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PNNL-32157-Rev.1

Commercial Building Energy Code Field Study

Data Collection Methodology and Protocol

January 2023

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J Huckett
M Tyler

U.S. DEPARTMENT OF ENERGY

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

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Acronyms and Abbreviations

AFUE	annual fuel utilization efficiency
AHJ	authority having jurisdiction
AHRI	Air Conditioning, Heating, and Refrigeration Institute
AHU	Air-handling unit
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BAS	building automation system
bhp	brake horsepower
Btu/h	British thermal unit per hour
CBECS	Commercial Buildings Energy Consumption Survey
cfm	cubic feet per minute
COP	coefficient of performance
Cx	commissioning
CZ	climate zone
DCV	demand control ventilation
DOAS	direct outdoor air system
DOE	United States Department of Energy
DX	direct expansion
EER	energy efficiency ratio
ERV	energy recovery ventilation
FPC	finite population correction
FCU	fan coil unit
hp	horsepower
HVAC	heating, ventilation, and air conditioning
IBC	International Building Code
ICC	International Code Council
IECC	International Energy Conservation Code
IMT	Institute for Market Transformation
kW	kilowatts
LPD	lighting power density
MBh	thousand British thermal units per hour
MERV	minimum efficiency reporting value
NFRC	National Fenestration Rating Council
OA	outdoor air
OAT	outdoor air temperature
PNNL	Pacific Northwest National Laboratory

PTAC	packaged terminal air conditioner
PTHP	packaged terminal heat pump
SAT	supply air temperature
SEER	seasonal energy efficiency ratio
SHGC	solar heat gain coefficient
SOO	sequence of operations
SRR	skylight to roof ratio
VAV	variable air volume
VFD	variable frequency drive
VSD	variable speed drive
WSHP	water source heat pump
WWR	window to wall ratio

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1.0 Introduction

This version supersedes a prior version, PNNL-32157. Previous sample sizes were calculated based on stratified survey sampling formulas. New (lower) sample sizes were calculated based on regression standard deviation and corresponding Coefficient of Variation (CV) estimates. The regression analysis was able to leverage all data points across strata rather than only those data points in a single stratum, leading to smaller standard errors and CV values, and thus lower sample sizes than the survey sampling approach. A minimum sample size of ten is now imposed prior to calculating the median CV and sample size and used for cases when CV = N/A.

In support of the U.S. Department of Energy's (DOE) Commercial Buildings Energy Code Field Study (DOE Field Study)[1] this data collection methodology and protocol (DOE Commercial Methodology) provides guidance on all aspects of undertaking a compliance study, from development of a sampling plan to recruitment to code requirements and compliance checks for each energy code measure specified to be collected. The protocol also includes a data collection form that captures all key information needed for analysis of commercial energy code compliance. This methodology was developed by the Institute for Market Transformation in coordination with Pacific Northwest National Laboratory (PNNL) and the U.S. Department of Energy (DOE) Building Energy Codes Program with the objective of assisting states, jurisdictions, utilities and others as they seek to measure and demonstrate compliance rates with energy codes in commercial buildings, as well as to target areas for improvement through increased energy code compliance and broader energy-efficiency programs. It is also intended to facilitate a consistent and replicable approach to research studies of this type and establish a transparent data set representing baseline construction practices across the U.S.

DOE is directed to participate in industry processes to develop model building energy codes, issue determinations as to whether updated codes result in energy savings and provide technical assistance to states to support code implementation[2]. In recent years, the DOE Building Energy Codes Program has emphasized assistance for states demonstrating compliance, and accompanying workforce education and training initiatives, with the ultimate goal of ensuring that cost-effective savings promised by building energy codes are fully realized by U.S. households and businesses. Previously, DOE developed a commercial compliance methodology and associated tools focused on determining a percentage-based compliance rate at the state level. This was completed in 2010 to support the American Recovery and Reinvestment Act of 2009. The approach calculated an average compliance score for a sample set of buildings based on a binary decision (i.e., yes or no) indicating whether individual requirements met code. The percentage of requirements where the building complied established the score for each individual building. This approach did not explicitly distinguish between varying levels of non-compliance nor did it evaluate the energy impact of individual requirements.

To move from a binary assessment of commercial building code compliance to a compliance methodology that focuses on estimating lost savings due to non-compliance, PNNL developed a new methodology in 2014. This updated methodology was capable of determining, for a sample of buildings, the amount of energy cost savings that could potentially be gained through better compliance with the code.

[1] https://www.energycodes.gov/compliance/energy-code-field-studies
[2] https://www.energycodes.gov/about/statutory-requirements

PNNL tested this new approach in a pilot study of nine office buildings in climate zone 4C. Following on the development of the new method and a pilot field test, in 2016 DOE released a Funding Opportunity Announcement (FOA) to test and finalize the methodology by scaling the field test to two additional climate zones and a larger sample of commercial buildings. The current report documents the completed development of this version of the methodology.

This updated DOE Commercial Methodology is based on key items—a subset of code requirements identified as having the largest direct impact on commercial energy efficiency. Plan review and field data for these items, in addition to basic information about a building, is collected from permitting departments and newly constructed commercial buildings from a defined geographic area (usually an entire state).

The DOE Commercial Methodology is provided primarily for states and other entities conducting their own studies and will help ensure that results are comparable with similar research. The resulting findings will be of value to a diverse set of stakeholders, including state energy offices, local governments and their building departments, builders and contractors, utilities and policymakers. Ideally, states would conduct a study using the DOE Commercial Methodology every 3–5 years to establish trends in commercial new construction and identify areas of change. Ultimately, the results can be used to identify savings opportunities, develop more effective and targeted training programs, create and validate more accurate energy forecasts, inform industry consensus processes, and serve as a baseline for broader energy-efficiency programs and R&D efforts.

2.0 Measures and Building Types

The DOE Commercial Methodology has been developed for commercial office and retail buildings in Climate Zones 2A and 5A only. For expansion to new climate zones and new building types, key measures may need to be analyzed and re-ranked based on worst-case analysis to determine potential levels of impact for investigation in those cases. A worst-case analysis could be completed in advance of future field studies. However, actual results will of course vary with field data from future studies.

2.1 Key Measures

The following is the identified list of key measures on which data collection is focused—those with the greatest direct impact on commercial energy consumption. These form the foundation of the DOE Commercial Methodology and drive the data analysis and resulting savings projections. Measures identified here will not be applicable to all IECC or ASHRAE versions and are identified based on code and standard section in Appendix B. The 67 key measures in the DOE Field Study are:

A. Envelope
   1. Roofs shall be insulated to meet climate zone (CZ) requirements
   2. Low-slope roofs in CZ 1–3 shall be cool roofs
   3. Above-grade frame walls shall be insulated to meet CZ requirements
   4. Above-grade mass walls shall be insulated to meet CZ and density requirements
   5. Exterior frame floors shall meet the insulation requirements
   6. Exterior mass floors shall meet the minimum R-value or U-value by assembly type
   7. Opaque rollup doors shall meet U-factor requirements
   8. Window-to-wall ratio shall meet maximum limits
   9. Skylight-to-roof ratio shall meet maximum limits
   10. Windows shall meet U-factor requirements
   11. Windows shall meet SHGC requirements
   12. Skylights shall meet U-factor requirements
   13. Skylights shall meet SHGC requirements
   14. Building shall meet continuous air barrier requirements
   15. Stair and shaft vent leakage
   16. Building entrances shall be protected with an enclosed vestibule
   17. Fenestration orientation

B. Mechanical/Plumbing
   1. Packaged air conditioner efficiency
   2. Packaged heat pump efficiency
   3. Gas furnace efficiency

4. Boiler efficiency
5. WSHP efficiency
6. Air-cooled chiller efficiency
7. Water-cooled chiller efficiency
8. Heat pump supplementary heat control
9. Thermostat deadband requirement
10. Thermostat heating setback
11. Thermostat cooling setback
12. Night fan control
13. Optimal start controls
14. Snow and ice-melting system control
15. Demand control ventilation
16. Energy recovery requirement
17. Exterior (outside building) duct insulation
18. Duct leakage requirement
19. Hydronic piping HW insulation requirement
20. Mechanical commissioning
21. Fan power limit requirement for Pkg AC
22. Fan power limit requirement for VAV
23. Outdoor heating: radiant and controlled
24. Economizer supplies 100% design supply air
25. Water economizer capacity meets requirements
26. Multi-zone reheat systems shall be VAV with appropriate zone minimums, and fans with motors ≥threshold hp shall be variable speed or pitch
27. Static pressure reset for multi-zone VAV fans
28. Each WSHP in a system exceeding 10 hp pump shall have a two-position valve
29. Multiple chillers shall reduce flow when a chiller is shut down
30. Multiple zone HVAC systems shall have supply-air temperature reset controls
31. VAV ventilation optimization
32. Single-zone VAV
33. Parking garage fan controls
34. Zone isolation
35. SWH pipe insulation—Recirculated

C. Lighting/Electrical

1. Manual lighting control

2. Automatic time switch control
3. Occupancy sensor control
4. Daylighting control
5. For large, high-bay spaces, total daylight zone under skylights at least 1/2 of floor area
6. Display lighting control
7. Lighting for nonvisual applications shall be controlled separately
8. Exterior lighting control
9. Interior lighting power allowance
10. Additional retail lighting power allowance
11. Exterior lighting power allowance
12. Occupant-based parking garage light control
13. Receptacle controls
14. Lighting testing or commissioning
15. Optional on-site renewables

The preceding measure list was developed for commercial office and retail buildings in Climate Zones 2A and 5A only. Many of these measures could also apply to additional building types and climate zones. There could be additional measures that would be worthwhile to consider adding to this list when investigating other building types. For example, additional measures that could be considered for multifamily buildings include:

1. Gas boiler efficiency for central DHW
2. PTAC efficiency
3. PTHP cooling efficiency
4. PTHP heating efficiency
5. Ductless minisplit cooling efficiency
6. Ductless minisplit heating efficiency
7. Water heater efficiency, Gas storage in dwelling unit
8. Water heater efficiency, Electric storage in dwelling unit
9. Water heater efficiency, Electric tankless in dwelling unit
10. Heat traps for DHW storage tanks
11. Central DHW demand recirculation controls and/or heat trace
12. Central DHW temp maintenance system

2.2 Applicable Commercial Building Types

This methodology has been developed for commercial office and retail buildings only. The following building subtypes have been determined to comply with the definitions of commercial office and retail building construction (Table 1). A full accounting of activities and subcategories reviewed for inclusion in this study is presented in Appendix C. Additional building types, subcategories, and descriptions are available in the Commercial Buildings Energy Consumption Survey (CBECS).[1]

Table 1. Applicable Building Activities and Categories

Principal Activity	Subcategory	Description/Examples
Retail other than mall	Vehicle dealership/ showroom	Dealership or showroom for vehicles or boats
	Retail store[2]	Department store, furniture, clothing, hardware, sporting goods, office supplies, drugstore, bookstore, building supplies, auto parts, lumber, home improvement, farm equipment, lawn and garden, floral, crafts, gifts, antiques, pawn shop, wholesale club.
	Other retail	Beer, wine, or liquor store;[3] rental center, such as for equipment furnishings or movies; studio or gallery; showroom; wholesale supply.
Strip shopping mall	Strip shopping mall[4]	Strip shopping center buildings containing establishments that are operated independently of each other; strip shopping center buildings that are reported at the building level in the Commercial Building Energy Consumption Survey.
Office	Administrative/ professional office	Administrative or professional such as consulting, insurance, law, utilities, publishing, or college administration; nonprofit or social services; religious office; research and development; sales or leasing office.
	Bank/other financial	Bank, credit union, home finance
	Government office	Government office, city hall, city center
	Medical office (non-diagnostic)	Doctor's or dentist's office that did not report equipment for medical diagnosis or treatment.
	Mixed-use office	Mixed-use office
	Other office	Call center; contractor's office such as construction, plumbing, or HVAC.

[1] https://www.eia.gov/consumption/commercial/building-type-definitions.php
[2] Chain retail stores should be limited to three per chain, and further limited to no more than two per designer or contractor.
[3] Liquor stores should be limited to those with small amounts of refrigeration. Areas of large beer coolers that begin to mimic the typical amount of refrigeration found in convenience stores should be avoided.
[4] Assuming the strip and multiple tenants fit into the requirements for building recruitment, an individual center can be used three times: once for the core and shell construction, and up to two more times for tenant fit-out construction.

3.0 Sampling Plan Development

The DOE Commercial Methodology requires the project team to define a geographic area for data collection and create a sampling plan of commercial buildings within that area. The sampling plan will at a minimum specify the number of each building type required to be included in data collection and may specify the number of observations needed for each, or a subset of, key measures.

The sampling plan has two main purposes: 1) to determine target numbers for buildings to include in the field study, within relevant size strata and building types; and 2) to identify jurisdictions within each state (or geographic areas within each city) in which to prioritize recruitment of participating buildings.

The development of the sampling plan includes the following steps:

1. Enumerate population of construction starts
2. Stratify population
3. Determine sample size by stratum
4. Allocate stratum sample sizes to geographic areas
5. Calculate measure sample size requirements
6. Review and finalize

These steps follow a set of recommendations with potential modifications based on building size strata, geographic proportionality, and required level of statistical accuracy as presented below. Projects can be successfully completed by generating a simple sampling plan using only Steps 1-3 and 6. Steps 4 and 5 can be used to develop more detailed sampling plans depending on the goals and needs of each study.

3.1.1 Step 1: Enumerate Population of Construction Starts

Data sources for identifying construction starts. Project teams have two primary options for estimating building construction starts sizes: purchasing data from Dodge Data and Analytics[1], or making direct requests to permitting jurisdictions. Collecting data from jurisdictions is labor intensive, with results hinging directly on the willingness of the jurisdictions to provide timely support and quality of provided data. Depending on the time and cost constraints on the project team implementing the DOE Commercial Methodology, either method is viable for determining populations.

Project teams should note that in most states and smaller geographic areas (i.e., counties or cities) it is unlikely that there will be sufficient numbers of construction starts to create a sampling plan that can return a high degree of statistical confidence within these areas due to the variety of commercial construction typologies combined with the variations in compliance and construction methods to comply with the commercial energy code.

- Review most-recent available Dodge Data
  - If you believe data are accurate for purposes of enumerating the population of new starts, and prioritizing jurisdictions to collect data in, skip to Step 2.

[1] https://www.construction.com/

  - If you do not believe is the data are accurate, propose an alternative approach. Examples include:
    - Direct data collection from major jurisdictions
    - Available census data
    - Available GIS or other data set maintained at the jurisdiction level

- Define alternative data needs:
  - Define why you believe the alternative data source is more accurate.
  - Information required: You will need, at minimum, building type, building size, and permitting jurisdiction to complete the steps in this process.
  - Timeline: At least 12 months, but ideally in line with a calendar year so potential faults in Dodge Data can be assessed.
  - Filter to qualifying office and retail buildings using the guidance in Table 1.

3.1.2 Step 2: Stratify Population

- Create a table with counts of new starts by building type by size stratum:
  - Small (≤25,000 sq. ft.)
  - Medium (>25,000 sq. ft. and ≤60,000 sq. ft.)
  - Large (>60,000 sq. ft. and <250,000 sq. ft.)
  - X-large (>250,000 sq. ft. and ≤400,000 sq. ft.)
  - XX-large (>400,000 sq. ft.)

Table 2. TEMPLATE: Stratified Population (Number of New Starts)

Stratum	Office	Retail
Small (≤25,000 sq. ft.)		
Medium (>25,000 – ≤60,000 sq. ft.)		
Large (>60,000 – ≤250,000 sq. ft.)		
Extra-Large (XL) (>250,000 – ≤400,000 sq. ft.)		
Extra-Extra-Large (XXL) (>400,000 sq. ft.)		
TOTAL BUILDINGS		

3.1.3 Step 3: Determine Sample Size by Stratum

The practitioner should review the stratified population sizes. If each stratum population is sufficiently large, sample sizes can be calculated as described here. Otherwise, two alternative approaches are provided below.

Sample sizes should be calculated within each stratum based on its population size, assumed CV, and desired confidence and precision of results. Standard sample size formulas that apply

finite population correction (FPC) should be used.[1] Applying FPC reduces the number of observations required to meet confidence and precision targets in small populations, such as commercial new starts.

