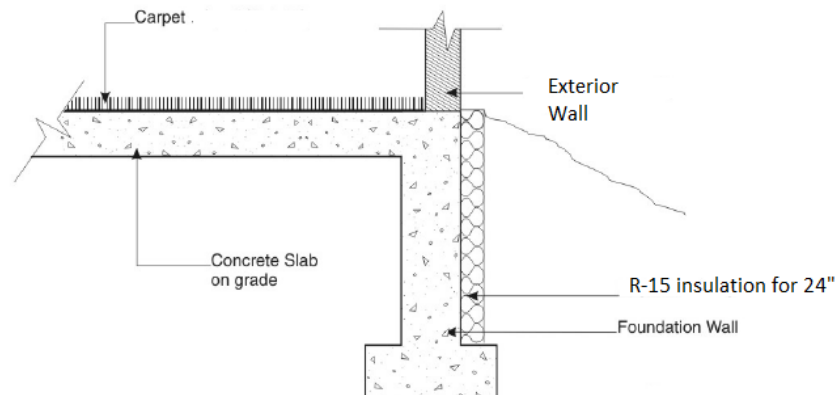


Table 7: Opaque Surface Radiative Property Summary

	Interior Surface			Exterior Surface		
	Thermal Absorptance	Solar Absorptance	Visible Absorptance	Thermal Absorptance	Solar Absorptance	Visible Absorptance
Exterior Roof	0.9	0.7	0.7	0.9	0.7	0.7
Exterior Wall	0.9	0.7	0.7	0.9	0.7	0.7
Interior Walls	0.9	0.7	0.7	NA	NA	NA
Interior Floors	0.9	0.7	0.8	NA	NA	NA
Ceiling	0.9	0.7	0.2	NA	NA	NA

E1.7.2.3.2. Fenestration

- Fenestration properties are based on product dimensions for an individual product shown in Table 8.

- b. Fenestration test cases are described in Table 9 and include references to a fenestration description file. *[Note to reviewers: these will eventually be hosted at <https://data.ashrae.org/>. For the purposes of letter ballot, the fenestration description files have been included as supplemental text files]*
- c. Each exterior wall shall include window elements as shown in Figures 2&3 that reflect the performance requirements for each test case.

Table 8: Window Dimension Summary

Parameter Description	Specification – SI Units (IP Units)
Window height (including frame)	1.4 m (4.45 ft)
Window width (including frame)	1.22 m (4.00 ft)

Table 9: Window Property Summary

Vertical Fenestration Type 1: Assembly is described using overall performance properties Assigned to: All Windows	
Parameter Description	Specification – SI Units (IP Units)
U-factor (excluding air-films)	3.231 W/m ² -K (0.569 Btu/h-ft ² -F)
SHGC	0.386
V-T	0.421
Fenestration description file	[see file " 229 RPD Test Product 1.txt "]

E1.7.2.3.3. Infiltration

- a. Air leakage rate for each zone shall be modeled using rates and modeling method specified in Table 10. Infiltration schedule, if applicable, shall be as specified in Table 12.
- b. The infiltration rates specified in Table 10 are not based on measurement (i.e., there are no blower door test values.)

Table 10: Infiltration Flow Rate Summary

Infiltration Method 1: The amount of air leakage is determined for each simulation timestep using the specified infiltration flow rate adjusted to account for the specified schedule and weather conditions. The weather adjustment may be based on windspeed, zone height and the difference between indoor and outdoor temperature. Informative note: This should map to weather_driven infiltration method as defined in the <i>ruleset evaluation schema</i> .		
Assigned to: Core Zone 1 and Perimeter Zone 1		
Core Zone 1	Air changes per hour (ACH)	0
Prm Zone 1		0.5
Infiltration Method 2: Air leakage constant at each time step as specified below without weather or schedule adjustment. Informative note: This should map to the "CONSTANT" infiltration method as defined in the <i>ruleset evaluation schema</i> .		
Assigned to: Perimeter Zone 2		
Prm Zone 2	Flow per exterior wall area	0.5862 l/s·m ² (0.1154 cfm/ft ²)

Infiltration Method 3: Air leakage during each time step is equal to the rate specified below for each zone multiplied by the infiltration schedule fraction from Table 12. Informative note: This should map to the “CONSTANT_SCHEDULED” infiltration method as defined in the <i>ruleset evaluation schema</i> .		
Assigned to: Perimeter Zone 3		
Prm Zone 3	Flow per floor area	0.3884 l/s·m ² (0.07646 cfm/ft ²)
Infiltration Method 4: Air leakage constant at each time step as specified below without weather or schedule adjustment. Informative note: This should map to weather_driven infiltration method as defined in the <i>ruleset evaluation schema</i> .		
Assigned to: Perimeter Zone 4		
Prm Zone 4	Flow rate	53.7 l/s (113.8 cfm)

E1.7.2.4 Internal Loads

The section provides modeling inputs for occupants, lighting, and plug loads.

- Internal loads shall be modeled as specified in Table 11 for all zones, unless noted.
- The internal loads shall be modeled using the schedules in Table 12
- Internal gains from occupants shall be 55% sensible, 45% latent.
- No daylighting and occupancy sensor controls shall be modeled.
- Internal gains from miscellaneous equipment shall be 100% sensible, 0% latent.

Table 11: Internal Load Summary

Parameter Description	Specification – SI Units (IP Units)
Occupancy	
People/Floor Area	0.05382 person/m ² (0.005 person/ft ²)
Total Heating Rate per person	120 W (409.457 Btu/h)
Lighting	
Power Density	11.03 W/m ² (1.025 W/ft ²)
Miscellaneous Equipment	
Fuel type	Electricity
Equipment/Floor Area	8.07 W/m ² (2.558 Btu/h·ft ²)