The following table provides sample sizes for a range of population sizes and CV values. These population sizes are nominal. The CV values are based on average building present value of lost savings ($/kSF) and total and standard deviation in the sample data collected in a previous study (Tyler et al., 2023). The low, mid, and high CV values were set to 1x, 2x, and 3x of the sample CV, respectively. Sample sizes were calculated using the FPC and with 80% confidence/20% precision targets.

Table 3. Sample Sizes for a Range of Population Sizes and CV Values

Assumptions	Population Size (New Starts)	CV	Confidence Level	Precision Target	Sample Size with FPC (New Starts)
Small population size & low CV	20	1.08	80%	20%	15
Small population size & mid CV	20	2.15	80%	20%	19
Small population size & high CV	20	3.23	80%	20%	20
Large population size & low CV	200	1.08	80%	20%	39
Large population size & mid CV	200	2.15	80%	20%	98
Large population size & high CV	200	3.23	80%	20%	137

The practitioner should calculate sample sizes based on the population size of new construction starts in their study, as determined in Step 2. CV values from the previous study can be used or they can be updated based on additional information available for the study. To generate a simplified sampling plan, a CV value from the table above (i.e., assume 1.08 for low expected CV, 2.15 for mid expected CV, or 3.23 for high expected CV) is recommended. The resulting sample sizes should be reported in a table like the following template.

The CVs and sample sizes provided above are based on the results of one previous study and intended to provide input for future studies. Upon completion of a new study, data collected therein should be used to calculate the lost savings estimates, corresponding observed CV values, and precision for each measure in that study. It is important to appreciate the iterative nature of using prior information to inform future studies which then calculate these values anew using collected data. Further, CV values based on the collected data will differ from those provided above, which will impact the calculated precision for that study.

[1] Standard sample size calculation with FPC: first calculate $n_{initial} = \left(\frac{CV \times z}{precision}\right)^2$ and then apply FPC to calculate the stratum sample size $n_{FPC} = \frac{n_{initial} \times N}{n_{initial} + N}$, where N is the stratum population size.

Table 4. TEMPLATE: Stratified Sample Sizes

Stratum	Assumed CV for Office	Sample Size for Office	Assumed CV for Retail	Sample Size for Retail
Small (≤25,000 sq. ft.)				
Medium (>25,000 – ≤60,000 sq. ft.)				
Large (>60,000 – ≤250,000 sq. ft.)				
Extra-Large (XL) (>250,000 – ≤400,000 sq. ft.)				
Extra-Extra-Large (XXL) (>400,000 sq. ft.)				
TOTAL BUILDINGS				

In many cases, upon reviewing the strata population sizes from Step 2, the practitioner may determine that using a census sampling approach for some strata is warranted or that combining strata would provide an improvement.

Census sample approach. Large, XL and XXL buildings are important for inclusion in the sampling plan for two key reasons: 1) greater quantities of energy savings are at stake; 2) they commonly contain energy efficiency measures such as complex HVAC equipment and lighting controls not present in smaller buildings. Therefore, to the extent that such measures are of importance to the study, the project team must get into large buildings to find them.

The number of newly constructed large, XL and XXL buildings may be relatively low across the study area, even in populous and economically vibrant areas. Where they are scarce, it is recommended that the study employ a census approach[1], while recognizing that timing and recruitment constraints will likely not result in 100% inclusion. In these cases, the sample sizes can be set equal to the population sizes in the sampling plan, with a note explaining the rationale.

Alternative approach. Assess the population sizes and adjust strata definitions as necessary. In cases where large, XL, and/or XXL new start population sizes are too small for the sample plan approach above but do not justify a census sample approach, strata can be combined as follows.

- Where there are small populations of XL and XXL buildings, combine those size strata with the large strata and redefine all strata as follows:
  - Small (≤25,000 sq. ft.)
  - Medium (>25,000 sq. ft. and ≤75,000 sq. ft.)
  - Large (>75,000 sq. ft.)
- Where appropriate, small and medium may also be combined into a single category, thereby creating only two size strata.
- Review the new start populations based on the final strata.

[1] A census approach selects all of the new starts in a particular stratum, compared to a sampling approach, which selects a subgroup of new starts (often at random).

- Determine a sample size in each stratum using a standard sample size calculation described above.

Sample sizes should be included within the final strata in a table like that shown in the following template, updated based on final strata definitions.

Table 5. TEMPLATE: Sample Size by Stratum with Two Final Strata

Stratum	Office	Retail
Small/Medium (≤75,000 sq. ft.)		
Large (>75,000 sq. ft.)		
TOTAL BUILDINGS		

For many simple applications of this protocol, practitioners can choose to stop here, the sample generated through Step 3 can be used to understand the building stock compliance by providing qualitative directional information. Teams wishing to use a simplified method can skip to Step 6.

3.1.4 Step 4: Allocate Sample Sizes to Geographic Areas

Often, development of a sampling plan that includes geographical considerations of the individual states or other bounded areas is valuable, especially if study results are intended to inform stakeholder or political decision making in those areas. Alternatively, study resources (time and cost) are often limited, such that concentration of sampling in areas with high construction volume would be the most efficient use of resources.

The goals of the study should be reviewed to determine if a specific distribution of the sample over geographic areas is required. Options may include allocating the sample sizes equally to all areas, allocating proportional to the new starts in each area, and/or allocating more sample points to some areas and fewer or none to others. Not all allocation options will be possible or necessary for all studies. The office in charge of the study should consult with stakeholders to determine if any geographic sampling requirements are desired. If not required, skip to Step 5.

Geographic sample allocation.

- One method for creating a sampling plan with geographic proportionality is presented in the DOE Residential Energy Code Field Study (DOE, 2018) Appendix B and can be used with commercial data if desired.
- A geographically representative sampling plan of commercial buildings should ensure the larger size strata are able to be collected in each geographic area. Large, XL, and XXL buildings are more likely to be constructed in dense population areas and sample sizes may need to be allocated in higher numbers to a select set of jurisdictions to ensure data collection of these building sizes is feasible.

For many simple applications of this protocol, practitioners can choose to stop here, as the sample generated through Step 4 can be used to understand the building stock compliance by providing qualitative directional information. Teams wishing to use a simplified method can skip to Step 6.

3.1.5 Step 5: Calculate Measure Sample Size Requirements

The sample sizes calculated through Step 3 will provide statistically significant building-level results with the specified precision and confidence levels (e.g., 80% confidence and 20% precision), provided the observed CVs in the collected data are similar to those assumed in the sample size calculation. If a goal of the study is to achieve statistical significance at other level(s) (e.g., measure-level), then corresponding sample sizes must be calculated. If these sample sizes are not achieved, results could end up providing qualitative directional information rather than quantitative statistically significant results.

Given that measure-level statistical significance is often of interest, guidance based on a previous study (Tyler et al., 2023) is provided here. Present value lost energy savings ($ per kSF) from each verified measure was estimated using a regression analysis and the resulting standard errors were used to derive CV values for each measure, which were used to calculate future sample size requirements for estimating mean lost savings with 80% confidence and 20% precision in a new study. The following table provides measure categories and descriptions, the number of observations used to calculate the CV in Tyler et al. (2023), and the sample sizes in terms of the number of verified measures that would be required to measure lost savings in a future study. CV entries are “NA” when too few observations were made to calculate the sample size or when there was no variation in the observations (i.e., all measures were compliant and the standard error was zero, resulting in CV equal to zero). For these measures, we used the median CV and corresponding sample size (median CV=0.84 and sample size n=29). The resulting CV values were between 0.35 and 0.91. When the CV values were estimated based on fewer than n=10 observations, the sample sizes were set to n=29, corresponding to the median CV; a minimum sample size of n=10 was enforced. No FPC was applied for measure sample sizes because measure population sizes were unknown. The resulting measure sample sizes ranged from 22 to 35.

During the study, the practitioner should compare the number of verified measures to the sample sizes below to manage expectations about achievable precision. For example, consider the first measure in the table specifying that roofs shall be insulated to meet CZ requirements, where the sample size in the table is 31 verified measures (based on CV=0.87). If the study is on track to collect fewer verified measure observations, then the precision of final lost savings estimates could be worse than 20% (at 80% confidence). On the other hand, if the study is on track to collect a greater number of observations or if the variability of observed present value lost savings is lower than in Tyler et al. (2023)—leading to a lower CV, then the precision could be better than 20%.

Table 6. Sample Size by Measure

Category	Description	Number of Observed Measures	CV	Sample Size for 80/20
Envelope	Roofs shall be insulated to meet CZ requirements	103	0.87	31
Envelope	Low slope roofs in CZ 1-3 shall be cool roofs	13	0.74	23
Envelope	Above grade frame walls shall be insulated to meet CZ requirements	25	0.76	24

Category	Description	Number of Observed Measures	CV	Sample Size for 80/20
Envelope	Above grade mass walls shall be insulated to meet CZ and density requirements	105	0.87	32
Envelope	Exterior frame floors shall meet the insulation requirements	8	0.72	29
Envelope	Exterior mass floors shall meet the minimum R-value or U-value by assembly type	1	NA	29
Envelope	Opaque rollup doors shall meet U-factor requirements	45	0.77	25
Envelope	Window-to-wall ratio shall meet maximum limits	170	0.81	28
Envelope	Skylight to roof ratio shall meet maximum limits	83	0.85	30
Envelope	Windows shall meet U-factor requirements	17	0.77	25
Envelope	Windows shall meet SHGC requirements	10	0.73	22
Envelope	Skylights shall meet U-factor requirements	7	0.72	29
Envelope	Skylights shall meet SHGC requirements	7	0.72	29
Envelope	Building shall meet continuous air barrier requirements	81	0.84	29
Envelope	Stair and shaft vent leakage	87	0.79	26
Envelope	Building entrances shall be protected with an enclosed vestibule	187	0.85	30
Envelope	Fenestration orientation	66	0.82	28
Mechanical/Plumbing	Packaged air conditioner efficiency	22	0.78	25
Mechanical/Plumbing	Packaged heat pump efficiency	105	0.87	32
Mechanical/Plumbing	Gas furnace efficiency	85	0.79	26
Mechanical/Plumbing	Boiler efficiency	45	0.77	25
Mechanical/Plumbing	WSHP efficiency	NA	NA	29
Mechanical/Plumbing	Air-cooled Chiller efficiency	2	0.35	29
Mechanical/Plumbing	Water-cooled chiller efficiency	NA	NA	29
Mechanical/Plumbing	Heat pump supplementary heat control	1	NA	29
Mechanical/Plumbing	Thermostat deadband requirement	14	0.75	24
Mechanical/Plumbing	Thermostat heating setback	21	0.76	24
Mechanical/Plumbing	Thermostat cooling setback	138	0.82	28
Mechanical/Plumbing	Night fan control	13	0.74	23
Mechanical/Plumbing	Optimal start controls	158	0.88	32
Mechanical/Plumbing	Snow and ice-melting system control	2	0.35	29
Mechanical/Plumbing	Demand control ventilation	44	0.82	28
Mechanical/Plumbing	Energy recovery requirement	8	0.72	29
Mechanical/Plumbing	Duct insulation requirement	3	0.56	29

Category	Description	Number of Observed Measures	CV	Sample Size for 80/20
Mechanical/Plumbing	Duct leakage requirement	7	0.72	29
Mechanical/Plumbing	Hydronic Piping Insulation Requirement HW	135	0.81	28
Mechanical/Plumbing	Commissioning requirement	22	0.78	25
Mechanical/Plumbing	Fan power limit requirement for PkgAC	12	0.76	24
Mechanical/Plumbing	Fan power limit requirement for VAV	NA	NA	29
Mechanical/Plumbing	Outdoor heating shall be radiant and controlled with occupancy sensor	9	0.73	29
Mechanical/Plumbing	Economizer supplies 100% design supply air	24	0.78	25
Mechanical/Plumbing	Water economizer capacity meets requirements	1	NA	29
Mechanical/Plumbing	Multi-zone systems shall be VAV and fans with motors ≥threshold hp shall have variable speed, variable pitch axial, or fan demand reduction	2	0.35	29
Mechanical/Plumbing	Static pressure sensors used to control VAV fans shall be properly placed	1	NA	29
Mechanical/Plumbing	Each WSHP in a system exceeding 10 hp pump shall have a two-position valve	1	NA	29
Mechanical/Plumbing	Multiple chillers shall reduce flow when a chiller is shut down	NA	NA	29
Mechanical/Plumbing	Multiple zone HVAC systems shall have supply-air temperature reset controls	2	0.35	29
Mechanical/Plumbing	VAV ventilation optimization	NA	NA	29
Mechanical/Plumbing	Single zone VAV	1	NA	29
Mechanical/Plumbing	Parking garage fan controls	3	0.56	29
Mechanical/Plumbing	Zone Isolation	2	0.35	29
Mechanical/Plumbing	SWH Pipe Insulation - Recirculated	4	0.65	29
Lighting/Electrical	Manual lighting control	12	0.76	24
Lighting/Electrical	Automatic time switch control	65	0.81	27
Lighting/Electrical	Occupancy sensor control	156	0.87	32
Lighting/Electrical	Daylighting control	101	0.86	31
Lighting/Electrical	For large, high-bay spaces total daylight zone under skylights at least 1/2 of floor area	73	0.79	26
Lighting/Electrical	Display lighting control	15	0.75	24
Lighting/Electrical	Lighting for nonvisual applications shall be controlled separately	2	0.35	29
Lighting/Electrical	Exterior lighting control	214	0.91	35
Lighting/Electrical	Interior lighting power allowance	147	0.85	30
Lighting/Electrical	Additional retail lighting power allowance	39	0.81	28

Category	Description	Number of Observed Measures	CV	Sample Size for 80/20
Lighting/Electrical	Exterior lighting power allowance	191	0.86	31
Lighting/Electrical	Parking garage lighting controls	1	NA	29
Lighting/Electrical	Plug load controls	14	0.75	24
Lighting/Electrical	Lighting Testing or Commissioning	168	0.91	34
Lighting/Electrical	Optional on-site renewables	NA	NA	29

The following table provides a summary of CV values for cases where individual measures are different from those listed above, no prior information on CV exists, and the CV is expected to be higher or lower than listed in the table above.

- Individual verified measures: provides the maximum, 75th quartile, and median CV values from the table above (Tyler et al., 2023). These CV values can be used if information is available to indicate that variation in the new study is expected be similar to the results above (use the median), a bit higher (use the 75th quartile), or much higher (use the max CV).
- Combined measures within building type & climate zones: provides the maximum, 75th quartile, and median CV values when verified measures were combined within each building type and climate zone stratum (Tyler et al., 2023). Use similar guidance as in the first bullet about which CV to use based on expectations about variability.
- Combined measures within building type: provides the maximum and minimum CV values when verified measures were combined within each building type stratum. Only two building types were included in the study, so no quartiles were observed. Use the similar guidance as in the first bullet about which CV to use based on expectations about variability.

Table 7. Summary of CV Values and Sample Sizes

Results	CV		Confidence Level	Precision Target	Sample Size (Measures)
Individual verified measures	Maximum	0.91	80%	20%	35 (per measure)
	75th quartile	0.87	80%	20%	32 (per measure)
	Median	0.84	80%	20%	29 (per measure)
Combined measures within building type & climate zones	Maximum	3.96	80%	20%	645 total
	Minimum	2.63	80%	20%	284 total
Combined measures within building type	Maximum	4.59	80%	20%	866 total
	Minimum	3.99	80%	20%	655 total

The CVs and sample sizes provided above are based on the results of one previous study and intended to provide input for future studies. Upon completion of a new study, data collected therein should be used to calculate the lost savings estimates, corresponding observed CV values, and precision for each measure in that study (using a similar regression analysis as that used to determine the values above). It is important to appreciate the iterative nature of using prior information to inform future studies which then calculate these values anew using collected data. Those published results can then be used to inform additional future studies.

The number of measures will be unknown prior to recruiting sites, reviewing plans, and completing site visits. Thus, sample sizes in terms of new starts (buildings) tend to be more helpful than measure sample sizes during project planning, budgeting, and recruiting. Unfortunately, the number of measures is not a direct function of the number of sites.

If the intent is to rank measures by lost savings or to assign lost savings at the measure level with a reasonable degree of confidence and precision, it is important to achieve a measure level sample size following the approach outlined above. This may require sampling additional sites to collect sufficient data for a specific measure. It is important to understand that the sample sizes listed above may not be attainable and the final achieved sample sizes will not be known until site visits have been completed. Further, CV values based on the collected data will differ from those provided above, which will impact the calculated precision of each measure for that study.