Table 12: Schedule Summary

		Hour of the Day																							
Type	Day	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24
Building Open Hours																									
Fraction	Weekdays	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Fraction	Saturday	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
Fraction	Sunday	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Occupancy																									
Fraction	Weekdays	0	0	0	0	0	0	0.1	0.2	0.95	0.95	0.95	0.95	0.5	0.95	0.95	0.95	0.95	0.3	0.1	0.1	0.1	0.1	0.05	0.05
Fraction	Saturday	0	0	0	0	0	0	0.1	0.1	0.3	0.3	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0	0	0	0	0
Fraction	Sunday	0	0	0	0	0	0	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0	0	0	0	0	0
Fraction	Heating Design Day	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fraction	Cooling Design Day	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Lighting																									
Fraction	Weekdays	0	0	0	0	0	0	0.1	0.2	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.3	0.1	0.1	0.1	0.1	0.05	0.05
Fraction	Saturday	0	0	0	0	0	0	0.1	0.1	0.3	0.3	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0	0	0	0	0
Fraction	Sunday	0	0	0	0	0	0	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0	0	0	0	0	0
Fraction	Heating Design Day	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fraction	Cooling Design Day	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Plug Load																									
Fraction	Weekdays	0.31	0.31	0.31	0.31	0.31	0.31	0.38	0.38	0.86	0.86	0.86	0.76	0.86	0.86	0.86	0.86	0.86	0.48	0.38	0.38	0.38	0.38	0.38	0.38
Fraction	Saturday	0.23	0.23	0.23	0.23	0.23	0.23	0.38	0.38	0.48	0.48	0.48	0.48	0.33	0.33	0.33	0.33	0.33	0.29	0.29	0.23	0.23	0.23	0.23	0.23
Fraction	Sunday	0.23	0.23	0.23	0.23	0.23	0.23	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.23	0.23	0.23	0.23	0.23	0.23
Fraction	Heating Design Day	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Fraction	Cooling Design Day	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Infiltration																									
Fraction	Weekdays	1	1	1	1	1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1	1
Fraction	Saturday	1	1	1	1	1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1	1	1	1	1	1	
Fraction	Sunday	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
Fraction	Heating Design Day	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Fraction	Cooling Design Day	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Minimum Relative Humidity Setpoints																									
Fraction	Weekdays	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Fraction	Saturday	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Fraction	Sunday	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Fraction	Heating Design Day	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Fraction	Cooling Design Day	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Maximum Relative Humidity Setpoints																									
Fraction	Weekdays	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Fraction	Saturday	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Fraction	Sunday	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Fraction	Heating Design Day	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Fraction	Cooling Design Day	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Heating Thermostat Setpoints (°C)																									
Temperature	Weekdays	15.6	15.6	15.6	15.6	15.6	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	15.6	15.6
Temperature	Saturday	15.6	15.6	15.6	15.6	15.6	21	21	21	21	21	21	21	21	21	21	21	21	15.6	15.6	15.6	15.6	15.6	15.6	15.6
Temperature	Sunday	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6
Temperature	Heating Design Day	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
Cooling Thermostat Setpoints (°C)																									
Temperature	Weekdays	26.7	26.7	26.7	26.7	26.7	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	26.7	26.7
Temperature	Saturday	26.7	26.7	26.7	26.7	26.7	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	26.7	26.7
Temperature	Sunday	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7
Temperature	Cooling Design Day	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24

E1.7.3 HVAC System Configuration Description

E1.7.3.1. Overview

The *ruleset project description generation software* shall analyze the base test description individually with each of the HVAC system tests described in Sections E1.7.3.1.1 through E1.7.3.1.3.

Informative Notes:

The HVAC system configuration tests evaluate the presence of key data elements, also described below.

- The specified HVAC system tests evaluate the following aspects of the *ruleset project description generation software*:
 - Ability to populate schema elements to accurately represent common HVAC system types.
 - Ability to populate schema elements from sizing runs, including sensible heating and cooling capacity, design airflows, and design electric power for fans and pumps.
 - Ability to populate the system efficiency for various efficiency metrics.
 - Ability to determine if the systems are sized based on design day sizing runs.

2. The *ruleset project description* for the baseline building for ASHRAE 90.1-2019 Performance Rating Method must have the design capacity for the heating system specified and the design sensible cooling capacity for the cooling systems specified for the associated airside systems. The design capacities are used to determine the conditioning status of zones served by the system.
3. The *ruleset project description* for the baseline building for ASHRAE 90.1-2019 Performance Rating Method with DX cooling systems, furnace heating systems, heat pump heating systems, chillers, and boilers must have the rated capacity specified for the associated heating or cooling system. The rated capacity is used to determine the expected efficiency rating for each system.

E1.7.3.1.1 HVAC Test Case 1: Packaged Single Zone Heat Pump (Standard 90.1-2019, Performance Rating Method, Baseline System 4)

Each zone shall be modeled with a dedicated packaged single-zone heat pump (PSZ-HP) system. HVAC components shall include the typical single-zone fan system, cooling system, heating system, zones, and terminals as specified in Table 13.

Table 13: Test Case 1 - Air-Side System Parameters

Parameter Description	Specification (typical for all systems/zones)
System Service	Dedicated System per Zone
Cooling System Type	Direct Expansion
Cooling Capacity Sizing Method	Determined Based on Design Day Run
Rated Total Cooling Capacity	Shall be populated, but value is not checked
Design Sens. Cooling Capacity	Shall be populated, but value not checked
Cooling Oversizing Factor	15%
Cooling Efficiency, Full Load	3.1 COP _{nfcooling}
Preheat System Type	Omitted, or NONE
Heating System Type	Heat Pump
Heating Capacity Sizing Method	Determined Based on Design Day Run
Rated Heating Capacity	Shall be populated, but value is not checked
Design Heating Capacity	Shall be populated, but value not checked
Heating Oversizing Factor	25%
Heating Efficiency, Full Load	3.1 COP _{nfheating}
Auxiliary Heat Type	Electric
Auxiliary Heat Lockout Temp	4.4°C (40°F)
Heat Pump Low Lockout Temp	-23.3°C (-10°F)
Supply Fan Operation	Occupied: Continuous Unoccupied: Cycling to maintain temperature setpoints
Supply Fan Control	Constant Volume
Supply Fan Power	0.64 W·s/L (0.3 W/CFM)
Supply Fan Flow Sizing Method	Determined Based on Design Day Run
Design Supply Fan Airflow	Shall be populated, but value is not checked
Cooling Thermostat Temperature	Scheduled – per Table 12
Heating Thermostat Temperature	Scheduled – per Table 12
Ducted Supply	True

Terminal Type	Constant Volume
Design Cooling Supply Air Temperature	12.8°C (55°F)
Design Heating Supply Air Temperature	32.2°C (90°F)
Terminal Fan	Omitted, or {}
Terminal Cooling	Omitted, or NONE
Terminal Heating	Omitted, or NONE
Terminal Minimum Outdoor Airflow	0.61 L/(s·m ²) (0.12 CFM/ft ²)
Economizer	Differential dry-bulb temperature
Economizer Locks Out Compressor	False
Exhaust Air Energy Recovery	Enthalpy HX
Energy Recovery Operation	On when Minimum OA
Energy Recovery Leaving Air Temp Control	Fixed Setpoint
Sensible Recovery Effectiveness	50%
Latent Recovery Effectiveness	50%

E1.7.3.1.2. HVAC Test Case 2: Chilled Water VAV with Hot Water Reheat (Performance Rating Method Baseline System 7)

A chilled water VAV air handler shall be modeled serving all zones, and hot water reheat shall be modeled at each terminal. HVAC components and plant systems shall include a hot water heating loop with two boilers and two pumps, a primary chilled water loop with two chillers and two pumps, a secondary chilled water loop with one pump, and a condenser water loop with one heat rejection device. System parameters shall be based on Tables 14A-B.

Table 14A: Test Case 2 - Air-Side System Parameters

Parameter Description	Specification (typical for all systems/zones)
System Service	1 System Serves All Zones
Cooling System Type	Chilled Water
Cooling Capacity Sizing Method	Input as Specified (Not Determined Based on Design Day Run)
Rated Total Cooling Capacity	87,921 W (300,000 Btu/h)
Design Sens. Cooling Capacity	Shall be populated, but value not checked
Preheat System Type	Hot Water
Preheat Capacity Sizing Method	Input as Specified (Not Determined Based on Design Day Run)
Rated Heating Capacity	87,921 W (300,000 Btu/h)
Design Heating Capacity	Shall be populated, but value not checked
Preheat Leaving Air Temp	10°C (50°F)
Heating System Type	Omitted, or NONE
Supply Fan Operation	Occupied: Continuous