3.1.6 Step 6: Finalize and Review

The final sampling plan should include description of data sources, table with building population figures by strata, and prioritized jurisdictions. Sampling plans should be reviewed and assessed periodically throughout the data collection process to make necessary adjustments based on available buildings.

4.0 Data Collection

The data collection protocol was developed for use primarily with projects pursuing prescriptive or envelope trade off paths under the 2012 International Energy Conservation Code (IECC) and ASHRAE Standard 90.1-2010; however, it is easily adapted to other versions of the codes and standards. States assessing other code versions, or significantly amended versions of the model code, may need to modify the protocol. It is the responsibility of the data collection team for each state to be knowledgeable of the state energy code and its provisions. For projects using the performance path, additional information may be needed by data collectors for quality assurance and data analysis.

The protocol details what key information should be sought and how that information is entered into the data collection form. In addition, it provides field teams with instructions on completing plan reviews and field observations, as well as insight on valuable best practices.
Data Collection is based on the following process (Figure 1):

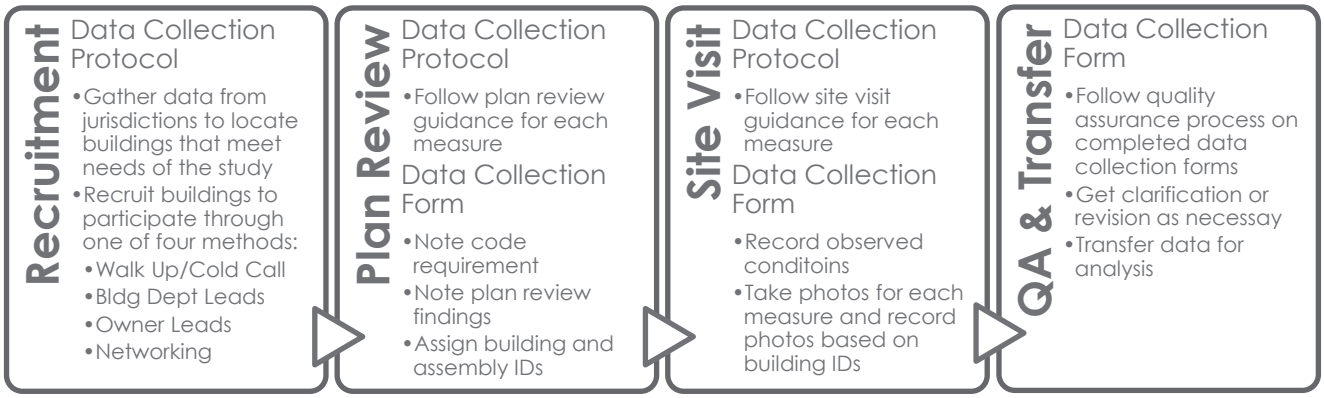

Figure 1. Data Collection Process

4.1 Building Recruitment

To begin, each team must find buildings that fit within the parameters of the study and recruit them to fulfill the project sample. Project teams should gather and review basic building permit information from multiple jurisdictions before any outreach begins by researching the online permit information and making direct requests to departments. With permit information in hand, project teams will need to identify buildings that would qualify for the study, and begin to contact builders, designers, or code officials for permission to go on site.

Building recruitment strategies can take on multiple forms. Four primary recruitment methods are described here, along with potential successes and obstacles.

4.1.1 Building Department Leads

Description: Collect permit lists from counties and cities within the study area and identify potential study sites based on building type, date of permit issuance, and code year. From the permit data, request building departments put data collection teams directly in contact with general contractors.

Successes: Uses a direct connection from the building department to the contractors in the area, which eliminates the need to cold call.

Obstacles: Involves a fair amount of follow up with contractors for scheduling. To avoid bias on behalf of the building department, it is critical that the data collection team identify projects that they wish to be put in touch with and not allow the building department to drive the selection.

4.1.2 Walk-Ups

Description: Collect permit lists from counties and cities within the study area and identify potential study sites based on building type, date of permit issuance, and code year. From the permit data, use timing of most recent inspections to determine if the building may be ready for site visit. Data collection team proceeds directly to the construction site ready to be allowed on site (full Personal Protective Equipment, data collection forms, etc.), asks to speak with the general contractor, and introduces the project with a request to be allowed on site.

Successes: Relatively low recruitment time effort compared to others because a few minutes on site will determine if the team is allowed on, rather than multiple phone calls or scheduling emails.

Obstacles: Works best in an area where there are multiple potential sites within short driving distance. A single building that is in a more remote location is not ideal because, if turned down, the low time effort has been negated by a long drive. Additionally, this effort may be most effective in projects that are still in active construction. Data collection teams should note that this effort restricts building plan review until after the site visit has been completed. Review of plans can be time consuming and is therefore not suggested before access is granted.

4.1.3 Owner/Developer Leads

Description: As above, collect permit lists from counties and cities within the study area and identify potential study sites based on building type, date of permit issuance, and code year. Using the permit data, data collection teams contact owners and property managers directly (no third-party introduction) to describe the study and ask if they would be willing to participate.

Successes: A single owner/developer may have multiple buildings in the study area, giving a high return on contact.

Obstacles: May involve a significant time conducting outreach and follow up. Calls may be redirected to reach the right person. Refusals to participate can be wide ranging from lack of interest in energy evaluation or inability to devote any resources toward the effort.

4.1.4 High-Level Networking

Description: Contact trade association and membership organization chapters, boards, and staff of real estate, owners and construction groups to introduce the project and develop connections and leads. Organizations and chapters may include:

- American Institute of Architects (AIA)
- Building Owners and Managers Association (BOMA)
- Commercial Real Estate Development Association (NAIOP)

- Institute of Real Estate Management (IREM)
- International Code Council (ICC)
- International Council for Shopping Centers (ICSC)
- Local Building Officials Associations
- Urban Land Institute (ULI)
- US Green Building Council (USGBC)

Successes: In comparison to a cold calling method of outreach, this method provides a direct introduction through a source that is familiar to the architect, owner, developer, or contractor and promotes broader awareness of the goals of the project. Connections through this method can be strung together to build a larger pipeline of potential samples.

Obstacles: Will require a good amount of follow up time.

4.2 Plan Review

In this step, data collection teams review the building plans, project specifications, and other available energy code compliance documentation (e.g., COMcheck[1] or performance-based submissions). This allows teams to identify key information for each measure listed on the data collection form and within this protocol. Data gathered through plan review also helps ensures a richer data set for later analysis. Ideally, the data collection team should conduct the plan review portion of the process prior to the field visit (though after securing clear permission to have site access).

4.2.1 Building Department Outreach

Data collection teams should reach out to building departments to clarify the data request protocol that needs to be followed. If required by the building department, data collection teams are recommended to submit data requests for the necessary documents for plan review well ahead of scheduled site visits. In most jurisdictions, once a building permit is issued, the building permit documents are public records and can be requested directly from the building department without filing a Freedom of Information Act (FOIA) request. Each state and jurisdiction may have varying requirements around these requests that range from a small fee (most common if documents need to be physically copied or printed), to requirements of residency.

4.2.2 Data Collection Form

The data collection form was developed to capture all pertinent information needed from plan review and site inspection for each code measure. The form was developed for direct electronic input which helps limit the amount of time spent transferring data. If necessary, data collection teams can choose to fill out a printed copy of the data collection form template, understanding that data transfer back to the digital form will be required.

[1] https://www.energycodes.gov/comcheck

The data collection form has four main sections, and the following sheets:

- Building Information
- Envelope
  - Roof
  - Walls
  - Floor
  - Additional Envelope Measures
- Mechanical/Plumbing
  - HVAC System
  - HVAC Log
  - Ventilation Controls
  - Complex Mechanical Controls
  - Additional Mechanical Measures
- Electrical/Lighting
  - Fixtures
  - Controls
  - Lighting System
  - Additional Electrical Measures

4.2.3 Personally Identifiable Information

Personally identifiable information (PII) is sensitive personal information which can be used to distinguish or trace an individual or building. For purposes of this project, these include information such as builder name, site address, jurisdiction name, and any photographs that may include PII, such as images of faces, the building address, or identifiable location information. Data collection teams are required to keep such information for confidential and only share building identifiers. The project team should have a documented plan to manage and safeguard PII, and personnel should only have access to PII on a need-to-know basis to preserve appropriate anonymity of study participants. At no point should PII be transmitted or disclosed to DOE or PNNL.

To avoid sending PII, the data collection form should include only a coded identification number, or identifier, assigned to each building in this format: two-letter state abbreviation + a unique number assigned by the project team. Naming Protocols are detailed in Table 3. If issues are found during the data review process, the data collection team will be contacted with this identifier. The data collection teams are responsible for managing raw data and ensuring that no identifiable information is transmitted to non-authorized parties.

Table 8. File and Folder Naming Protocols

Naming Protocol for	Protocol Description	Example
Building Identifier	[State Abbreviation] [Triple Digit Number]	FL001
Photos	[Building Identifier]_[Measure Number from the Data Collection Form]_[Double Digit Number]	FL01_5012_01
Site Photos Folder	[Building Identifier]_[“Site Photos”]	FL01_SitePhotos
Data Collection Form	[Building Identifier]_[“Form”]	FL01_Form

4.2.4 Plan Review

The data collectors for plan reviews and field inspections should provide their name and note the building identifier (as assigned by data collection teams; see PII above) in the data collection form before the data collection process begins. To begin, gather and enter basic building/project information on the Building Characteristics Sheet, including the following:

- Site contact information: Name, contact phone number, and company/organization[1]
- Building location: City, county, state and zip code location, ASHRAE Climate Zone
- Completion date and occupation
- Building size: Gross floor area, Conditioned floor area, and number of stories (above grade only)
- Building type and occupancies: Indicate if project is Office or Retail as primary type.
  - Typical storage areas do not need to be identified separately from the primary type.
  - Include information on secondary and tertiary types of occupancy (select from list) with % floor area for each when:
    - There are small portions (<~10%) of the building that are different from the main office or retail occupancy (example: a small coffee shop in a large office building), or
    - The office or retail space can be clearly and separately distinguished from other occupancies (example: ground floor retail in a large apartment building).
- Code compliance: Select the code (IECC or ASHRAE) and year the project is constructed under, along with the compliance path
  - If the code is a state modification, select the base code and note the modification in the comment section. If the code is not listed, select “other” and note the appropriate code in the comment section.
  - If the compliance path is not clearly indicated, protocol assumes prescriptive.
  - For projects complying with the prescriptive or envelope tradeoff compliance paths of the IECC, indicate which efficiency option from Section C406 is followed. If not clearly indicated, protocol assumes LPD.
- Building comments: Add any general comments or notes relevant to data input

[1] This information is for reference and use by the data collection teams only and is not to be transmitted to DOE or PNNL.

Note plan review findings for each measure under the “Plan Review” sections of the data collection form. Where requested, note units specified along with the affected quantity (see data collection form for units) on the data collection form.

Plan review is required in order to acclimate teams to what is expected in the field and to more fully depict the features affecting energy use in the subject building. Data gathered through plans and other sources (e.g., input from a designer or owner’s representative) may be used to supplement direct observations, especially in situations where a particular measure is unable to be observed directly, but it should never be used in lieu of field data.

Recommendations for completing the various sections of the data collection form are provided measure by measure in Appendix A Data Collection Measures. Data collection teams are required to fill out all the information applicable to the building, as requested in the data collection form. Please note that cells requiring input are coded in white. Many cells include a dropdown menu for ease of data collection. Where a dropdown is provided, use the options given. Cells coded in gray are not to be edited. These are either descriptions or have built in formulas to calculate information based on input to other cells. Where there are different assemblies or equipment in parts of the building, data collection teams should log each assembly under a different ID. All potential systems that may have multiple assemblies or equipment types have preset IDs across the top of each data collection sheet.

Where trade off or performance path are used, data collection teams must be sure to gather all necessary documentation for data transfer and analysis. If no information on plan review can be found to indicate which compliance path was used, all data collection and analysis should assume the prescriptive path.

4.3 Field Inspection

The DOE Commercial Methodology prioritizes field observations over data gathered through any other source. In this step, data collection teams walk through the building and observe the as-found condition to identify key information for each measure listed on the data collection form for the analysis. Any discrepancies between plan review data and that observed in the field should be clearly noted. In all cases, field data has primacy.

Project teams should determine length of study and funding to determine if a single site visit or multiple visits will be used for data collection. If a single site visit is used, to get a diverse sample of all measures the project team must visit buildings at a variety of stages, from framing to early occupancy. Not all applicable measures for each building will be able to be field verified in any single visit. Multiple site visits will not guarantee on site verification of 100% of measures but will increase the overall number of measures verified.

4.3.1 Preparation for the Site Visit

Data collectors are advised to gather the following items for their site visit:

- Data collection form (recommended to take a tablet on site for data entry and notes directly into digital form)
- Business cards and identification
- Camera (cell phone camera is typically sufficient)
- PPE and safety tools: hard hat, vest, gloves, mask, goggles, flashlight, ladder

- Technical tools: IR camera, SHGC and U-value tool, light level meter
- Measurement tools: architect's scale for plan takeoffs, tape measure, laser measuring tool

Before arriving on site, ensure that basic information is in the data collection form (example: name of data collector and building identifier on the cover of the data collection form). This type of entry either in the plan review stage or in preparation for the visit will allow time-constrained site visits to be efficient.

4.3.2 During Site Visit

Data collection teams walk through the building and note the as-found condition for each applicable measure on the data collection form. It is required to note units where requested along with the affected quantity (see data collection form for units).

Of critical importance to the QA and analysis process is to clearly indicate if a measure is directly observable. This is included for each key area on the data collection sheet with a “yes/no” indication by the field data collector. Where the measure is not directly visible, the data collector is required to note such, while also indicating the data source used to infer the observation. Appendix A Data Collection Measures provides recommendations measure by measure for data collection strategies when a feature for a specific measure is not viewable so that a similar level of confidence is achieved for data collection.

Data collection teams are also expected to take photos of products, labels, and observed conditions for each measure. Each measure requiring a site photograph is indicated in the data collection form. All site photos should be logged and shared for final quality assurance checks. Data collection teams are required to use the file and folder naming protocols described in Table 2 above.

4.4 Data Management

It is recommended that a cloud-based drive be established for data collection teams to upload their documents for data collection activities. Completed data collection forms, site photos, and copies of relevant documents (e.g., energy code documentation) should be uploaded to folders based on assigned building identifier (see Table 2). Shared access among the team members will allow for version control, access to information in the event of illness or turnover in staff, and less potential for data misplacement via email or other data transfer. In selecting data management strategies, including cloud-based and electronic formats, careful consideration should also be given to PII management.

5.0 Quality Assurance and Data Transfer

A quality assurance (QA) data collection lead will be assigned for each data collection team. The QA lead should have in-depth code and compliance expertise and will be responsible for both internal quality assurance and the transfer of data to the analysis forms. Throughout the data collection and review process, the QA lead will closely coordinate with the field staff regarding any missing data, anomalies, discrepancies with the data, or questionable results. It is important to establish and begin a QA process early and perform these actions on a rolling basis. This will ensure that issues are found and corrected for the remaining data collection process.

5.1 Internal Quality Assurance

Once a data collection activity is completed, the data collection team should perform initial quality control on all data collection forms. This step is crucial to ensuring a smooth handoff between the data collection and analysis teams, as well as to prevent mistakes and avoid problems in the analysis stage.

The QA lead will review the data collection forms as soon as possible after they are completed for each site to ensure overall completeness and accuracy using the following steps:

5.1.1 Overall Form Review Process

1. Verify that the information required on the Project Information form is complete and that the Building Identifier number is assigned to the project. (See Table 2).
2. Verify that the data collection forms are complete and ensure that all pages are submitted and that all data input fields are completed with no missing values or units.
3. Verify that any photos that accompany the data collection forms are properly identified (labeled) so that they can be linked to the collected data.
4. If any questions arise on specific data collected in the field:
    a. Send the question to the field staff who conducted that site visit as soon as possible.
    b. Request them to recheck if the data on the form matches their field observations.
    c. Update any data on the form as needed, based on the recheck by the field staff.
5. Verify that all measures are accounted for in each building even if the measure is not applicable to the building. If it is not immediately obvious why a measure is not applicable, a note should be provided. This step avoids confusion in the analysis phase, where it may not be clear if fields were left blank accidentally or purposefully.