	Unoccupied: Off
Supply Fan Control	Variable Speed Drive
Supply Fan Flow Sizing Method	Input as Specified (Not Determined Based on Design Day Run)
Design Supply Fan Airflow	4,719 L/s (10,000 CFM)
Supply Fan Design Pressure Rise	871 Pa (3.5 in. W.G.)
Supply Fan Total Efficiency	60%
Return Fan Design Pressure Rise	498 Pa (2.0 in. W.G.)
Return Fan Total Efficiency	60%
Supply Air Temp Setpoint	12.8°C (55°F)
Supply Air Temp Control	Zone Reset – 15.6°C (60°F) at minimum load
Design Return Fan Flow Rate	4,248 L/s (9,000 CFM)
Ducted Return	True
Air Filter(s)	MERV 13
Terminal Type	Variable Volume
Cooling Thermostat Temperature	Scheduled – per Table 12
Heating Thermostat Temperature	Scheduled – per Table 12
Design Thermostat Heating Setpoint	21.1°C (70°F)
Design Heating Supply Air Temperature	32.2°C (90°F)
Design Thermostat Cooling Setpoint	23.9°C (75°F)
Design Cooling Supply Air Temperature	12.8°C (55°F)
Ducted Supply	True
Primary Airflow	943.9 L/s (2,000 CFM)
Terminal Minimum Airflow	141.6 L/s (300 CFM)
Zone Ventilation Requirements	Maximum of area and occupant-based rates
Zone Area-Based Ventilation	0.05 L/s/m ² (0.01 CFM/ft ²)
Zone Occupant-Based Ventilation	4.7 L/s/person (10 CFM/person)
Zone Air Distribution Effectiveness	1.2
Terminal Fan	Omitted, or {}
Terminal Cooling	Omitted, or NONE
Terminal Heating	Hot Water
Terminal Heat Capacity Sizing Method	Input as Specified (Not Determined Based on Design Day Run)
Rated Heating Capacity	1,758 W (6,000 Btu/h)
Design Heating Capacity	Shall be populated, but value not checked
Economizer	21.1°C (70°F) high-limit shutoff
Economizer Integrated with CHW Control	True
Demand Control Ventilation	Return Air CO ₂ Sensor
Exhaust Air Energy Recovery	Enthalpy Wheel
Energy Recovery Operation	Interlocked with Supply Fan
Energy Recovery Leaving Air Temp Control	Mixed Air Reset
Sensible Recovery Effectiveness	50%

Latent Recovery Effectiveness	50%
Humidification Type	Steam (Non-Adiabatic)
Minimum Relative Humidity Setpoint	40%
Dehumidification Type	Mechanical Cooling
Maximum Relative Humidity Setpoint	70%

Table 14B: Test Case 2 – Water-Side System Parameters

Parameter Description	Specification
Loop Type	Hot Water
Loop Operation	Intermittent/On-Demand
Loop Sized Based on Coincident Loads	False
Loop Design Supply Temperature	82.2°C (180°F)
Loop Design Return Temperature	54.4°C (130°F)
Loop Flow Control	Variable Flow
Loop Pump Speed Control	Variable Speed
Loop Pump Power	301 W·s/L (19 W/GPM)
Pump Quantity	2
Pump Flow Sizing Method	Determined Based on Design Day Run
Pump Design Flow	Shall be populated, but value is not checked
Hot Water Supply Temperature (HWST) Reset	None
Boiler Quantity	2
Boiler Type	Gas-Fired Natural Draft
Boiler Rated Capacity	Shall be populated, but value not checked
Boiler Staging	As required by load
Boiler Minimum Load Ratio	33%
Boiler Efficiency	90% E _c
Loop Type	Chilled Water (Primary Loop)
Child Loops	[[Secondary Loop ID]]
Loop Sized Based on Coincident Loads	True
Loop Design Supply Temperature	6.7°C (44°F)
Loop Design Return Temperature	13.3°C (56°F)
Chilled Water Supply Temperature (CHWST) Reset	OAT < 15.6°C (60°F): CHWST 12.2°C (54°F) OAT 15.6-26.7°C (60-80°F): CHWST ramped linearly 6.7-12.2°C (44-54°F) OAT > 26.7°C (80°F): CHWST 6.7°C (44°F)
Loop Operation	Continuous
Loop Flow Control	Constant Flow
Loop Pump Speed Control	Fixed Speed
Loop Pump Power	143 W·s/L (9 W/GPM)

Pump Quantity	2
Pump Flow Sizing Method	Determined Based on Design Day Run
Pump Design Flow	Shall be populated, but value is not checked
Pump Interlocked with Chiller	False
Chiller Quantity	2
Chiller 1 Type	Water-cooled Centrifugal
Chiller 2 Type	Screw Chiller
Chiller Rated Capacity	Shall be populated, but value not checked
Chiller Rated Condenser Entering Temperature	29.4°C (85°F)
Chiller Rated Evaporator Leaving Temperature	6.7°C (44°F)
Chiller Design Capacity	Shall be populated, but value not checked
Chiller Part Load Efficiency	0.5 IPLV
Chiller Minimum Load Ratio	0.25
Loop Type	Chilled Water (Secondary Loop)
Child Loops	Omitted, or []
Loop Sized Based on Coincident Loads	True
Loop Operation	Continuous
Loop Flow Control	Variable Flow
Loop Minimum Flow Ratio	0.25
Loop Design Supply Temperature	6.7°C (44°F)
Loop Design Return Temperature	13.3°C (56°F)
Chilled Water Supply Temperature (CHWST) Reset	OAT < 15.6°C (60°F): CHWST 12.2°C (54°F) OAT 15.6-26.7°C (60-80°F): CHWST ramped linearly 6.7-12.2°C (44-54°F) OAT > 26.7°C (80°F): CHWST 6.7°C (44°F)
Loop Pump Speed Control	Variable Speed
Loop Pump Power	206 W·s/L (13 W/GPM)
Pump Quantity	1
Pump Flow Sizing Method	Determined Based on Design Day Run
Pump Design Flow	Shall be populated, but value not checked
Pump Design Power	Shall be populated, but value not checked
Integrated Waterside Economizer	True
Loop Type	Condenser Water
Loop Sized Based on Coincident Loads	True
Loop Flow Control	Constant Flow
Loop Pump Speed Control	Fixed Speed
Loop Pump Power	301 W·s/L (19 W/GPM)
Pump Quantity	1
Pump Flow Sizing Method	Determined Based on Design Day Run

Pump Design Flow	Shall be populated, but value not checked
Pump Design Power	Shall be populated, but value not checked
Pump Interlocked with Chiller	False
Heat Rejection Type	Open-Circuit with Axial Fan
Heat Rejection Fan Control	Variable Speed
Heat Rejection Rated Water Flow Rate	Shall be populated, but value not checked
Leaving Water Setpoint Temperature	21.1°C (70°F)
Design Wetbulb Temperature	25°C (77°F)
Heat Rejection Approach	3.9 K (7°F)
Heat Rejection Range	5.6 K (10°F)

E1.7.3.1.3. Test Case 3: Packaged VAV with Reheat and Baseboard Supplementary Heating

A packaged VAV system shall be modeled serving all zones with hot water reheat coils at each terminal and hot water baseboard supplementary heating. HVAC components and plant systems shall include parameters as specified in Tables 15A-B. The hot water heating loop shall be modeled with one boiler and pump, and the chilled water loop shall be modeled as primary-only with one air-cooled chiller and a pump.

Table 15A: Test Case 3 – Air-Side System Parameters

Parameter Description	Specification (typical for all systems/zones)
System Service	1 System Serves All Zones
Cooling System Type	Direct Expansion
Cooling Efficiency, Full Load	3.0 COP
Rated Total Cooling Capacity	87,921 W (300,000 Btu/h)
Design Sens. Cooling Capacity	Shall be populated, but value not checked
Preheat System Type	Hot Water
Preheat Capacity Sizing Method	Input as Specified (Not Determined Based on Design Day Run)
Rated Heating Capacity	43,961 W (150,000 Btu/h)
Design Heating Capacity	Shall be populated, but value not checked
Preheat Leaving Air Temp	10°C (50°F)
Heating System Type	Omitted, or NONE
Supply Fan Operation	Occupied: Continuous Unoccupied: Off
Supply Fan Control	Variable Speed Drive
Fan System Supply Air Temperature Control	Zone Reset
Supply Fan Flow Sizing Method	Input as Specified (Not Determined Based on Design Day Run)
Design Supply Fan Airflow	4,719 L/s (10,000 CFM)
Supply Fan Shaft Power	7,457 W (10 bhp)
Supply Fan Motor Efficiency	90%
Terminal Supply Air Temp Control	Zone Reset
Supply Flow Reset	Design Load Reset

Cooling Thermostat Temperature	Scheduled – per Table 12
Heating Thermostat Temperature	Scheduled – per Table 12
Zone Air Distribution Effectiveness	0.8
Terminal 1 Type	Variable Volume
Primary Airflow	943.9 L/s (2,000 CFM)
Terminal Minimum Outdoor Airflow	94.4 L/s (200 CFM)
Design Cooling Supply Air Temperature	12.8°C (55°F)
Design Heating Supply Air Temperature	32.2°C (90°F)
Terminal 1 Fan	Omitted, or {}
Terminal 1 Cooling	Omitted, or NONE
Terminal 1 Heating	Hot Water
Terminal 1 Heat Capacity	7,034 W (24,000 Btu/h)
Terminal 2 Type	Baseboard
Design Heating Supply Air Temperature	32.2°C (90°F)
Terminal 2 Fan	Omitted, or {}
Terminal 2 Cooling	Omitted, or NONE
Terminal 2 Heating	Hot Water
Terminal 2 Heat Capacity	1,758 W (6,000 Btu/h)
Economizer	Differential Enthalpy
Economizer Locks Out Compressor	False
Exhaust Air Energy Recovery	Sensible Heat Wheel
Energy Recovery Operation	Scheduled On/Off
Energy Recovery Leaving Air Temp Control	Fixed Setpoint
Sensible Recovery Effectiveness	80%
Outside Airflow	471.9 L/s (1,000 CFM)
Exhaust Airflow	424.8 L/s (900 CFM)
Humidification Type	Adiabatic
Minimum Relative Humidity Setpoint	40%
Dehumidification Type	Desiccant
Maximum Relative Humidity Setpoint	70%

Table 15B: Test Case 3 - Water-Side System Parameters

Parameter Description	Specification
Loop Type	Hot Water
Child Loops	Omitted, or []

Loop Sized Based on Coincident Loads	True
Loop Operation	Scheduled, but schedule values not checked
Loop Flow Control	Constant Volume
Loop Pump Speed Control	Fixed Speed
Loop Pump Power	301 W·s/L (19 W/GPM)
Loop Design Supply Temperature	82.2°C (180°F)
Loop Design Return Temperature	54.4°C (130°F)
Pump Quantity	1
Pump Flow Sizing Method	Input as Specified (Not Determined Based on Design Day Run)
Pump Design Flow	1.26 L/s (20 GPM)
Pump Design Power	380 W
Hot Water Supply Temperature (HWST) Reset	Load Reset
Hot Water Supply Temperature (HWST) Setpoint at Low Load	71.1°C (160°F)
Boiler Type	Forced Draft
Boiler Rated Capacity	87,921 W (300,000 Btu/h)
Boiler Efficiency	90% Et

Informative Appendix F: Additional Ruleset Project Description Generation Software Tests

F1. Additional HVAC Test Case Variations

This informative appendix provides additional *ruleset project description generation software* tests for multiple HVAC system configurations. Each test utilizes the base *ruleset project description* test defined in Section E1.7.2. The additional HVAC system tests are listed in Table 1 and available at the link provided in the table for each test case.

[Note for reviewers: The test cases are hosted on a temporary page for publication public review. The content will be moved to <http://data.ashrae.org/> upon publication.]

Table 1: HVAC System Tests

Test ID and Link	HVAC System Designation	HVAC System Description	Fan Control	Cooling Type	Heating Type	App G Baseline System #
100	PTAC	Packaged terminal air conditioner	Constant volume	Direct expansion	Hot-water fossil fuel boiler	1
110	PTHP	Packaged terminal heat pump	Constant volume	Direct expansion	Electric heat pump	2
120	PSZ-AC	Packaged rooftop air conditioner	Constant volume	Direct expansion	Fossil fuel furnace	3
130	Packaged VAV with reheat	Packaged rooftop VAV with reheat	VAV	Direct expansion	Hot-water fossil fuel boiler	5
140	Packaged VAV with PFP boxes	Packaged rooftop VAV with parallel fan power boxes and reheat	VAV	Direct expansion	Electric resistance	6
150	VAV with PFP boxes	VAV with parallel fan powered boxes and reheat	VAV	Chilled water	Electric resistance	8
160	Heating and ventilation	Warm air furnace, gas fired	Constant volume	None	Fossil fuel furnace	9
170	Heating and ventilation	Warm air furnace, electric	Constant volume	None	Electric resistance	10
180	SZ-VAV	Single-zone VAV	VAV	Chilled water	Electric resistance or boiler	11
190	SZ-CV-HW	Single-zone system	Constant volume	Chilled water	Hot-water fossil fuel boiler	12
200	SZ-CV-ER	Single-zone system	Constant volume	Chilled water	Electric furnace	13
210	FCU	Fan-coil unit	Constant Volume	Chilled water	Hot-water fossil fuel boiler	NA
220	FCUP	Fan-coil unit with purchased heat/CHW	Constant volume	Purchased CHW	Purchased HW	NA
230	WSHP	Water-source heat pump	Constant volume	DX	DX	NA
240	WSHP+DOAS	Water-source heat pump + constant volume dedicated outdoor air unit	Constant volume	DX	DX	NA

To minimize repetition of HVAC parameter specifications, typical system components have been established in Tables 3-10. Test cases reference these typical system components as a basis for the system specifications, then modify parameters or specify additional parameters to be applied to the respective test case. Table 2 provides a visual representation of the typical system components that are used in each test case.