5.1.2 Building Envelope

1. Ensure that the data collection forms include all of the following assemblies to form a complete building:
    a. Floor assembly
    b. Wall assembly

   c. Roof assembly
   d. Glazing
2. Verify the installed levels of efficiency are recorded for each assembly.
3. For features that were not viewable at the building site, verify that sufficient support information has been provided to draw a logical conclusion as to the level of efficiency installed and to the quality of the installation (if this data is required for the feature).
4. Verify that an assembly form (floor, wall, and roof) used to calculate the assembly U-factor has been completed for each assembly type in the building based on the data collected at the building site.

5.1.3 Building Mechanical System

1. Verify that each building has at least one of each of the following:
   a. Heating and cooling source (e.g. packaged AC, packaged heat pump, etc.)
   b. Ventilation source
   c. Controls
2. Verify that the HVAC log is complete.
3. For features that were not viewable at the building site, verify that sufficient support information has been provided to draw a logical conclusion as to the level of efficiency installed and to the quality of the installation (if this data is required for the feature).

5.1.4 Lighting System

1. Verify that each building has at least one of each of the following:
   a. Lighting
   b. Controls
2. Verify that the Lighting Power Density (LPD) is recorded for each building for both interior and exterior lighting (if exterior lighting is installed). If energy code compliance documentation (COMcheck) was present, the LPD should be recorded on the form. In addition, verify that the installed lighting has been documented for the building and an LPD calculated for the installed lighting.
3. Verify that a control ID has been recorded for each type of light fixture documented.
4. Verify that a control form has been completed for each different control type found in the building and that a Control ID number has been assigned to each different type of control.
5. For features that were not viewable at the building site, verify that sufficient support information has been provided to draw a logical conclusion as to the level of efficiency installed and to the quality of the installation (if this data is required for the feature).

5.2 Data Transfer to Analysis Tool

PNNL has developed an Excel-based analysis tool (analysis tool) that works in tandem with the DOE Commercial Methodology and the data collection form. This analysis tool calculates the lost savings on a building level based on data from that building. The analysis tool is critical to the final analysis but is too complex to prove useful to field data collection teams. For this reason, the data transfer to the analysis form should be completed by the QA lead.

For quality assurance, the analysis tool provides some early determinations of applicability and assistance to the QA lead at the front end of the data transfer process. To begin each transfer, it is recommended that the QA lead enter basic building information in rows 1–9 of the analysis tool and hit the “Initialize Applicability” button. This will automatically review the measures for their applicability to the building type, HVAC type and CZ selected, removing some burden from the QA lead of determining the applicability for every measure.

The QA lead must then gather and enter the minimum code requirements based on code, code version, and compliance path indicated for each measure in the analysis form. Prescriptive requirements will come directly from the code version selected for most measures (see Appendix B for a review of measure numbers to applicable code sections), trade-off information should be found in COMcheck reports, and performance code requirements should be found in energy model documentation.

The QA lead will need to determine the appropriate level of verification (verified, inferred or unknown) from the data collection form. Only measures that are directly observed by data collection team personnel should be recorded as verified field data. The data collection form should include how the measure was verified if not observable. These measures can be recorded as inferred data based on the level of information available. The Code Requirements and Compliance Checks section provides specific guidance measure by measure on what can be used as verified, inferred or unknown categories for data analysis.

The QA lead should rereview the completed analysis tool using the following steps before transmission to the analysis team:

5.2.1 Analysis Tool QA

1. Verify all measures have been complete (Column L). For all incomplete measures, reference data collection forms and call team for clarification to get data to complete the form
2. Verify total measure time is within reason
3. Verify compliance path and actual code are correctly input
4. Verify applicability to building:
    a. All envelope portions are applicable, even if traded off (Y)
    b. All exceptions that lead to a trade-off are applicable (Y)
    c. All exceptions that are true exceptions are not applicable (N)
    d. Xs will be generated by the initialize applicability button only
5. Verify code requirement matches compliance path selected

6. Verify equipment in building is complete (All Y/N) and matches measure level equipment selections.
7. Review Measure Level Comments for all data that appears to be atypical

If there are questions, reach back out to field team to identify which information is missing and if the forms need to be sent back for changes or if changes can be made and verified in the QA process alone.

5.2.2 Before Transfer for Analysis:

1. Verify all information from the Analysis Form QA list has been provided
2. Verify all identifying information has been removed from forms being transferred

6.0 Conclusion

The intent of this protocol is to provide a method by which states, utilities and other entities interested in code compliance can assess baseline energy efficiency in commercial buildings and identify opportunities for targeted improvement. Through the prescribed approach, studies can generate data sets informing the implementation of state codes and broader energy-efficiency programs. Findings can be used to estimate related savings potential as well as target areas for improvement with a focus on the measures with the highest savings potential.

Ideally, states would conduct a study using this methodology every 3-5 years to establish baseline trends in commercial new construction and identify changes over time. The methodology is provided primarily for states and other entities conducting their own studies to help ensure that results are comparable with other similar research efforts. The findings resulting from this methodology will be of value to a diverse set of stakeholders, including state energy offices, local government building departments, builders, utilities and policy makers. Ultimately, the results can be used to identify energy savings opportunities, develop increasingly effective and targeted training programs, inform industry consensus processes, and serve as a baseline for broader energy-efficiency programs and R&D efforts.

This document will be updated over time based on the findings and experiences of ongoing and future studies that utilize and expand upon this methodology. The latest updates and information will be made available at energycodes.gov.[1]

[1] https://www.energycodes.gov/commercial-energy-code-field-study at the time of this report's printing.

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Appendix A – Data Collection Measures

A.1 Overview

This section is an overview of the information you will find in each data collection measure description in this Appendix. Information and tasks that are repeated for each measure are included here. Information under the individual measures is specific to that measure. Measures that were developed initially under this project, but were not tested by the field data collection teams due to a lack of buildings where that measure was applicable or present, have not been updated to this format and are marked with the word "DRAFT."

A.1.1 Measure # Measure Name

A.1.1.1 Measure Description and Applicability

If a measure is mandatory, it is noted here. This is a basic description of the measure.

How this measure will typically apply to buildings in the field study sample is noted here, including:

1. Applicability to tenant fit-outs.
2. Guidance on including differing assemblies, equipment or compliance levels in data set.
3. If a specific code does not use this measure.
4. Common exceptions to this measure. Exceptions noted in this protocol are those that are common to retail and office uses only, therefore not all code exceptions will be included.

A.1.1.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
This line will include code section references for this measure across the model codes listed.					

This section will include specific instructions based on measure (where applicable). Energy code compliance path should be determined before any review work is complete. Projects primarily will use the IECC, ASHRAE 90.1, or a modified state/local version of one of these codes. The code year is critical, as there are changes between versions. This section is used to record the code requirement. This will be found through one of the following compliance paths:

1. **Prescriptive:** One sentence will describe a prescriptive compliance path. Code requirement will come directly from the code book. All mandatory requirements apply.
2. **Trade Off:** One sentence will describe trade-off compliance path (envelope measures only). Envelope requirements will come from a COMcheck report. All other requirements follow the prescriptive path. All mandatory requirements apply.
3. **Performance:** One sentence will describe a performance compliance path (where applicable). Requirements that can be traded off will come from an energy model report. All mandatory requirements apply.

A.1.1.3 Plan Review

In the Data Collection Form, measures that are directly related are presented on the same tab. For these grouped measures, the assembly ID is only included at the top of the sheet and should be used for all related measures. Plan review steps include:

1. Determine the total number of different assemblies, equipment, or compliance levels present in the building sample.
    a. Data for each different assembly, equipment, or compliance level must be entered separately.
2. Review the drawing set and energy code compliance documentation to determine the proposed assembly, equipment, or compliance level.
3. Provide information on the affected quantity (ex. square feet, tons, etc.) of the measure. Applicable units are provided on each measure.

A.1.1.4 Field Inspection

Information regarding sampling for field inspections will be included here. Steps include:

1. Indicate if the measure is visible during your field inspection.
    a. If not, and a separate source of information is available (ex. receipts, photographs, certificates), note the source of information. Information may need to be requested from the on-site construction superintendent if not readily available.
    b. If it is not visible because it is not yet on site, include a note with measure under comments.
    c. Measures that have products on site but that are not yet installed should have data gathered and noted as on site but not installed.
2. Verify the assemblies, equipment, or compliance levels match what was found during plan review. If there are any discrepancies, note them on the data collection form.

A.1.1.5 QA and Data Transfer

Field data collection forms will provide all of the necessary information to make determinations about applicability of measures, specific information about each applicable measure, and verification level.

1. Determine applicability of a measure. Typically, if information about a measure was found during plan review and inspection, it applies to the building. In some cases, the measure may not apply, based on the code being used. It is the job of the QA lead to determine applicability and log it accurately. If a measure applies to your building sample, select “yes” under “Measure Applicable.” If a measure does not apply to your building sample, select “no” and provide a brief note why. For all applicable measures, provide information for the code, plan, and as-found conditions to complete the PNNL analysis form.
2. Determine and record the minimum code requirement based on energy code documentation (plans, specifications, energy model, COMcheck). If there is no documentation or the documentation does not specify the selected compliance path for the project, assume prescriptive requirements are followed.

3. Enter the information found in the field data collection form for plan review and inspections for factor, condition, and affected quantity.
4. Determine the verification level of the inspection data.
    a. **Verified**: Field data collector saw the measure on site. Data seen on site is verified if it matches with plan review expectations or not.
    b. **Inferred**: Field data collector was provided some information on site that appeared to match with plans for that item.
    c. **Unknown**: Field data collector was not given any information on site, or information on site appeared inconsistent with plan review information.

A.2 Envelope Measures

A.2.1 5012 Roof Insulation

A.2.1.1 Measure Description and Applicability

Roofs shall be insulated to meet the minimum requirements defined in the applicable energy code.

1. This measure will apply to all building samples except tenant fit-outs. For tenant fit-outs, when the core and shell of the building are permitted separately and no information is available to the data collection team, Measure Applicable should be "No" and reason should be "Tenant fit-out."
2. All roof assemblies that are greater than 10% of the total roof area should be included in the data set.
    a. For each assembly with a unique performance value, assign a Roof Assembly ID. Copy and paste the data form the number of times necessary to capture each assembly.
    b. Multiple roof areas that have the same performance can be included under the same Assembly ID.

A.2.1.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
502.1.2	C402.2.1	C402.2.2	5.5.3.1	5.5.3.1	5.5.3.1

For each assembly type, select roof type from the following drop-down menu:

1. Insulation entirely above deck
2. Metal buildings
3. Attic and other

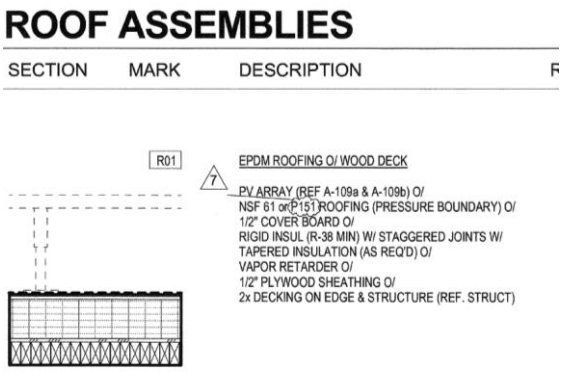
Include R-value and U-factor from code tables or energy documentation:

1. **Prescriptive:** A minimum insulation R-factor and maximum U-factor is listed in the code based on the climate zone and assembly type.
2. **Trade Off:** Insulation R-value and U-factor are found in the COMcheck Envelope Report.
3. **Performance:** Insulation U-factor is dictated by the energy model submission input reports.
4. Where no documentation includes compliance path, assume prescriptive.

A.2.1.3 Plan Review

In the architectural drawing set, locate a wall section or wall and roof details sheet (example: Figure 5012.1).

Figure 5012.1 Roof Assembly



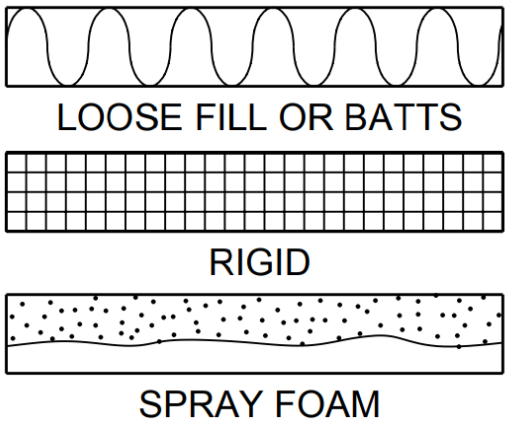
For each roof assembly, enter key information under a different Roof Assembly ID on the Roof tab of the data collection form.

Roof insulations are shown with different symbols based on the insulation type, such as loose fill, batt, rigid, or spray foam (example: Figure 5012.2).

The symbols can be verified in the symbol legend, which is typically within the first few pages of a drawing set. If no symbol legend is included, defer to industry standard representations presented in Figure 5012.2. An accounting of industry-accepted R-values can be found in Table 5012.1.

To determine the R-value and U-factor, complete one of the following:

Figure 5012.2 Insulation Types



1. Fill out the Envelope – Roof Assembly section of the data collection supplemental worksheets.
    a. Provide a description, detail (such as product information), and effective R-value for each layer of the roof assembly.
    b. Form will automatically sum R-values for a total and invert for U-factor.
    c. Duplicate form where there is more than one roof assembly.
    d. Manually enter resulting R and U values into the Roof Tab.
2. Look up U-factor by referencing ASHRAE 90.1 Appendix A based on assembly construction.

3. Use the architectural drawings set determine net roof area (sq. ft.) for each assembly ID using a scale and drawing take-offs.

A.2.1.4 Field Inspection

Each unique roof assembly should be viewed to verify insulation installation for both R-value and quality.

If roof insulation is visible:

1. Mark “Yes” under visible.
2. Determine the roof insulation R-value for all layers of the roof assembly.
3. Verify the Assembly U-factor matches the Assembly U-factor calculated during plan review. If there are any discrepancies, note it on the data collection form and recalculate the Assembly U-factor.
4. Rate and record the installation quality of the insulation as one of the following:
    a. Good installation
    b. Fair installation = gaps over 2.5% area
    c. Poor installation = gaps over 5% area

    Installation quality should be recorded as good if roof assembly is insulation entirely above deck. Installation quality of areas that cannot be viewed should be inferred from the quality in areas that can be viewed based on the worst quality seen on site. It should be recorded as fair unless there is evidence on site suggesting it is not.
5. Verify the area of the roof compared to plans. This should be a visual estimate. Where the area appears to be much different from plans, measure new roof area. Note a field inspection change.

If roof insulation is not visible:

1. Mark “No” under visible.
2. Decide if the value can be determined by one of the following:
    a. Request shop drawings for the roofing system from the on-site construction superintendent and product specifications from the insulation contractor.
    b. Request pictures or other documentation the contractor may have on site.
    c. Request inspection report by local authority having jurisdiction (AHJ).
    d. Measure the depth of the roof assembly.
3. Note the data source for all field information.

Information gathered on site may need to be compared back to plan data. If there are any discrepancies that do not match the assembly U-factor calculated in plan review stage, note it on the data collection form and recalculate the assembly U-factor.