Table 2: Typical System Components by Test Case

Test ID	Typical System Components							
	Single-Zone Fan	Multi-Zone Fan	Cooling	Heating	Zone/Terminal	Chilled Water Loop	Hot Water Loop	Condenser Water Loop
100	✓		✓	✓	✓		✓	
110	✓		✓	✓	✓			
120	✓		✓	✓	✓			
130		✓	✓		✓		✓	
140		✓	✓		✓			
150		✓	✓		✓	✓		
160	✓			✓	✓			
170	✓			✓	✓			
180	✓		✓	✓	✓	✓		
190	✓		✓	✓	✓	✓	✓	✓
200	✓		✓	✓	✓	✓		
210	✓		✓	✓	✓	✓	✓	
220	✓		✓	✓	✓			
230	✓		✓	✓	✓			✓
240	✓		✓	✓	✓			✓

Table 3: Typical Single-Zone HVAC Fan System (Parameters may be overridden in Test Cases)

Parameter Description	Specification
Supply Fan Operation	Occupied: Continuous Unoccupied: Off
Supply Fan Control	Constant Volume

Supply Fan Flow Sizing <u>Method</u>	Input as Specified (Not Determined Based on Design Day Run)
Supply Fan Power, Full Load	600 W
Design Supply Fan Airflow	943.9 L/s (2,000 CFM)

Table 4: Typical Multi-Zone HVAC Fan System (Parameters may be overridden in Test Cases)

Parameter Description	Specification
Fan System Supply Air Temperature Control	Constant
Supply Fan Operation	Occupied: Continuous Unoccupied: Off
Supply Fan Control	Variable Speed Drive
Supply Fan Flow Sizing <u>Method</u>	Input as Specified (Not Determined Based on Design Day Run)
Supply Fan Power, Full Load	10,000 W
Design Supply Fan Airflow	4,719 L/s (10,000 CFM)

Table 5: Typical Cooling System (Parameters may be overridden in Test Cases)

Parameter Description	Specification
Cooling Capacity Sizing <u>Method</u>	Input as Specified (Not Determined Based on Design Day Run)
Rated Total Cooling Capacity	17,584 W (60,000 Btu/h)
Design Sens. Cooling Capacity	Shall be populated, but value not checked

Table 6: Typical Heating System (Parameters may be overridden in Test Cases)

Parameter Description	Specification
Preheat System Type	Omitted, or NONE
Heating Capacity Sizing <u>Method</u>	Input as Specified (Not Determined Based on Design Day Run)
Rated Heating Capacity	17,584 W (60,000 Btu/h)
Design Heating Capacity	Shall be populated, but value not checked

Table 7: Typical Zone/Terminal (Parameters may be overridden in Test Cases)

Parameter Description	Specification
Ducted Supply	True
Terminal Type	Constant Volume
Design Cooling Supply Air Temperature	12.8°C (55°F)
Design Heating Supply Air Temperature	32.2°C (90°F)
Terminal Fan	Omitted, or {}
Terminal Cooling	Omitted, or NONE
Terminal Heating	Omitted, or NONE
Primary Airflow	943.9 L/s (2,000 CFM)

Terminal Minimum Outdoor Airflow	94.4 L/s (200 CFM)
Zone Air Distribution Effectiveness	0.8

Table 8: Typical Primary Chilled Water Loop (Parameters may be overridden in Test Cases)

Parameter Description	Specification
Child Loops	Omitted, or []
Loop Sized Based on Coincident Loads	True
Loop Operation	Continuous
Loop Flow Control	Variable Flow
Loop Minimum Flow Ratio	0.25
Loop Design Supply Temperature	6.7°C (44°F)
Loop Design Return Temperature	13.3°C (56°F)
Chilled Water Supply Temperature (CHWST) Reset	OAT < 15.6°C (60°F): CHWST 12.2°C (54°F) OAT 15.6-26.7°C (60-80°F): CHWST ramped linearly 6.7-12.2°C (44-54°F) OAT > 26.7°C (80°F): CHWST 6.7°C (44°F)
Loop Pump Speed Control	Variable Speed
Loop Pump Power	349 W·s/L (22 W/GPM)
Pump Flow Sizing Method	Input as Specified (Not Determined Based on Design Day Run)
Pump Design Flow	3.785 L/s (60 GPM)
Pump Design Power	1,320 W
Pump Interlocked with Chiller	False
Chiller Type	Screw Chiller
Chiller Condensing Loop	{Condenser Water Loop ID}
Chiller Rated Capacity	87,921 W (25 tons)
Design Condenser Entering Temp	29.4°C (85°F)
Design Evaporator Leaving Temp	10°C (50°F)
Chiller Minimum Load Ratio	0.25

Table 9: Typical Hot Water Loop & Boiler (Parameters may be overridden in Test Cases)

Parameter Description	Specification
Child Loops	Omitted, or []
Loop Sized Based on Coincident Loads	True
Loop Operation	Continuous
Loop Flow Control	Variable Flow
Loop Minimum Flow Ratio	0.25
Hot Water Supply Temperature (HWST) Reset	OAT < 6.7°C (20°F): HWST 82.2°C (180°F) OAT 6.7-10°C (20-50°F):

	HWST ramped linearly 82.2-65.6°C (180-150°F) OAT > 10°C (50°F): HWST 65.6°C (150°F)
Loop Pump Speed Control	Variable Speed
Loop Pump Power	301 W·s/L (19 W/GPM)
Loop Design Supply Temperature	82.2°C (180°F)
Loop Design Return Temperature	54.4°C (130°F)
Pump Flow Sizing Method	Input as Specified (Not Determined Based on Design Day Run)
Pump Design Flow	1.26 L/s (20 GPM)
Pump Design Power	380 W
Boiler Type	Gas-Fired Natural Draft
Boiler Rated Capacity	87,921 W (300,000 Btu/h)

Table 10: Typical Condenser Water Loop and Heat Rejection (Parameters may be overridden in Test Cases)

Parameter Description	Specification
Child Loops	Omitted, or []
Loop Operation	Continuous
Loop Flow Control	Variable Flow
Loop Pump Speed Control	Variable Speed
Loop Pump Power	301 W·s/L (19 W/GPM)
Pump Flow Sizing Method	Input as Specified (Not Determined Based on Design Day Run)
Pump Design Flow	4.73 L/s (75 GPM)
Pump Design Power	1,425 W
Pump Interlocked with Chiller	True
Heat Rejection Type	Open-Circuit with Axial Fan
Heat Rejection Fan Control	Variable Speed
Heat Rejection Rated Water Flow Rate	4.73 L/s (75 GPM)
Leaving Water Setpoint Temperature	21.1°C (70°F)
Design Wet-bulb Temperature	25°C (77°F)
Heat Rejection Approach	3.9 K (7°F)
Heat Rejection Range	5.6 K (10°F)

F3.2. Test Case 100: Packaged Terminal Air Conditioner (App G Baseline System 1)

Each zone shall be modeled with a dedicated packaged terminal air conditioner (PTAC) system. HVAC components shall include the typical single-zone fan system, cooling system, heating system, zones and terminals, and hot water heating loop with one boiler and pump. Typical component parameters shall be based on Tables 3-10 with additional parameters and/or parameter modifications as specified in Tables 11A-B.

Table 11A: Test Case 100: Air-Side System Parameters

Parameter Description	Specification (typical for all systems/zones)
System Service	Dedicated System per Zone
Cooling System Type	Direct Expansion
Cooling Efficiency, Full Load	3.1 COP _{nfcooling}
Heating System Type	Hot Water
Ducted Supply	False

Table 11B: Test Case 100: Water-Side System Parameters

Parameter Description	Specification
Loop Type	Hot Water
Boiler Efficiency	84% AFUE

F3.3. Test Case 110: Packaged Terminal Heat Pump (PTHP) (App G Baseline System 2)

Each zone shall be modeled with a dedicated packaged terminal heat pump (PTHP) system. HVAC components shall include the typical single-zone fan system, cooling system, heating system, zones, and terminals. System parameters shall be based on Tables 3-10 with additional parameters and/or parameter modifications as specified in Table 12A.

Table 12A: Test Case 110: Air-Side System Parameters

Parameter Description	Specification (typical for all systems/zones)
System Service	Dedicated System per Zone
Cooling System Type	Direct Expansion
Cooling Efficiency, Full Load	12.3 IEER
Heating System Type	Heat Pump
Heating Efficiency, Full Load	8.0 HSPF
Auxiliary Heat Type	Gas Furnace
Supply Fan Operation	Occupied: Continuous Unoccupied: Continuous
Ducted Supply	False
Minimum Outdoor Airflow	283.2 L/s (600 CFM)
Max. Outdoor Airflow	943.9 L/s (2,000 CFM)

F3.4. Test Case 120: Packaged Single Zone (PSZ) (App G Baseline System 3)

All zones shall be modeled with a dedicated packaged single-zone air conditioning (PSZ) system. HVAC components shall include the typical single-zone fan system, cooling system, heating system, zones, and terminals. Typical component parameters shall be based on Tables 3-10 with additional parameters and/or parameter modifications as specified in Table 13A.

Table 13A: Test Case 120 - Air-Side System Parameters

Parameter Description	Specification (typical for all systems/zones)
System Service	Dedicated System per Zone

Cooling System Type	Direct Expansion
Cooling Efficiency, Full Load	3.0 COP
Heating System Type	Furnace
Heating Efficiency, Full Load	78% AFUE
Exhaust Air Energy Recovery	Sensible HX
Energy Recovery Operation	Interlocked with Supply Fan
Energy Recovery Leaving Air Temp Control	Fixed Setpoint
Sensible Recovery Effectiveness	80%

F3.5. Test Case 130: Packaged VAV with Hot Water Reheat (App G Baseline System 5)

A packaged VAV air handler shall be modeled serving all zones, and hot water reheat shall be modeled at each terminal. HVAC components shall include the typical multi-zone fan system, cooling system, zones and terminals, and hot water heating loop with one boiler and pump. Typical component parameters shall be based on Tables 3-10 with additional parameters and/or parameter modifications as specified in Tables 14A-B.

Table 14A: Test Case 130 - Air-Side System Parameters

Parameter Description	Specification (typical for all systems/zones)
System Service	1 System Serves All Zones
Cooling System Type	Direct Expansion
Cooling Efficiency, Full Load	10.0 EER
Rated Total Cooling Capacity	87,921 W (300,000 Btu/h)
Preheat System Type	Hot Water
Preheat Capacity Sizing Method	Input as Specified (Not Determined Based on Design Day Run)
Rated Heating Capacity	43,961 W (150,000 Btu/h)
Heating System Type	Omitted, or NONE
Terminal Type	Variable Volume
Terminal Minimum Airflow	141.6 L/s (300 CFM)
Terminal Heating	Hot Water
Terminal Heat Capacity	8,792 W (30,000 Btu/h)

Table 14B: Test Case 130 - Water-Side System Parameters

Parameter Description	Specification
Loop Type	Hot Water
Boiler Efficiency	84% AFUE

F3.6. Test Case 140: Packaged VAV with Parallel Fan-Powered Boxes (App G Baseline System 6)

A packaged VAV air handler shall be modeled serving all zones, and parallel fan-powered boxes shall be modeled at each terminal. HVAC components shall include the typical multi-zone fan system, cooling

system, zones, and terminals. Typical component parameters shall be based on Tables 3-10 with additional parameters and/or parameter modifications as specified in Table 15A.

Table 15A: Test Case 140 - Air-Side System Parameters

Parameter Description	Specification (typical for all systems/zones)
System Service	1 System Serves All Zones
Cooling System Type	Direct Expansion
Cooling Efficiency, Full Load	11.0 CEER
Rated Total Cooling Capacity	87,921 W (300,000 Btu/h)
Preheat System Type	Electric Resistance
Preheat Capacity Sizing Method	Input as Specified (Not Determined Based on Design Day Run)
Rated Heating Capacity	43,961 W (150,000 Btu/h)
Preheat Leaving Air Temp	10°C (50°F)
Heating System Type	Omitted, or NONE
Terminal Type	Variable Volume
Terminal Secondary Airflow	2,831.7 L/s (6,000 CFM)
Terminal Minimum Airflow	141.6 L/s (300 CFM)
Terminal Fan	1 Fan in Parallel Configuration
Terminal Heating	Electric Resistance
Terminal Heat Capacity	8,792 W (30,000 Btu/h)
Supply Air Temp Control	Scheduled: 5AM-5PM: (55°F), 5PM-5AM: (65°F)

F3.7. Test Case 150: Chilled Water VAV with PFP Boxes (App G Baseline System 8)

A chilled water VAV air handler shall be modeled serving all zones, and parallel fan-powered boxes shall be modeled at each terminal. HVAC components shall include the typical multi-zone fan system, cooling system, zones, and terminals. Plant systems shall include a typical primary chilled water loop with one air-cooled chiller and pump. Typical component parameters shall be based on Tables 3-10 with additional parameters and/or parameter modifications as specified in Tables 16A-B.

Table 16A: Test Case 150 – Air-Side System Parameters

Parameter Description	Specification (typical for all systems/zones)
System Service	1 System Serves All Zones
Cooling System Type	Chilled Water
Rated Total Cooling Capacity	87,921 W (300,000 Btu/h)
Preheat System Type	Electric Resistance
Preheat Capacity Sizing Method	Input as Specified (Not Determined Based on Design Day Run)
Preheat Leaving Air Temp	10°C (50°F)
Rated Heating Capacity	43,961 W (50,000 Btu/h)
Heating System Type	Omitted, or NONE
Central Heat Operation	Locked Out During Unoccupied Hours

Terminal Type	Variable Volume
Terminal Minimum Airflow	141.6 L/s (300 CFM)
Terminal Secondary Airflow	2,831.7 L/s (6,000 CFM)
Terminal Fan	1 Fan in Parallel Configuration
Terminal Heating	Electric Resistance
Exhaust Air Energy Recovery	Heat Pipe
Energy Recovery Operation	Interlocked with Supply Fan
Energy Recovery Leaving Air Temp Control	Fixed Setpoint
Sensible Recovery Effectiveness	50%
Dehumidification Type	Series Heat Recovery

Table 16B: Test Case 150 – Water-Side System Parameters

Parameter Description	Specification
Loop Type	Chilled Water
Chiller Part Load Efficiency	0.5 NPLV
Chiller Condensing Loop	Omitted
Heat Rejection Type	Air-Cooled Condenser
Heat Rejection Fan Control	Two-speed

F3.8. Test Case 160: Gas-Fired Heating and Ventilation (App G Baseline System 9)

Each zone shall be modeled with a dedicated gas-fired heating and ventilation system. HVAC components shall include the typical single-zone fan system, heating system, zones, and terminals. Typical component parameters shall be based on Tables 3-10 with additional parameters and/or parameter modifications as specified in Table 17A.

Table 17A: Test Case 160 – Air-Side System Parameters

Parameter Description	Specification (typical for all systems/zones)
System Service	Dedicated System per Zone
Cooling System Type	Non-mechanical
Non-Mechanical Cooling Supply Fan Flow	118.0 L/s (250 CFM)
Non-Mechanical Cooling Supply Fan Power	90 W
Heating System Type	Furnace
Heating Efficiency, Full Load	78% AFUE
Design Thermostat Cooling Setpoint	Omitted
Design Cooling Supply Air Temperature	Omitted
Zonal Exhaust Fan	23.6 L/s (50 CFM) design airflow; 100% motor heat to airflow, 0% motor heat to zone

F3.9. Test Case 170: Electric Resistance Heating and Ventilation (App G Baseline System 10)

Each zone shall be modeled with a dedicated electric resistance heating and ventilation system. HVAC components shall include the typical single-zone fan system, heating system, zones, and terminals. Typical component parameters shall be based on Tables 3-10 with additional parameters and/or parameter modifications as specified in Table 18A.