Table 5012.1. Common Materials and Associated R-Values

Common Materials	R-values	Units	Common Materials	R-values	Units
AIR			**INSULATION**		
Air Film - Exterior	0.17		Fiberglass Batt	3.14	/inch
Air Film - Interior Wall	0.68		Fiberglass Blown (attic)	2.2	/inch
Air Film - Interior Ceiling	0.61		Fiberglass Blown (wall)	3.2	/inch
Air Space (0.5-4 inch)	1		Rock Wool Batt	3.14	/inch
			Rock Wool Blown (attic)	3.1	/inch
CONSTRUCTION			Rock Wool Blown (wall)	3.03	/inch
Gyp. Board 1/2"	0.45		Cellulose Blown (attic)	3.13	/inch
Gyp. Board 5/8"	0.5625		Cellulose Blown (wall)	3.7	/inch
Stucco/Plaster	0.2	/inch	Vermiculite	2.13	/inch
Plywood (General)	1.25	/inch	Air-entrained Concrete	3.9	/inch
Plywood 1/4"	0.31		Urea terpolymer foam	4.48	/inch
Plywood 3/8"	0.47		Rigid fiberglass (> 4 lb/ft3)	4	/inch
Plywood 1/2"	0.62		Expanded Polystyrene (beadboard)	4	/inch
Plywood 5/8"	0.77		Extruded Polystyrene	5	/inch
Plywood 3/4"	0.94		Polyurethane (foamed-in-place)	6.25	/inch
Common Brick 4"	0.8		Polyisocyanurate (foil-faced)	7.2	/inch
Face Brick 4"	0.44		Open cell spray foam	3.7	/inch
Concrete Block/CMU 4"	0.8		Closed cell spray foam	6	/inch
Concrete Block/CMU 8"	1.11		Polyvinyl	1.22	/inch
Concrete Block/CMU 12"	1.28				
Concrete 60lb	0.52	/inch	**FLOORING**		
Concrete 70lb	0.42	/inch	Plywood	1.25	/inch
Concrete 80lb	0.33	/inch	Particle Board (underlayment)	1.31	/inch
Concrete 90lb	0.26	/inch	Hardwood Flooring	0.91	/inch
Concrete 100lb	0.21	/inch	Tile, Linoleum	0.05	/inch
Concrete 120lb	0.13	/inch	Carpet (w/fibrous pad)	2.08	/inch
Concrete 150lb	0.07	/inch	Carpet (w/rubber pad)	1.23	/inch
Concrete 144lb - Typical Normal Weight		/inch			
Soft Wood Lumber	1.25	/inch			
2x2" Nominal	1.88				

Common Materials	R-values	Units	Common Materials	R-values	Units
2x4" Nominal	4.38				
2x6" Nominal	6.88				
Cedar	1.33	/inch			
Asphalt Shingles	0.44				
Wood Shingles	0.97				

A.2.1.5 References and Examples

Figure 5012.3 Attic Insulation and Insulation Entirely Above the Roof Deck[1]

Figure 5012.4 Roof Insulation in Metal Buildings[2]

[1] Britt/Makela Group and Ryan Meres. *2009 International Energy Conservation Code for Simple Commercial Buildings Compliance Guide*. 2014

[2] Department of Energy. Evaluating Commercial Buildings for Energy Code Compliance. September 2010.

A.2.2 5014 Cool Roofs

A.2.2.1 Measure Description/Applicability

Low-sloped roofs in Climate Zones 1, 2, or 3 are required to meet the roof solar reflectance and or thermal emittance requirements.

1. For projects in Climate Zones 4–8, mark “No” under applicable and list CZ as explanation.
2. For projects that comply with IECC 2009, mark “No” under applicable and list code as explanation
3. Determine if the project meets one of the listed exceptions. Mark “No” under applicable and list exception as explanation:
    a. Portions of roof covered by PV systems; solar air/water heating; green roof; roof decks; skylights; HVAC equipment.
    b. Portions of roof shaded during peak sun angle.
    c. Portions of roof that are ballasted.
    d. Roofs where 75% complies with one or more of the above.

Note: The full area of the roof may not be required to comply, but any area greater than 25% that does not meet any of the exceptions will be required to comply. Where a portion of the roof must comply, note that it is not the full roof.

4. All other projects mark “Yes” and continue to code requirement.

A.2.2.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
N/A	C402.2.1.1	402.3	5.5.3.1.1	5.5.3.1.1	5.5.3.1.1

Include the three-year aged solar reflectance value:

1. **Prescriptive:** A minimum three-year aged solar reflectance is listed in the code.
2. **Trade Off:** This measure cannot be traded off; use the minimum three-year aged solar reflectance is listed in the code.
3. **Performance:** Solar reflectance is dictated by the energy model submission input reports.
4. Where no documentation includes compliance path, assume prescriptive.

A.2.2.3 Plan Review

In the architectural drawing set, locate a roof plan or roof details sheet:

1. Cool roof requirements may be indicated as a note, or as a specific material ID.
2. Material IDs may be defined in the drawing set, or may reference a project specification.

3. If a product is specified, but no reflectance value is given, look the product up online to determine its three-year aged value.
4. If there is no indication of a cool roof in the drawing set, enter plan value as “0.”

Using the architectural drawings set, determine net roof area (sq. ft.) for each assembly ID using a scale and drawing take-offs.

A.2.2.4 Field Inspection

If the roof material is visible:

1. Mark “Yes” under visible.
2. If installed material has documentation available, enter the field inspection value form the documentation.
3. If installed roof is a white roof, but no documentation is available, enter field inspection value as “0.55” and note value from generic white roof.
4. If installed roof is not a white roof and no documentation is available, enter field inspection value as “0.”
5. Verify the area of the roof compared to plans for area of cool roof. (Note: This may be less than the area of the whole roof.) This should be a visual estimate. Where the area appears to be much different from plans, measure new roof area. Note a field inspection change.

If the data collector is not allowed to see/access the roof, mark on the form that visual inspection was not completed.

A.2.2.5 QA and Data Transfer

Where roof material value is entered based on visual inspection of color only (options 3 or 4 from field inspection above), field data should be logged as “inferred.”

A.2.3 5018A/B Above-Grade Wall Insulation

A.2.3.1 Measure Description/Applicability

Above grade walls shall meet the minimum insulation requirements.

1. This measure will apply to all building samples except tenant fit-outs. For tenant fits-outs, when the core and shell of the building were permitted separately and no information is available to the data collection team, Measure Applicable should be “No” and reason should be “Tenant fit-out”.
2. The data set should include all roof assemblies that are greater than 10% of the total wall area.
    a. For each assembly with a unique performance value, assign a Wall Assembly ID. Copy and paste the data form the number of times necessary to capture each assembly.

    Multiple wall areas that have the same performance can be included under the same Assembly ID.

A.2.3.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
502.2.3	402.2.3	402.2.3	5.5.3.2	5.5.3.2	5.5.3.2

For each Assembly ID, select Wall type from drop down. This type will dictate the code requirement for a prescriptive path:

1. Mass
2. Metal Building
3. Metal Framed
4. Wood Framed and other

Include R-value and U-factor from code tables or energy documentation:

1. **Prescriptive:** A minimum insulation U-factor is listed in the code based on the climate zone and assembly type.
2. **Trade Off:** Insulation R-value and U-factor are found in the COMcheck Envelope Report.
3. **Performance:** Insulation U-factor is dictated by the energy model submission input reports.
4. Where no documentation includes compliance path, assume prescriptive.

A.2.3.3 Plan Review

In the architectural drawing set, locate a wall section or wall details sheet (Figure 5018(1)).

1. For each wall assembly, enter key information under a different Wall Assembly ID on the Walls tab of the data collection form.
2. Determine wall type based on framing type or mass wall.
3. Wall insulations are shown with different symbols based on the insulation type, such as loose fill, rigid, or spray foam.

The symbols can be verified in the symbol legend, which is typically within the first few pages of a drawing set. If no symbol legend is included, defer to industry standard representations, presented in Figure 5012(2).

To determine the R-value and U-factor, complete one of the following:

1. Fill out the Envelope – Wall Assembly tab of the data collection supplemental worksheets.

a. Provide a description, detail (such as product information), and effective R-value for each layer of the roof assembly.

b. Form will automatically sum R-values for a total and invert for U-factor.

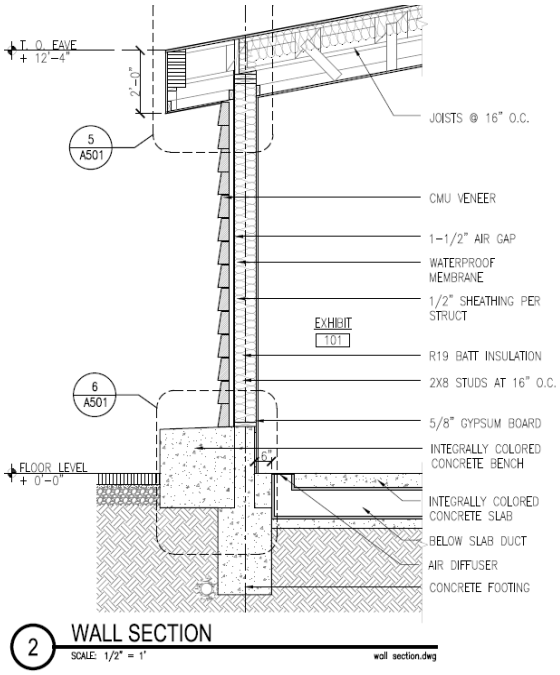
c. Where there is more than one wall assembly, this form will need to be duplicated.

d. Resulting R and U values should be manually entered into the Wall Tab.

2. Reference ASHRAE 90.1 Appendix A based on assembly construction to look up U-factor.

    a. If this method is used, directly override the equation linking the Wall tab to the Wall Assembly tab with the found R-value from plans and U-factor from Appendix A.

Figure 5018.1 Example of Wall Assembly



Using the architectural drawings set determine net wall area (sq. ft.) for each assembly ID using a scale and drawing take-offs. Gross wall area is the total wall area including fenestration; Do not subtract window area.

A.2.3.4 Field Inspection

Each wall assembly should be viewed to determine U-factor.
If wall insulation is visible:

1. Mark “Yes” under visible.
2. Determine the wall insulation R-value for all layers of the wall assembly.
    a. Verify the assembly U-factor matches the assembly U-factor calculated during plan review. If there are any discrepancies and layers do not match the assembly U-factor calculated in plan review stage, note it on the data collection form and recalculate the assembly U-factor.
3. Rate and record the installation quality of the insulation as one of the following:
    a. Good installation
    b. Fair installation = gaps over 2.5% area
    c. Poor installation = gaps over 5% area

Installation quality should be recorded as good if wall assembly is only continuous insulation. Installation quality of areas that cannot be viewed should be inferred from the quality in areas that can be viewed based on the worst quality seen on site. Should be recorded as fair unless there is evidence on site suggesting it is not.

If wall insulation is not visible:

1. Mark “No” under visible.
2. Determine if the value can be determined by one of the following:
    a. Request shop drawings for the wall system from the on-site construction superintendent and product specifications from the insulation contractor.
    b. Request pictures or other documentation the contractor may have on site.
    c. Request inspection report by local authority having jurisdiction (AHJ).
    d. Measure the depth of the wall assembly.

Information gathered onsite may need to be compared back to plan data. If there are any discrepancies that do not match the Assembly U-factor calculated in plan review stage, note it on the data collection form and recalculate the Assembly U-factor.

Figure 5018.2 Example of Cavity Insulation[1]

Figure 5018.3 Example of Continuous Insulation[2]

A.2.4 5023A/B Exterior Floor Insulation

A.2.4.1 Measure Description/Applicability

Exterior floors shall meet the minimum insulation requirements defined in the applicable energy code.

1. This measure will apply to all building samples except tenant fit-outs.
2. All floor assemblies that are greater than 10% of the total exterior floor area should be included in the data set.
    a. For each assembly with a unique performance value, assign a Floor Assembly ID. Copy and paste the data form the number of times necessary to capture each assembly.

[1] Source: Britt/Makela Group and Ryan Meres. 2009 International Energy Conservation Code for Simple Commercial Buildings Compliance Guide. 2014
[2] Source: Britt/Makela Group and Ryan Meres. 2009 International Energy Conservation Code for Simple Commercial Buildings Compliance Guide. 2014

b. Multiple floor areas that have the same performance can be included under the same Assembly ID.

3. This measure is for exterior floors over unconditioned space (garages or direct outdoors) only; it does not include slabs on grade.

A.2.4.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
502.2.5	C402.2.5	C402.2.4	5.5.3.4	5.5.3.4	5.5.3.4

Select floor type from drop down. This type will dictate the code requirement for a prescriptive path:

1. Frame (this covers both wood and metal framing)
2. Mass

Include R-value and U-factor from code tables or energy documentation:

1. **Prescriptive:** A minimum insulation R-value and maximum U-factor is listed in the code based on the climate zone and assembly type.
2. **Trade Off:** Insulation R-value and U-factor are found in the COMcheck Envelope Report.
3. **Performance:** Insulation U-factor is dictated by the energy model submission input reports.
4. Where no documentation includes compliance path, assume prescriptive.

A.2.4.3 Plan Review

In the architectural drawing set, locate a wall section or floor details sheet.

1. For each floor assembly, enter information under a unique Floor Assembly ID.
2. Determine floor type based on framing type, and framing spacing or mass floor.
3. Floor insulations are shown with different symbols based on the insulation type, such as loose fill, rigid, or spray foam.
4. The symbols can be verified in the symbol legend, which is typically within the first few pages of a drawing set. If no symbol legend is included, defer to industry standard representations, presented in Figure 5012(2).

To determine the R-value and U-factor complete one of the following:

1. Fill out the Envelope – Floor Assembly tab of the data collection supplemental worksheets.
    a. Provide a description, detail (such as product information), and effective R-value for each layer of the floor assembly.
    b. Form will automatically sum R-values for a total and invert for U-factor.

c. Duplicate the form where there is more than one floor assembly.

d. Manually enter the resulting R and U values into the Floor Tab.

2. To look up U-factor, reference ASHRAE 90.1 Appendix A based on assembly construction.

    a. If this method is used, directly override the equation linking the Floor tab to the Floor Assembly tab with the found R-value from plans and U-factor from Appendix A.

Using the architectural drawings set determine net floor area (sq. ft.) for each assembly ID using a scale and drawing take-offs.

A.2.4.4 Field Inspection

Each floor assembly should be viewed to determine U-factor.

If floor insulation is visible:

1. Mark “Yes” under visible.
2. Determine the floor insulation R-value for all layers of the floor assembly.
    a. Verify the Assembly U-factor matches the Assembly U-factor calculated during plan review. If there are any discrepancies and layers do not match the Assembly U-factor calculated in plan review stage, note it on the data collection form and recalculate the Assembly U-factor.
3. Rate and record the installation quality of the insulation as one of the following:
    a. Good installation
    b. Fair installation = gaps over 2.5% area
    c. Poor installation = gaps over 5% area

Installation quality should be recorded as good if wall assembly is only continuous insulation. Installation quality of areas that cannot be viewed should be inferred from the quality in areas that can be viewed based on the worst quality seen on site. Quality should be recorded as fair unless there is evidence on site suggesting it is not.

If floor insulation is not visible:

1. Decide if the value can be determined by one of the following:
    a. Request shop drawings for the floor system from the on-site construction superintendent and product specifications from the insulation contractor.
    b. Request pictures or packaging the contractor may have on site.
    c. Request inspection report by local authority having jurisdiction (AHJ).
2. Measure the depth of the floor assembly.

Information gathered on site may need to be compared back to plan data. If there are any discrepancies that do not match the Assembly U-factor calculated in plan review stage, note it on the data collection form and recalculate the Assembly U-factor.

A.2.5 5029B Opaque Roll-up Doors

A.2.5.1 Measure Description/Applicability

Opaque doors are defined as doors that have less than 50% glass area. Opaque roll-up doors shall meet the minimum insulation requirements defined in the energy code.

1. This measure will apply based on occurrence of an opaque roll-up door. If no roll-up doors exist, mark applicability as “No.”
2. This measure will not apply to tenant fit-outs.
3. All doors should be included in the data set.

A.2.5.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
502.2.7	C402.2.7	C402.4.4	5.5.3.6	5.5.3.6	5.5.3.6

Include R-value and U-factor from code tables or energy documentation:

1. **Prescriptive:** A minimum insulation R-value and maximum U-factor is listed in the code based on the climate zone and assembly type.
2. **Trade Off:** U-factor is found in the COMcheck Envelope Report.
3. **Performance:** U-factor is dictated by the energy model submission input reports.
4. Where no documentation includes compliance path, assume prescriptive.

A.2.5.3 Plan Review

In the architectural drawing set, locate a door schedule sheet.

1. Review schedule and notes for R-value or U-factor of door.

If no information is found in plans or specs, use the default values presented in Table 5029.

Table 5029.1 Unlabeled Opaque Doors[1]

Description	U-factor
Uninsulated, single-layer, metal doors	1.45
Uninsulated, double-layer, metal doors	0.70
Insulated metal doors	0.50
Wood doors, min. thickness 1.75”	0.50
Any other wood door	0.60

Using the architectural drawings set, determine area (sq. ft.) for each door using:

1. size information given in the door schedule.

[1] Derived from ASHRAE 90.1-2010 §A7

2. a scale and drawing take-offs.

Log the information for each door on the wall tab, under the wall in which the door is located in the Opaque Doors section.