Table 18A: Test Case 170 – Air-Side System Parameters

Parameter Description	Specification (typical for all systems/zones)
System Service	Dedicated System per Zone
Cooling System Type	Omitted, or NONE
Heating System Type	Electric Resistance
Heating Efficiency, Full Load	100% E_t
Design Thermostat Cooling Setpoint	Omitted
Design Cooling Supply Air Temperature	Omitted

F3.10. Test Case 180: Single-Zone VAV (App G Baseline System 11)

Each zone shall be modeled with a dedicated single-zone VAV system. HVAC components shall include the typical single-zone fan system, cooling system, heating system, zones, and terminals. Typical component parameters shall be based on Tables 3-10 with additional parameters and/or parameter modifications as specified in Tables 19A-B.

Table 19A: Test Case 180 – Air-Side System Parameters

Parameter Description	Specification (typical for all systems/zones)
System Service	Dedicated System per Zone
Cooling System Type	Chilled Water
Heating System Type	Electric Resistance
Heating Efficiency, Full Load	100% E_t
Supply Fan Control	Variable Speed Drive
Terminal Type	Variable Volume
Terminal Minimum Airflow	141.6 L/s (300 CFM)

Table 19B: Test Case 180 – Water-Side System Parameters

Parameter Description	Specification
Loop Type	Chilled Water
Chiller Part Load Efficiency	0.5 NPLV
Chiller Condensing Loop	Omitted
Heat Rejection Type	Air-Cooled Condenser

F3.11. Test Case 190: Single-Zone CV w/ CHW & HW Coils (App G Baseline System 12)

Each zone shall be modeled with a dedicated single-zone constant volume system with chilled water and hot water coils. HVAC components shall include the typical single-zone fan system, cooling system, heating system, zones, and terminals. Typical component parameters shall be based on Tables 3-10 with additional parameters and/or parameter modifications as specified in Tables 20A-B.

Table 20A: Test Case 190 – Air-Side System Parameters

Parameter Description	Specification (typical for all systems/zones)
System Service	Dedicated System per Zone
Cooling System Type	Chilled Water
Heating System Type	Hot Water
Economizer	High limit shutoff of (28 Btu/lb) of dry air
Economizer Locks Out Compressor	False

Table 20B: Test Case 190 – Water-Side System Parameters

Parameter Description	Specification
Loop Type	Hot Water
Boiler Efficiency	84% AFUE
Loop Type	Chilled Water
Chiller Part Load Efficiency	0.5 NPLV
Loop Type	Condenser Water
Heat Rejection Type	Closed-circuit cooling tower/fluid cooler
Heat Rejection Fan Control	Two-speed

F3.12. Test Case 200: Single-Zone CV w/ CHW & Electric Resistance (App G Baseline System 13)

Each zone shall be modeled with a dedicated single-zone constant volume system with chilled water and electric resistance coils. HVAC components shall include the typical single-zone fan system, cooling system, heating system, zones, and terminals. Typical component parameters shall be based on Tables 3-10 with additional parameters and/or parameter modifications as specified in Tables 21A-B.

Table 21A: Test Case 200 – Air-Side System Parameters

Parameter Description	Specification (typical for all systems/zones)
System Service	Dedicated System per Zone
Cooling System Type	Chilled Water
Heating System Type	Electric Resistance
Heating Efficiency, Full Load	100% E _t

Table 21B: Test Case 200 – Water-Side System Parameters

Parameter Description	Specification
Loop Type	Chilled Water
Chiller Part Load Efficiency	0.5 NPLV

Chiller Condensing Loop	Omitted
Heat Rejection Type	Air-Cooled Condenser

F3.13. Test Case 210: Fan Coil Unit with Chilled Water/Hot Water

Each zone shall be modeled with a dedicated single-zone fan coil unit with hot water and chilled water coils. HVAC components shall include the typical single-zone fan system, cooling system, heating system, zones, and terminals. Plant systems shall include a typical hot water heating loop with one boiler and pump, and a typical primary chilled water loop with one air-cooled chiller and pump. Typical component parameters shall be based on tables 3-10 with additional parameters and/or parameter modifications as specified in Tables 22A-B.

Table 22A: Test Case 210 – Air-Side System Parameters

Parameter Description	Specification (typical for all systems/zones)
System Service	Dedicated System per Zone
Cooling System Type	Chilled Water
Heating System Type	Hot Water

Table 22B: Test Case 210 – Water-Side System Parameters

Parameter Description	Specification
Loop Type	Hot Water
Boiler Efficiency	84% AFUE
Loop Type	Chilled Water
Chiller Part Load Efficiency	0.5 NPLV
Chiller Condensing Loop	Omitted
Heat Rejection Type	Air-Cooled Condenser

F3.14. Test Case 220: Fan Coil Unit with Purchased Chilled Water/Hot Water

Each zone shall be modeled with a dedicated single-zone fan coil unit served by a purchased hot water loop and a purchased chilled water loop. HVAC components shall include the typical single-zone fan system, cooling system, heating system, zones, and terminals. Typical component parameters shall be based on Tables 3-10 with additional parameters and/or parameter modifications as specified in Tables 23A-B.

Table 23A: Test Case 220 – Air-Side System Parameters

Parameter Description	Specification (typical for all systems/zones)
System Service	Dedicated System per Zone
Cooling System Type	Chilled Water
Heating System Type	Hot Water

Table 23B: Test Case 220 – Water-Side System Parameters

Parameter Description	Specification
Loop Type	Purchased Hot Water
Loop Type	Purchased Chilled Water

F3.15. Test Case 230: Water-Source Heat Pump

Each zone shall be modeled with a dedicated single-zone water-source heat pump system. HVAC components shall include the typical single-zone fan system, cooling system, heating system, zones, and terminals. Plant systems shall include a typical condenser water loop (heat pump loop) with one heat rejection device and one boiler. Typical component parameters shall be based on Tables 3-10 with additional parameters and/or parameter modifications as specified in Tables 24A-B.

Table 24A: Test Case 230 – Air-Side System Parameters

Parameter Description	Specification (typical for all systems/zones)
System Service	Dedicated System per Zone
Cooling System Type	Water-source Heat Pump
Cooling Efficiency, Full Load	13.0 EER
Heating System Type	Water-source Heat Pump
Heating Efficiency, Full Load	4.3 COP _{H, h, nf}

Table 24B: Test Case 230 – Water-Side System Parameters

Loop Type	Condenser Water
Boiler Type	Gas-Fired Natural Draft
Boiler Rated Capacity	87,921 W (300,000 Btu/h)
Boiler Efficiency	84% AFUE
Boiler Output Validation - Loop Load	Shall be populated, but value not checked
Boiler Output Validation - Consumption	Shall be populated, but value not checked

F3.16. Test Case 240: Water-Source Heat Pump with Dedicated Outdoor Air System

Each zone shall be modeled with a dedicated single-zone water-source heat pump system with ventilation provided by a dedicated outdoor air system. HVAC components shall include a typical multi-zone fan system with 100% outdoor air, and typical single-zone fan systems, cooling systems, heating systems, zones, and terminals. Plant systems shall include a typical condenser water loop (heat pump loop) with one heat rejection device (one boiler). Typical component parameters shall be based on Tables 3-10 with additional parameters and/or parameter modifications as specified in Tables 25A-B.