A.2.5.4 Field Inspection

Verify make and model number of opaque roll-up doors; get product specifications from the on-site construction superintendent, if available.

1. Verify, if possible, accurate National Fenestration Rating Council (NFRC) 100 or ANSI/DASMA 105-certified U-factors, either on an NFRC label or certificate.
2. Call NFRC to verify U-factor of the product if needed
3. If no label or certificate is available, use the default values presented in Table 5029.

Figure 5029.1 Example of Opaque Rollup Doors[1]

A.2.6 5034 Window-to-Wall Ratio

A.2.6.1 Measure Description/Applicability

Window-to-wall ratio (WWR) is the amount of fenestration area (windows, storefronts, non-opaque doors), divided by the gross wall area, expressed as a percentage. It is limited by code and compliance path selected.

1. This measure will apply to all projects with windows.
    a. It is rare, but not impossible that a project in the sample will not include windows. If plans and field inspection confirm no glazing, mark as applicability as “No.” Note condition in comments.
2. This measure will not apply to tenant fit-outs.
3. WWR will account for all fenestration in sample building.

[1] Source: Britt/Makela Group and Ryan Meres. 2009 International Energy Conservation Code for Simple Commercial Buildings Compliance Guide. 2014

A.2.6.2 Code Requirement

IECC			ASHRAE 90.1		
2009	2012	2015	2007	2010	2013
502.3.1	402.3.1	402.4.1	5.5.4.2.1	5.5.4.2.1	

Include percentage from code or energy documentation:

1. **Prescriptive:** Maximum base allowed WWR is 30% under IECC and 40% under ASHRAE 90.1. IECC has allowances for greater fenestration area if certain criteria area meet up to 40%.
2. **Trade Off:** WWR is found in the COMcheck Envelope Report.
3. **Performance:** WWR is dictated by the energy model submission input reports.
4. Where no documentation includes compliance path, assume prescriptive.

A.2.6.3 Plan Review

In the architectural drawing set, locate the elevations and window/glazing schedules.

1. Calculate the total area of the exterior walls. Record the area for each wall under its Wall Assembly ID under gross wall area.
2. Calculate total area of fenestration (include windows, storefront glass, non-opaque entrance doors). Record under Window Area.
3. The form will calculate the WWR and Net Opaque Wall Area.

A.2.6.4 Field Inspection

Verify all orientations of building look as expected from plan review.

1. Spot check the window area in several spaces in the building where area take-offs were performed.
2. Photograph all orientations of the building.

For IECC projects that used the allowance for greater WWR, verify that daylighting controls are present, and note non-compliance in measure comments where WWR was greater than 30% but project did not meet all requirements under allowance.

A.2.7 5035 Skylight-to-Roof Ratio

A.2.7.1 Measure Description/Applicability

Skylight-to-Roof ratio (SRR) is the amount of skylight area, divided by the gross roof area, expressed as a percentage. It is limited by code and compliance path selected.

1. This measure will apply to all projects with skylights.

2. This measure will not apply to tenant fit-outs.

A.2.7.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
502.3.1	402.3.1	402.4.1	5.5.4.2.2	5.5.4.2.2	

Include percentage from code or energy documentation:

1. **Prescriptive:** Maximum base allowed SRR is 3% under IECC, 5% under ASHRAE 90.1. IECC has allowances for SRR up to 5% if certain criteria are met.
2. **Trade Off:** SRR is found in the COMcheck Envelope Report.
3. **Performance:** SRR is dictated by the energy model submission input reports.
4. Where no documentation includes compliance path, assume prescriptive.

A.2.7.3 Plan Review

In the architectural drawing set, locate the roof plans, reflected ceiling plans, and skylight/glazing schedules (these are most-often found with window schedules).

1. Calculate the total area of the roof. Record area for each roof assembly under its Roof Assembly ID under Gross roof area.
2. Calculate total area of skylights. Record under Skylight Area.
3. The form will calculate the SRR and Net Opaque Roof Area.

A.2.7.4 Field Inspection

Verify roof areas look as expected from Plan Review.

1. Spot check the skylight area in several spaces in the building where area take-offs were performed.
2. Photograph roof in entirety. Recommend standing at one edge for one image, or standing near center and rotating taking multiple images.

For IECC projects that used the allowance for greater SRR:

1. Verify that daylighting controls are present.
2. Note non-compliance in measure comments where SRR was greater than 3% but project did not meet all requirements under allowance.

A.2.8 5042A Window U-factors

A.2.9 5042B Window SHGC

A.2.9.1 Measure Description/Applicability

Windows shall not exceed the maximum rate of heat-loss requirements and solar heat gain per the energy code. A maximum heat-loss rate and solar heat gain coefficient (SHGC) is listed in the code based on the climate zone and fenestration type.

1. This measure will apply based on occurrence of windows, including storefront or curtain-wall glazing systems.
2. This measure will not apply to tenant fit-outs.
3. All window assembly types that make up 10% of window area should be included in the data set.

A.2.9.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
502.3.2	402.3.3	402.4.3	5.5.4.3	5.5.4.3	
502.3.2	402.3.3	402.4.3	5.5.4.4.1	5.5.4.4.1	

Include U-factor and SHGC from code tables or energy documentation:

1. **Prescriptive:** A maximum U-factor and SHGC are listed in the code based on the climate zone and fenestration type.
2. **Trade Off:** U-factor and SHGC are found in the COMcheck Envelope Report.
3. **Performance:** U-factor and SHGC are dictated by the energy model submission input reports.
4. Where no documentation includes compliance path, assume prescriptive.

A.2.9.3 Plan Review

In the architectural drawing set, locate a window or glazing schedule sheet.

1. For each unique window assembly, create a duplicate of the Window tab on the data collection form and assign a unique Window Assembly ID.
2. Review schedule and notes for U-factors and SHGCs of windows.
3. If no information is found in plans or specs, use the default values presented in Table 5042.
4. Using the architectural drawings set determine area (sq. ft.) for each assembly ID using:
    a. Size information given in the window schedule.
    b. A scale and drawing take-offs.

Table 5042.1 Unlabeled Windows[1]

Description	U-factor	SHGC Clear	SHGC Tinted
Metal Frame, single pane	1.20	0.80	0.70
Metal frame, double pane	0.80	0.70	0.60
Metal frame with thermal break, single pane	1.10	0.80	0.70
Metal frame with thermal break, double pane	0.65	0.70	0.60
Non-metal frame, single pane	0.95	0.80	0.70
Non-metal frame, double pane	0.55	0.70	0.60
Glass Block	0.60	0.60	0.60

Figure 5042.1 Example of Window Schedule

WINDOW NO.	LOCATION	WINDOW OPENING			NO. OF PANELS	SILL HEIGHT AFF	MATERIAL/FINISH				DETAIL			
		WIDTH	HEIGHT	THICKNESS			WINDOW		FRAME		HEAD	JAMB	SILL	OTHER
1	EXHIBIT	6'-1"	11'-2"	1"	2	1'-4"	GL	LOW-E CLEAR	AL	–	SIM. 1/A603	SIM. 5/A603	SIM. 3/A603	SIM. 6/A603
2	EXHIBIT	12'-0"	14'-0" (1)	1"	6 (1)	0'-0"	GL	LOW-E CLEAR	AL	–	SIM. 1/A603	SIM. 5/A603 8/A603	SIM. 3/A603	6/A603 4/A604
3	OFFICE	5'-5"	11'-0"	1"	1	3'-0"	GL	LOW-E CLEAR	AL	–	SIM. 1/A603	SIM. 5/A603	SIM. 4/A603	
4	OFFICE (1)	5'-4 1/2"	8'-7 1/2"	1"	1	3'-0"	GL	LOW-E CLEAR	AL	–	SIM. 1/A603	SIM. 5/A603	SIM. 4/A603	
5	EXHIBIT	3'-0"	10'-0"	1"	2	0'-0"	GL	LOW-E CLEAR	AL	–	SIM. 1/A603	SIM. 5/A603	3/A603	SIM. 6/A603
6	EXHIBIT	5'-0"	10'-0"	1"	2	0'-0"	GL	LOW-E CLEAR	AL	–	SIM. 1/A603	SIM. 5/A603	3/A603	SIM. 6/A603
7	VESTIBULE	7'-8"	10'-0"	1"	3	0'-0"	GL	LOW-E CLEAR	AL	–	SIM. 1/A603	SIM. 5/A603 8/A603	3/A603 (1)	7/A603
8	CLASSROOM	2'-9 3/4"	10'-0"	1"	2	0'-0"	GL	LOW-E CLEAR	AL	–	SIM. 1/A603	SIM. 5/A603	3/A603	SIM. 6/A603
9	CLASSROOM (1)	7'-11 3/8"	10'-0"	1"	2	0'-0"	GL	LOW-E CLEAR	AL	–	SIM. 1/A603	SIM. 5/A603 8/A603	3/A603	7/A603
10	EXHIBIT/VESTIBULE	6'-1"	10'-0"	1"	1	0'-0"	GL	LOW-E CLEAR	AL	–	1/A603	SIM. 5/A603 8/A603 (1)	3/A603	SIM. 6/A603 7/A603
11	EXHIBIT	24'-5 3/8"	3'-1 1/2"	1"	5	VARIES	GL	LOW-E CLEAR	AL	–	10/A603 1/A604	8/A603 3/A604	11/A603 2/A604	12/A603
12	EXHIBIT	20'-2"	3'-1"	1"	4	VARIES	GL	LOW-E CLEAR	AL	–	10/A603 1/A604	8/A603 3/A604	11/A603 2/A604	12/A603
13	CLASSROOM	45'-2" (1)	5'-1 1/2"	1"	13 (1)	VARIES	GL	LOW-E CLEAR	AL	–	10/A603 1/A604	8/A603 3/A604	11/A603 2/A604	12/A603

05 WINDOW SCHEDULE
SCALE: –

A.2.9.4 Field Inspection

Verify no less than 10% of the windows on site.

1. Verify make and model number of windows; get product specifications from the on-site construction superintendent, if available.
2. Verify that the values on the National Fenestration Rating Council (NFRC) label (example: Figure 5042(2)) attached to the installed fenestration products match the U-factor values shown on the drawings and energy code compliance documentation.
3. Request copies of the NFRC certificates (if site-built windows, see example below) or product labels (if manufactured wood/vinyl/metal frame) from the construction manager or the authority having jurisdiction (AHJ). Only these three forms of NFRC certifications are acceptable:
    a. NFRC label affixed to the fenestration product
    b. NFRC site-built procedure label certificate (either affixed to building or included in compliance documentation)

[1] Derived from IECC Tables C303.1.3(1&3)

c. NFRC Component Modeling Approach (CMA) label certificate (either affixed to building or included in compliance documentation).

4. If no label or certificate is available:
   a. Use the default values presented in Table 5042.
   b. Record window type, frame type, size, and number of panes.

Figure 5042.2 Example of NFRC Label [1]

A.2.10 5043A Skylight U-factors

A.2.11 5043B Skylight SHGC

A.2.11.1 Measure Description/Applicability

Skylights shall not exceed the maximum rate of heat-loss requirements or solar heat gain per the energy code. A maximum heat loss rate and solar heat gain coefficient (SHGC) is listed in the code based on the climate zone.

1. This measure will apply based on occurrence of skylights.
2. This measure will not apply to tenant fit-outs.
3. Data set should include all skylight assembly types.

A.2.11.2 Code Requirement

IECC	ASHRAE 90.1

[1] Source: NFRC Website: http://nfrc.org/fenestrationfacts.aspx. Actual required values are determined by code requirements.

2009	2012	2015	2007	2010	2013
502.3.2	402.3.3	402.4.3	5.5.4.3	5.5.4.3	
502.3.2	402.3.3	402.4.3	5.5.4.4.1	5.5.4.4.1	

Include U-factor and SHGC from code tables or energy documentation:

1. **Prescriptive:** A maximum U-factor and SHGC are listed in the code based on the climate zone and fenestration type.
2. **Trade Off:** U-factor and SHGC are found in the COMcheck Envelope Report.
3. **Performance:** U-factor and SHGC are dictated by the energy model submission input reports.
4. Where no documentation includes compliance path, assume prescriptive.

A.2.11.3 Plan Review

In the architectural drawing set, locate a roof plan or reflected ceiling plan to determine if skylights are present on the building sample. Locate a window or glazing schedule sheet (example: Figure 5042(1)).

1. Each skylight should be logged under the roof assembly it is located in on the Roof tab.
2. Review schedule and notes for U-factors and SHGCs of skylights.
3. If no information is found in plans or specs, use the default values presented in Table 5043.
4. Using the architectural drawings set determine area (sq. ft.) for each skylight using:
    a. Size information given in the skylights schedule.
    b. A scale and drawing take-offs.

Table 5043.1 Unlabeled Skylights[1]

Description	U-factor	SHGC Clear	SHGC Tinted
Metal Frame, single pane	1.00	0.80	0.70
Metal frame, double pane	1.30	0.70	0.60
Metal frame with thermal break, single pane	1.90	0.80	0.70
Metal frame with thermal break, double pane	1.10	0.70	0.60
Non-metal frame, single pane	1.75	0.80	0.70
Non-metal frame, double pane	1.05	0.70	0.60
Glass Block	0.60	0.60	0.60

A.2.11.4 Field Inspection

Visually verify locations and number of skylights match expectations from plan review.

[1] Derived from IECC Tables C303.1.3(1&3)

1. Verify make and model number of skylights; get product specifications from the on-site construction superintendent, if available.
2. Verify that the values on the National Fenestration Rating Council (NFRC) label (example: Figure 5042(2)) attached to the installed fenestration products match the U-factor values shown on the drawings and energy code compliance documentation.
3. Request copies of the NFRC certificates or product labels from the construction manager or the authority having jurisdiction (AHJ). Only these three forms of NFRC certifications are acceptable:
    a. NFRC label affixed to the fenestration product
    b. NFRC site-built procedure label certificate (either affixed to building or included in compliance documentation)
    c. NFRC Component Modeling Approach (CMA) label certificate (either affixed to building or included in compliance documentation).
4. If no label or certificate is available:
    a. Use the default values presented in Table 5043.
    b. Record skylight type, frame type, size, and number of panes.

A.2.12 5056 Continuous Air Barrier

A.2.12.1 Measure Description/Applicability

Building shall meet continuous air barrier requirements.

1. This measure will not apply to tenant fit-outs where no envelope construction is being undertaken.

A.2.12.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
N/A	C402.4.1	C402.5.1	5.4.3.1	5.4.3.1	5.4.3.1

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.2.12.3 Plan Review

Review construction details for the roof, wall, and floor assemblies to determine if compliant air-barrier materials have been specified on the building plans.

1. Check to see if leakage testing is specified. Where testing is specified, testing results should be verified in field.
2. Check that materials and assemblies specified meet the code requirements. Materials deemed to comply are presented in Table 5056.

Table 5056.1 Materials deemed to comply with air barrier requirements

Material	Minimum Thickness to Comply (in inches)
Plywood	3/8
Oriented Strand Board	3/8
Extruded Polystyrene Insulation Board	½
Foil-back polyisocyanurate Insulation Board	½
Closed cell spray foam (min. density 1.5 pcf)	1.5
Open cell spray foam (density 0.4-1.5 pcf)	4.5
Gypsum board	½
Cement Board	½
Built up roofing membrane	N/A
Modified bituminous roofing membrane	N/A
Fully adhered single-ply roofing membrane	N/A
Portland cement parge	5/8
Gypsum Plaster	5/8
Case in place concrete	N/A
Precast concrete	N/A
Fully grouted concrete block	N/A
Sheet Steel	N/A
Sheet Aluminum	N/A

A.2.12.4 Field Inspection

Visually verify envelope for evidence of air sealing.

1. Verify that the air-barrier materials documented on the building plans are installed in the field. Look for evidence of air sealing between air-barrier materials in areas that are exposed.
2. Verify that the air barrier is continuous between wall and roof assemblies and between wall and floor assemblies.
    a. Note: Insulation must be in contact with an “air barrier” that prevents air from passing through the insulation, as would occur if installing the insulation directly under the roof deck or on top of a sheetrock ceiling. Ceilings with removable tile will not prevent air movement and are not considered air barriers.
3. Review the inspection notes from the authority having jurisdiction (AHJ) to determine if an air-sealing inspection has been conducted.
4. Request documentation to determine if the air barrier has been commissioned.
5. Note leakage rate; review the air leakage testing results if the testing option was taken.

A.2.13 5077 Stair and Shaft Vent Leakage

A.2.13.1 Measure Description/Applicability

Doors and other openings to shafts, chutes, stairways, and elevator lobbies must be sealed. Shaft dampers shall be low leak and closed during normal building operations.

1. This measure will apply based on occurrence of shafts and stairways.
2. This measure will not apply to tenant fit-outs.

A.2.13.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
502.4.5	C402.4.5	C402.5.5	6.4.3.4.1	6.4.3.4.1	6.4.3.4.1

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.2.13.3 Plan Review

In the architectural drawing set, locate a floorplan to count the number of stairwells and shafts. Log all information under the Stair and Shaft Vent Leakage section of the Additional Envelope Measures Tab.

1. Find door schedule to determine if doors and other entries to shafts/chutes/stairways are specified to be sealed. Log under Weather Stripping.
2. In the mechanical drawing set, locate a fan schedule to determine if the vents are specified to be closed during normal operation. Log under Normal Operation.
3. Determine if a leakage rate is present for vents and fans.
    a. Where fans/vents/dampers are labeled as Class 1, rate should be “Meets requirements”
    b. Where no leakage information is present, rate should be “Does not meet requirements”

A.2.13.4 Field Inspection

Visually verify that locations of vents and shafts match expectations from plan review.

1. Verify doors and other openings to shafts, chutes, stairways, and elevator lobbies are sealed as required. Note: This may include gaskets, weatherstripping, and other sealing.
2. Verify stair and shaft vents have motorized, low-leak dampers as required and are configured to be closed during normal operation.
    a. Visually inspect dampers to see if they are closed.
3. Verify model numbers or other information matches expectations from plan review.

A.2.13.5 QA and Data Transfer

Record damper and door condition per the designations provided in the Additional Envelope Measures section of the data collection form from one of the following choices, based on data entered in the field data collection form:

1. Dampers normally closed; Good weather stripping and seals; Dampers meet leakage requirements.
2. Dampers normally closed; Poor weather stripping and seals; Dampers meet leakage requirements.
3. Dampers normally closed; Good weather stripping and seals; Dampers do not meet leakage requirements.
4. Dampers normally closed; Poor weather stripping and seals; Dampers do not meet leakage requirements.
5. Dampers normally open; Good weather stripping and seals.
6. Dampers normally open; Poor weather stripping and seals.

A.2.14 5083 Vestibule

A.2.14.1 Measure Description/Applicability

Building entrances shall be protected with an enclosed vestibule. Vestibules are required based on climate zone and code selected. Unless specifically exempted, this measure is considered mandatory.

1. Projects in Climate Zones 1 and 2 do not require a vestibule.
2. For all other projects, mark “Yes” under applicable and move on to code requirement.

A.2.14.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
502.4.7	402.4.7	402.5.7	5.4.3.4	5.4.3.4	5.4.3.4

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.2.14.3 Plan Review

Not all doors will require a vestibule. Find architectural floor plans. Typically ground or first floor will have all entrances. Air curtain will be found on electrical or mechanical floor plans.

1. Log the number of entrances on the Additional Envelope Measures form.
2. Log the number of entrances that show a vestibule.
    a. Review door schedule or other notes to determine if timing of vestibule doors is set to open the doors at the same time or independently.

3. Log the number of entrances that show an air curtain.
    a. Review air curtain operations or other notes to determine if air curtains are scheduled to be adjusted and commissioned.

A.2.14.4 Field Inspection

On site, walk around to all building entrances. Confirm number of entrances.

1. Document number of entrances with vestibule installed.
    a. Walk through vestibule to determine if doors open at the same time or independently, and document result.
2. Document the number of entrances with air curtain installed.
3. Note any discrepancies on entries from plan review.

A.2.14.5 QA and Data Transfer

For applicability of this measure, review the following:

1. For projects in Climate Zones 1 and 2, mark “No” under applicable and list CZ as explanation.
2. For all other projects, determine if vestibule is required based on the applicable code. Factors in determining compliance include:
    a. Doors not intended for use by the public will not require vestibules.
    b. Doors opening directly from a sleeping or dwelling unit will not require vestibules.
    c. Revolving doors do not require vestibules (though adjacent accessible swinging doors do).
    d. Doors that open into a space that is below a size defined by the code under which the building was designed (this will range from 1,000 sq. ft.–3,000 sq. ft.).

If all doors on a building meet an exception to compliance, mark applicability as “No” and list primary exception.

Code condition should be selected based on installation of a vestibule or an air curtain:

1. Vestibule installed; Interior/exterior doors open different times.
2. Air curtain installed; Air curtain adjusted properly (allowed under ASHRAE 90.1-2013 only)

Select Plan Review condition based on review of data collection form:

1. Select “Vestibule Installed; Interior/exterior doors open different times; Air Curtain with vestibule” if both a vestibule and an air curtain are present.
2. Select “Vestibule Installed; Interior/exterior doors open different times” by verifying on door schedule that openers for the interior and exterior doors are independent or the doors are not automatic.

3. Select “Vestibule Installed; Interior/exterior doors open same time” by verifying on door schedule that openers for the interior and exterior doors are not independent.
4. Select “Air Curtain Installed; Air Curtain adjusted properly” for all plan review conditions with an air curtain.
5. Air Curtain Installed; Air Curtain not adjusted properly. This option will never apply to plan review, see Field Inspection notes for use in field.
6. Select “No vestibule or air curtain installed” for doors that are required to have a vestibule but do not.

Select inspection condition based on the following:

1. Select “Vestibule Installed; Interior/exterior doors open different times; Air Curtain with vestibule” if both a vestibule and an air curtain are present.
2. Select “Vestibule Installed; Interior/exterior doors open different times” if walking through the vestibule and seeing the doors open at different times.
3. Select “Vestibule Installed; Interior/exterior doors open same time” if walking through the vestibule and seeing the doors open at the same time.
4. Select “No vestibule or air curtain installed” if no vestibule is installed. Do not select this option if the site visit occurs too early for the vestibule to be fully installed. Note that site visit occurred before installation.

A.2.15 5089 Fenestration Orientation

A.2.15.1 Measure Description

Windows must be oriented in accordance with ASHRAE specifications: the area of the vertical fenestration facing south must be greater than the area facing west AND the area of fenestration facing south must be greater than the area facing east.

1. This measure will not apply to buildings complying with IECC.
2. This measure will not apply to buildings complying with ASHRAE 90.1-2007.
3. This measure will not apply to tenant fit-outs.

A.2.15.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
N/A	N/A	N/A	N/A	5.5.4.5	5.5.4.5

This measure will only apply to projects using **Prescriptive** compliance.

A.2.15.3 Plan Review

During plan review, each window will be logged under the Wall Assembly ID in which the window is located. Each wall assembly is required to include its cardinal direction. This is the direction the wall is facing on the exterior.

A.2.15.4 Field Inspection

Verify number, location, and size of installed windows matches approved plans for each orientation and that site construction matches calculations done during plan review. Note any discrepancies. If construction varies, note potential area differences in field and from photographs.

A.2.15.5 QA and Data Transfer

For applicability of this measure: This measure will only apply to projects using Prescriptive compliance. Projects using Trade off or Performance, mark applicability as “No.”.

Code requirement for this measure will always be 0 sq. ft.

Determine Plan Review area based on review of data collection form:

1. Determine area of fenestration on South, East, and West separately.
2. Compare fenestration areas of South to East. If area East is greater than South, record area.
3. Compare fenestration areas of South to West. If area West is greater than South, record area.
4. Combine areas from 2 and 3 above. Enter this total under plan review.

Determine Inspection area based on review of data collection form and photographs:

1. Determine area of fenestration on South, East, and West separately.
2. Compare fenestration areas of South to East. If area East is greater than South, record area.
3. Compare fenestration areas of South to West. If area West is greater than South, record area.
4. Combine areas from 2 and 3 above. Enter this total under inspections.

A.3 Mechanical/Plumbing Measures

A.3.1 6005A Packaged Air Conditioner Efficiency

A.3.2 6005B Packaged Heat Pump Efficiency

A.3.3 6005C Gas Furnace Efficiency

A.3.4 6005D Boiler Efficiency

A.3.5 6005E Water-Source Heat Pump Efficiency

A.3.5.1 Measure Description

Heating and cooling equipment must meet the minimum efficiency requirements when tested and rated in accordance with the applicable test procedure. Alternately, efficiency may be determined by other codes, tradeoffs, or optional efficiency measures.

1. This measure may not apply to tenant fit-outs where the base building has installed central heating and cooling equipment.

A.3.5.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
503.2.3	C403.2.3	C403.2.3	6.4.1.1	6.4.1.1	6.4.1.1

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.3.5.3 Plan Review

Use the HVAC equipment schedule on the mechanical plans (see example below) to identify equipment for review. During plan review, log basic information on the HVAC System Tab, including:

1. A count of each type of equipment,
2. A description of each type of equipment present, and
3. Spaces served by that equipment.

Note: There should be both heating and cooling equipment present in buildings. Where there is not, additional information should be provided to explain lack of heating or cooling. Where heating is provided by electric resistance only, log under notes/comments.

Under the HVAC Log Tab, record specific information for each piece of mechanical heating or cooling equipment including:

1. The equipment ID assigned on the mechanical schedule
2. The equipment type, sub type, and make and model
3. For Heating:
    a. Fuel source
    b. Capacity (and units)
    c. Performance efficiency (and units)
4. For Cooling:
    a. Fuel source
    b. Capacity (and units)
    c. Performance efficiency (and units)
5. Note: Some equipment performs heating or cooling ONLY. For those equipment types, skip the heating or cooling sections as necessary. See Table 6005 for specifics on heating and cooling supply by equipment type.
6. If performance efficiency data is not available on the plans, look up equipment efficiency using the make and model number of the unit, use the manufacturer's

website or the AHRI product directory:
https://www.ahridirectory.org/ahridirectory/pages/home.aspx

Table 6005.1 Heating and cooling supply by equipment type

Equipment Type	Log As	Heating Supplied?	Cooling Supplied?
Air conditioner	DX Cooling	No	Yes
Condensing Unit	DX Cooling	No	Yes
PTAC	DX Cooling	Yes	Yes
VRF	DX Cooling	Yes	Yes
Furnace	Gas Furnace	Yes	No
Air Source Heat Pump	Air-to-Air Heat Pump	Yes	Yes
Water Source Heat Pump	WSHP	Yes	Yes
VAV	VAV Reheat System	Yes	No
Boiler	Gas/Oil Boiler	Yes	No
Air-Cooled Chiller	Air-Cooled Chiller	No	Yes
Water-cooled Chiller	Water-cooled Chiller	No	Yes

A.3.5.4 Field Inspection

Verify that quantity, size, and efficiency match plan review.

1. Verify that the make and model number of the installed units match the numbers recorded during plan review.
2. If the make or model number does not match the plans, record the make and model numbers of the actual installed equipment in the data collection form
3. Take pictures of each nameplate on each piece of equipment for reference.

A.3.5.5 QA and Data Transfer

Mark Y or N for each equipment type under “Equipment in Building” under Columns MNO in rows 2–9. Ensure that both heating and cooling are present in buildings.

For applicability of each measure in main table: Each of these measures will only apply on presence of the type of equipment.

Look up code requirement in applicable code tables.

Log plan review and field inspection data from data collection form.

Figure 6005.1 Mechanical Schedule Showing Packaged Unit Efficiency

PACKAGE – GAS / ELECT. UNIT SCHEDULE

SYMBOL	MANUF.	MODEL NO.	EER	CFM	EXT. S.P. (IN)	TOTAL COOLING (BTUH)	INPUT HEATING (BTUH)	ELECTRICAL			HP	O.S.A	OPER. WT. (LBS.)	REMARKS
								MCA	MOCP	VOLTAGE				
AC 1 / AC 3	YORK	ZJ037NC	12.20	1,200	.75	37,000	60,000	18.5	25	230–3–60	1.5	430/170	835	PROVIDE UNIT W/ECONOMIZER, MERV–13 FILTERS
AC 2	YORK	ZJ049NC	12.20	1,600	1.0	50,000	80,000	23.9	30	230–3–60	1.5	360	857	PROVIDE UNIT W/ECONOMIZER, MERV–13 FILTERS

Figure 6005.2 Equipment Specifications Showing Cooling Efficiency Based on Unit Model Number

TRANE

General Data

(3 - 4 Tons)
Standard Efficiency

Table GD-1 — General Data

	3 Ton Convertible Units						4 Ton Convertible Units					
	YSC036A1			YSC036A3, A4, AW			YSC048A1			YSC048A3, A4, AW		
Cooling Performance[1]												
Gross Cooling Capacity	37,400			37,400			50,300			49,200		
SEER[2]	10.5			10.7			10.1			10.0		
Nominal CFM / ARI Rated CFM	1,200/1,200			1,200/1,200			1,600/1,600			1,600/1,600		
ARI Net Cooling Capacity	36,000			36,000			48,000			47,000		
System Power (KW)	3.91			3.79			5.28			5.40		
Heating Performance[4]												
Heating Models	Low	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High
Heating Input (Btu)	60,000	80,000	120,000	60,000	80,000	120,000	60,000	80,000	120,000	60,000	80,000	120,000
Heating Output (Btu)	47,000	63,000	95,000	48,000	64,000	96,000	47,000	63,000	95,000	48,000	64,000	96,000
AFUE %[5]	80	80	80	81	81	81	80	80	80	81	81	81
Steady State Efficiency (%)	80	80	80	81	81	81	80	80	80	81	81	81
No. Burners	2	2	3	2	2	3	2	2	3	2	2	3
No. Stages	1	1	1	1	1	1	1	1	1	1	1	1
Gas Supply Line Pressure												
Natural (minimum/maximum)		4.5/14.0			4.5/14.0			4.5/14.0			4.5/14.0	
LP (minimum/maximum)		10.0/14.0			10.0/14.0			10.0/14.0			10.0/14.0	
Gas Connection Pipe Size (in.)	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
Compressor												
No./Type		1/Hermetic			1/Hermetic			1/Scroll			1/Scroll	

Figure 6005.3 Typical Gas-Fired Furnace

Figure 6005.4 Boiler Mechanical Schedule Showing Boiler Input Capacity, Output Capacity, and Efficiency

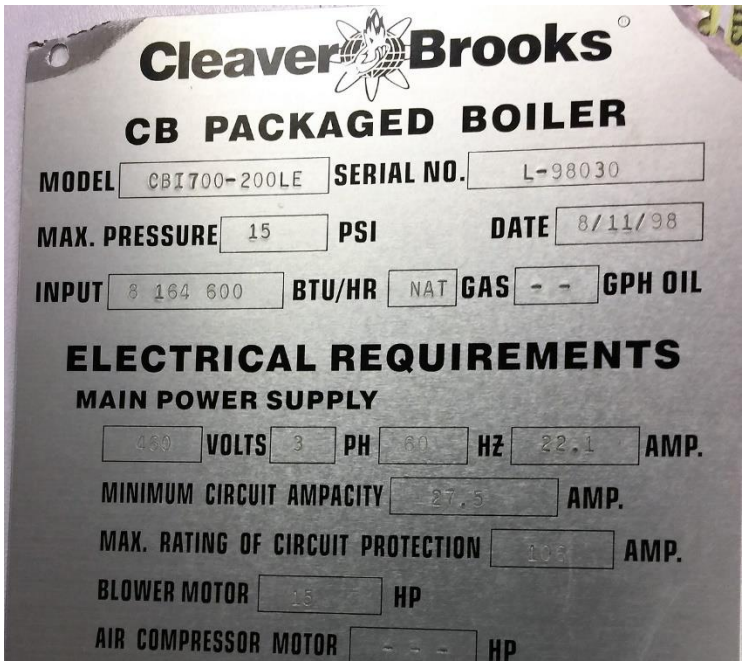
BOILER SCHEDULE

SYMBOL	MAKE	MODEL	TYPE	LOCATION	SERVICE	CAPACITY (MBH)		EFF (%)	GPM	EWT (°F)	LWT (°F)	△ P (PSI)	PRESS. RELIEF (PSI)	FUEL	MIN-MAX FUEL PRESSURE (W.C.")	ELECTRICAL		OPERATIONG WGT. (LBS)	REMARKS
						INPUT	OUTPUT									AMPS	VOLTAGE		
B-1	AERCO	BMK-195LN GLB	CONDENSING BOILER	BASEMENT MECH. ROOM	HEATING HOT WATER	1,950	1677	96	85	105	140	0.6	100	NAT. GAS	8-14	11	460/3/60	1,750	1, 2, 3, 4, 5
B-2	AERCO	BMK-195LN GLB	CONDENSING BOILER	BASEMENT MECH. ROOM	HEATING HOT WATER	1,950	1677	96	85	105	140	0.6	100	NAT. GAS	8-14	11	460/3/60	1,750	1, 2, 3, 4, 5

Figure 6005.5 Typical Condensing Boiler

Figure 6005.6 Typical Steam Boiler

Figure 6005.7 Boiler Nameplate Data



A.3.6 6007A Air-cooled chiller efficiency

A.3.7 6007B Water-cooled chiller efficiency

A.3.7.1 Measure Description

Chiller equipment must meet the minimum efficiency requirements when tested and rated in accordance with the applicable test procedure. Alternately, efficiency may be determined by other codes, tradeoffs, or optional efficiency measures.