Table 25A: Test Case 240 - Air-Side System Parameters

DOAS System Service	1 System Serves All Zones
Cooling System Type	Direct-expansion
Cooling Efficiency, Full Load	13.0 EER
Heating System Type	Furnace
Heating Efficiency, Full Load	78% AFUE
Minimum Outdoor Airflow	471.9 L/s (1,000 CFM)
Maximum Outdoor Airflow	471.9 L/s (1,000 CFM)
Supply Air Temp Control	Constant
Supply Fan Operation	Occupied: Continuous Unoccupied: Off

Supply Fan Control	Variable Volume
Supply Fan Flow Sizing Method	Input as Specified (Not Determined Based on Design Day Run)
Supply Fan Power, Full Load	1,000 W
Design Supply Fan Airflow	471.9 L/s (1,000 CFM)
Terminal Primary Airflow	94.4 L/s (200 CFM)
Design Cooling Supply Air Temperature	18.3°C (65°F)
Design Heating Supply Air Temperature	23.9°C (75°F)
WSHP System Service	Dedicated System per Zone
Cooling System Type	Water-source Heat Pump
Cooling Efficiency, Full Load	13.0 EER
Heating System Type	Water-source Heat Pump
Heating Efficiency, Full Load	4.3 COP _H

Table 25B: Test Case 240 - Water-Side System Parameters

Loop Type	Condenser Water
Boiler Type	Gas-Fired Natural Draft
Boiler Rated Capacity	87,921 W (300,000 Btu/h)
Boiler Efficiency	84% AFUE
Boiler Output Validation - Loop Load	Shall be populated, but value not checked
Boiler Output Validation - Consumption	Shall be populated, but value not checked

Informative Appendix G

INFORMATIVE REFERENCES

This appendix contains informative references for the convenience of users of Standard 229P and to acknowledge source documents when appropriate. Some documents are also included in Section 10, “Normative References,” because there are other citations of those documents within the standard that are normative.

Reference		Section
ANSI/ASHRAE/IBPSA Standard 232-2024	Common Content and Specifications for Building Data Schemas	
ASHRAE SI Guide for HVAC&R	ASHRAE Handbook: SI Guide for HVAC&R https://www.ashrae.org/technical-resources/ashrae-handbook/the-si-guide	7.3
ANSI/ASHRAE/IES Standard 90.1-2019	Energy Standard for Buildings Except Low-Rise Residential Buildings	Normative Appendix G
ACM Approval Manual	Title 24 Alternative Calculation Method Approval Manual	
Python unit conversion library Pint version 0.18	https://pint.readthedocs.io/en/0.18	7.3

Normative Appendix H: Ruleset Project Description Generation Software Test Report Schema

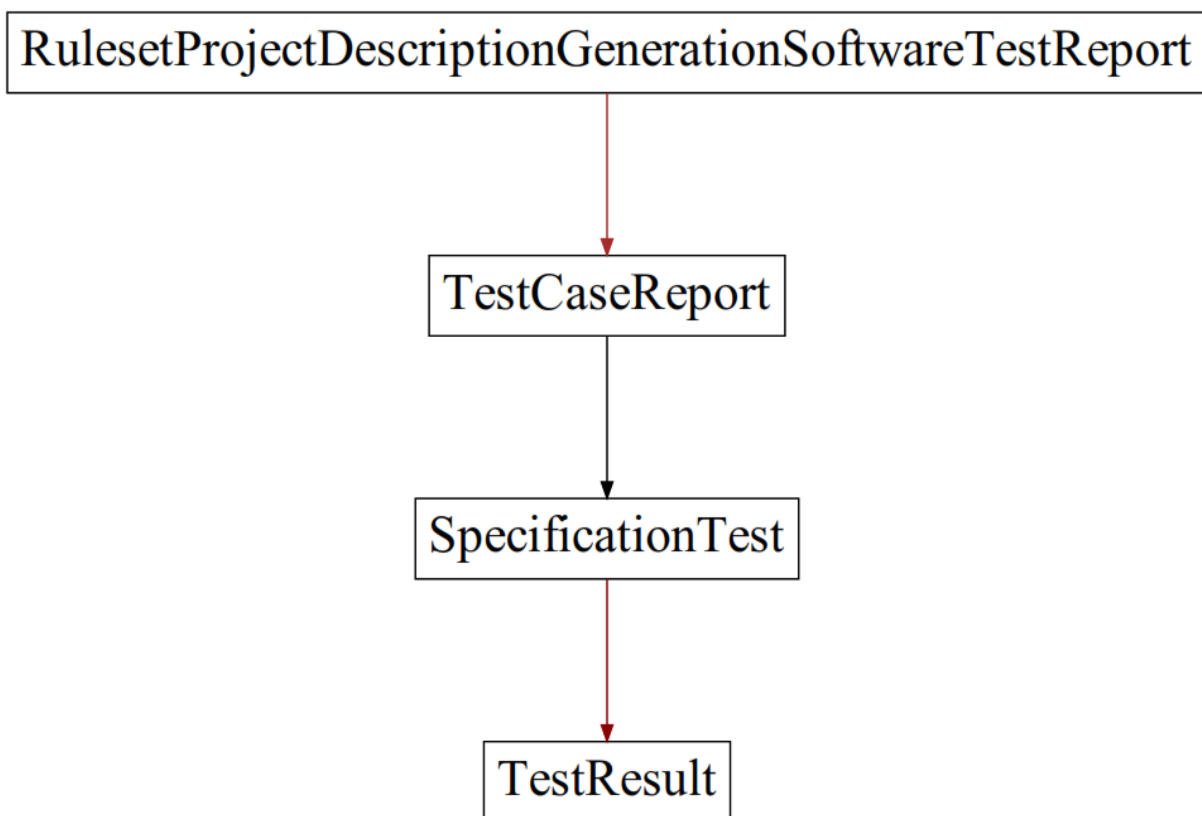
The *ruleset project description generation software* shall produce a software test report in *JSON* file format consistent with the *ruleset project description generation software* test report schema described in this appendix. The report shall contain the detailed results for all test results.

H.1 Format

The *ruleset project description generation software* test report schema shall be in *JSON* format following the rules described in Standard 205 Sections 5 except 5.1, 5.7, and 5.8; Section 6 except 6.1, 6.2, 6.3, 6.7, and 6.8; and Section 7.

H.2 Data Group Hierarchy (informative)

The hierarchy of the data groups is shown in the figure below.



H.3 Data Groups and Data Elements

The *ruleset checking tool* project evaluation report schema shall contain the data groups and data elements described at

https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/public%20review%20drafts/2025%20standard%20229/rpd_generation_software_test_report.schema.json

[Note for reviewers: The test cases are hosted on a temporary page for publication public review. The content will be moved to <http://data.ashrae.org/> upon publication.]

H.4. Data Group and Element Tables

[Note to reviewers:

The text of this PDF will be added here:

https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/public%20review%20drafts/2025%20standard%20229/rpd_generation_software_test_report.schema.pdf