1. This measure may not apply to tenant fit-outs where the base building has installed central heating and cooling equipment.

A.3.7.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
503.2.3	C403.2.3	C403.2.3	6.4.1.1	6.4.1.1	6.4.1.1

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.3.7.3 Plan Review

Use the HVAC equipment schedule on the mechanical plans (see example below) to identify if chiller equipment is present for review. During plan review, log basic information on the HVAC System Tab, including:

1. A count of each type of equipment,

2. A description of each type of equipment present, and
3. Spaces served by that equipment.

Under the HVAC Log Tab, record specific information for each piece of mechanical heating or cooling equipment including:

1. The equipment ID assigned on the mechanical schedule
2. The equipment type, sub type, and make and model
3. For Cooling (chillers are for cooling only, skip all heating rows):
    a. Fuel source
    b. Capacity (and units)
    c. Performance efficiency (and units)
4. If performance efficiency data is not available on the plans, look up equipment efficiency using the make and model number of the unit, use the manufacturer's website or the AHRI product directory: https://www.ahridirectory.org/ahridirectory/pages/home.aspx

A.3.7.4 Field Inspection

Verify quantity, size, and efficiency match plan review.

1. Verify that the make and model number of the installed units match the numbers recorded during plan review.
2. If the make or model number does not match the plans, record the make and model numbers of the actual installed equipment in the data collection form
3. Take pictures of each nameplate on each piece of equipment for reference.

A.3.7.5 QA and Data Transfer

For applicability of this measure: Each of these measures will only apply on presence of the type of equipment.

Look up code requirement in applicable code tables.

Log plan review and field inspection data from data collection form.

Figure 6007.1 Air-Cooled Chiller Nameplate

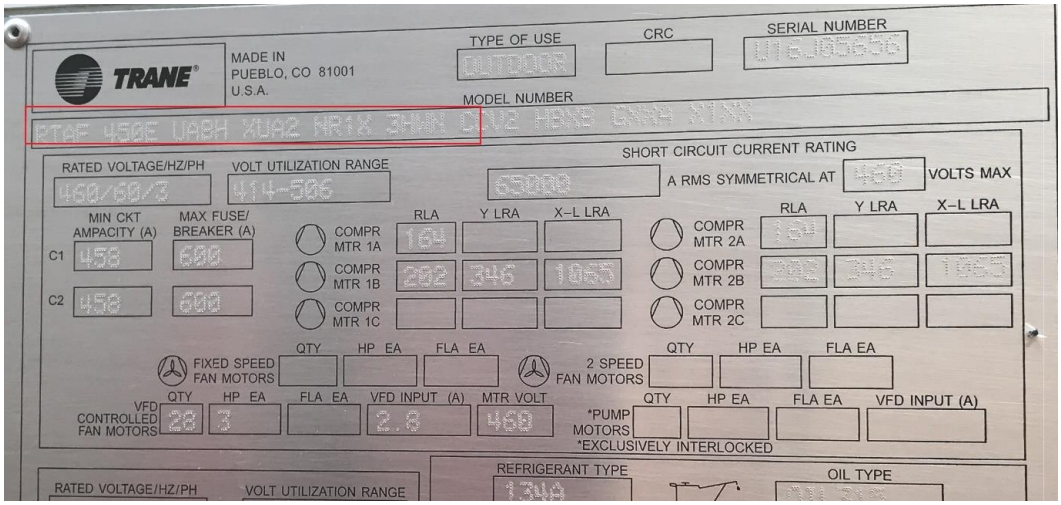


Figure 6007.2 Water-Cooled Chiller Mechanical Schedule

WATER COOLED CHILLER SCHEDULE

UNIT NO.	LOCATION	CAPACITY (TON)	EVAPORATOR						CONDENSER						EFFICIENCY KW/TON	NPLV KW/TON
			EWT (°F)	LWT (°F)	FLOW GPM	ΔP (FT.)	NO. OF PASSES	FOULING FACTOR	EWT (°F)	LWT (°F)	FLOW GPM	ΔP (FT.)	NO. OF PASSES	FOULING FACTOR		
CH-1	MECH. SERVICE YARD	350	58	44	600	14.8	2	0.0001	72	82	940	18.9	2	0.00025	0.411	0.313
CH-2	MECH. SERVICE YARD	104	58	44	178.3	25.1	2	0.0001	72	82	287.5	11.6	2	0.00025	0.567	0.478

REFRIGERENT TYPE	ELECTRICAL					MANUFACTURER / MODEL NO.	OPERATING WEIGHT	REMARKS
	VOLT/ø/Hz	UNIT POWER (KW)	MOP	MCA	LRA			
R134A	460/3/60	144	500	279	–	CARRIER / 23XRV3637NRVR351	21,000	1,2,3,4,5,7
R134A	460/3/60	58.9	175	126	–	CARRIER / 30HXC096	5,855	1,2,3,4,5,8,9

Figure 6007.3 Typical Air-Cooled Chiller

A.3.8 6017 Heat Pump Supplementary Heat Control

A.3.8.1 Measure Description

Heat pumps with supplementary heat must have controls that lock out electric resistance heat when the heat pump alone can meet the heating load. Examples include an outside air lockout at 40°F or warmer or a ramped startup setpoint.

1. This measure may not apply to tenant fit-outs where the base building has installed heating and cooling equipment.
2. This measure will only apply on the presence of heat pumps that contain back up electric resistance heating.

A.3.8.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
503.2.4.1.1	C403.2.4.1.1	C403.2.4.1.1	6.4.3.5	6.4.3.5	6.4.3.5

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.3.8.3 Plan Review

Use the HVAC equipment schedule on the mechanical plans, sequence of operation schedules, or heat pump specifications to identify back up heat. Under the HVAC Log Tab, provide the following information:

1. If the heat pump has supplementary heat control
2. At what outdoor air temperature the electric resistance is prevented from operating (lock out set point).

For each heat pump present, record information on the HVAC Log tab.

A.3.8.4 Field Inspection

Verify heat pump make and model match expectations from plans. If possible, test the supplementary thermostat by doing the following:

1. Test the thermostat by increasing the space temperature setpoint and measuring the supply air temperature (SAT). If the outside air temperature (OAT) is above 40°F and the SAT is warmer than 95°F, the system does not comply with code.
2. If the system uses a BAS instead of a thermostat:
    a. Raise the space temperature setpoint to test the system
    b. Measure the SAT
    c. If the OAT is above 40°F and the SAT is warmer than 95°F, the system does not comply with code.

3. Note any discrepancies or odd findings from field inspection.

A.3.8.5 QA and Data Transfer

For applicability of this measure: Measure will only apply if there is a heat pump.

Look up code requirement in applicable code tables.

Log plan review and field inspection data from data collection form:

1. Indicate which of the options from the data collection form best describes the system:
    a. Lock out supplementary heat OA≤30F; Comp Lock Out OA=0F; or special heat pump thermostat
    b. Lock out supplementary heat OA≤40F; Comp Lock Out OA≤10F; or special heat pump thermostat
    c. Lock out supplementary heat OA=50F; or Comp Lock Out OA≥20F
    d. No lock out supplementary heat or set OA=70F; or Comp Lock Out OA≥35F

A.3.9 6018 Thermostat Deadband

A.3.9.1 Measure Description

Zone thermostatic controls must have at least a 5°F deadband. A deadband is a temperature range in which neither heating nor cooling system turns on. The deadband prevents the thermostat from activating heat and cooling in rapid succession.

1. This measure may not apply to tenant fit-outs where the base building has installed thermostat control systems.

A.3.9.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
503.2.4.2	C403.2.4.2	C403.2.4.1.2	6.4.3.1.2	6.4.3.1.2	6.4.3.1.2

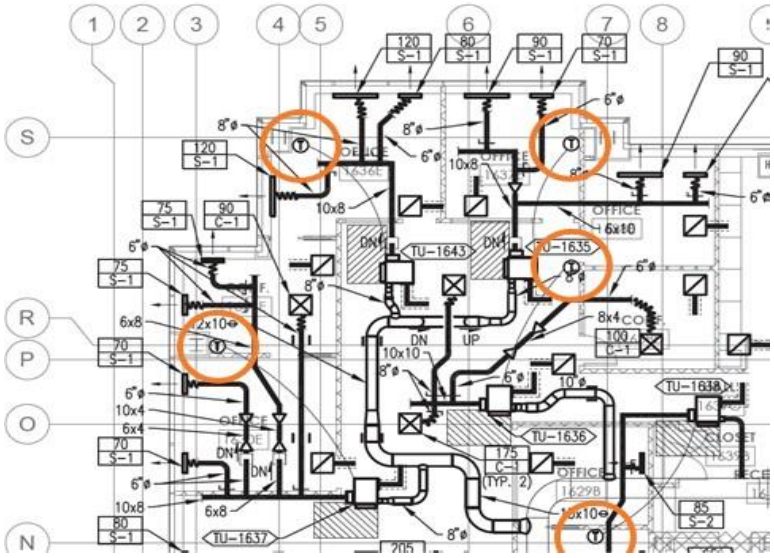
This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.3.9.3 Plan Review

Use the mechanical floor plans to identify any thermostats. Under the HVAC System Tab, record the following information:

1. Assign a control type to each equipment type present in building.
2. Include make and model of thermostat if available on plans.
3. Include notes for field visit on where to find, or other information.

Figure 6018.1 Mechanical Floor Plan Showing Thermostats in Multiple Locations



In the mechanical plans, locate the control specifications, sequence of operations for heating and cooling equipment, or general control notes.

1. Find a specific reference to “deadband” and log the value (should be in a whole number of degrees Fahrenheit)
2. Alternatively, find the values for the high value of indoor air temperature where heating is provided (often 68-70 degrees) and the low value of indoor air temperature where cooling is provided (often 72-75 degrees). Subtract these two values; this is the deadband.
3. Note if thermostat requires manual change over between heating and cooling.

A.3.9.4 Field Inspection

Field data should be gathered from at least three thermostats or 20% of the total number of thermostats installed, whichever is greater. Thermostats should be located in different occupancy areas within the building if possible (e.g. conference, open office, etc.) to complete sample.

1. Verify heating and cooling set points to determine deadband.
2. Note any discrepancies or odd findings from field inspection.

A.3.9.5 QA and Data Transfer

For applicability of this measure: Measure will apply to all thermostats, except thermostats requiring manual changeover between heating and cooling modes.

Code requirement will be 5 degrees.

Log plan review and field inspection data s from data collection form.

Figure 6018.2 Thermostat Showing Cooling Setpoint

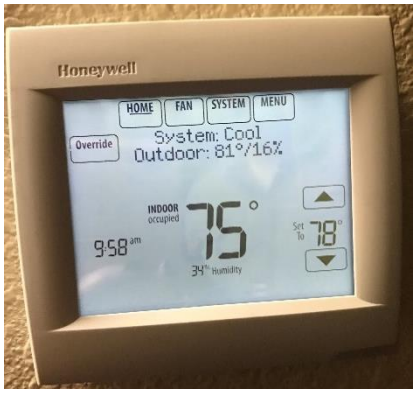
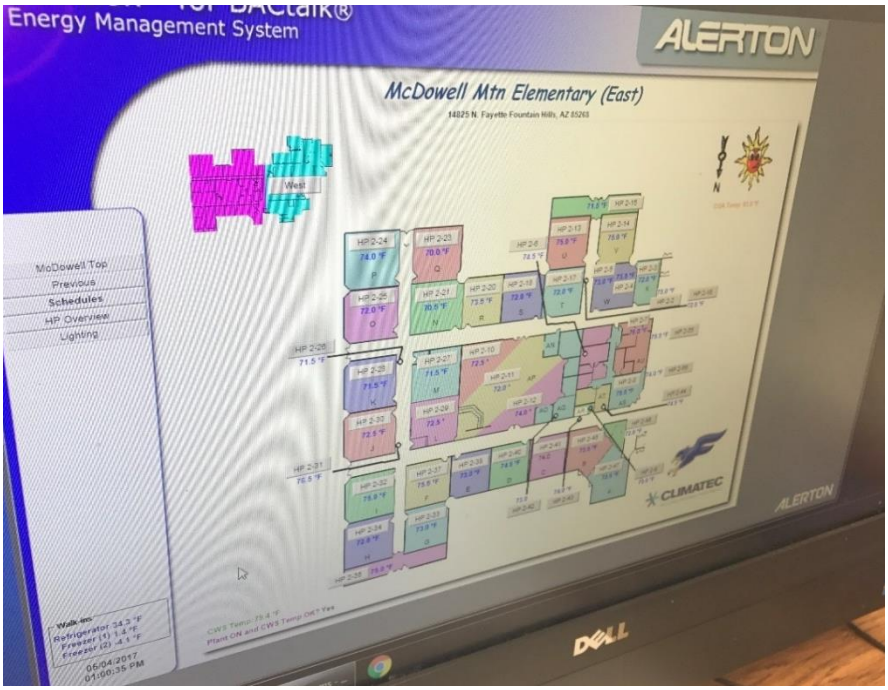


Figure 6018.3 Temperature Sensor[1]

Figure 6081.4 BAS Screenshot Showing Temperature Sensors Measuring Zone Temperatures



[1] PECI HVAC controls protocol

Figure 6018.5 BAS Screenshot Showing Temperature Setpoints for Each HVAC Unit

A.3.10 6019A Thermostat Heating Setback

A.3.11 6019B Thermostat Cooling Setback

A.3.11.1 Measure Description

Each zone must have thermostatic setback controls that are controlled by either an automatic time clock or programmable control system. Thermostatic controls must have the capability to set back or temporarily operate the system to maintain zone temperatures at setback levels defined by code.

A.3.11.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
503.2.4.3.1	C403.2.4.3.1	C403.2.4.2.1	6.4.3.3.2	6.4.3.3.2	6.4.3.3.2

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.3.11.3 Plan Review

In the mechanical plans, locate the control specifications, sequence of operations for heating and cooling equipment, or general control notes.

1. Find a specific reference to heating and cooling set points.
2. If no information can be found, note lack of data.

A.3.11.4 Field Inspection

1. For each thermostat in the sample, review the settings in the field to determine programmed temperatures.
2. Record the heating and cooling temperatures as programmed in degrees Farhrenheit.

A.3.11.5 QA and Data Transfer

For applicability of this measure: Measure will apply to all thermostats, except thermostats requiring manual changeover between heating and cooling modes.

Code requirement will be:

1. Projects using IECC:
    a. Enter the unoccupied heating setting in degrees Fahrenheit: 55.
    b. Enter the unoccupied cooling setting in degrees Fahrenheit: 85.
2. Projects using ASHRAE 90.1–2010:
    a. Enter the unoccupied heating setting in degrees Fahrenheit: 55.
    b. In Climate Zones 1b, 2b, 3b, enter the unoccupied cooling setting in degrees Fahrenheit: 90.
    c. In all other Climate Zones, enter the unoccupied cooling setting as N/A.
3. Projects using ASHRAE 90.1–2013:
    a. Determine the occupied heating set point. Enter the unoccupied heating set point as 10 degrees below the occupied heating set point in degrees Fahrenheit.
    b. If heating set point cannot be determined, enter: 60.
    c. Determine the occupied cooling set point. Enter the unoccupied cooling set point as 5 degrees above the occupied cooling set point in degrees Fahrenheit.
    d. If cooling set point cannot be determined, enter: 80.

Log plan review and field inspection data from data collection form.

A.3.12 6019C Night Fan Control

A.3.12.1 Measure Description

Fans that control ventilation related to HVAC systems shall be scheduled to “off” during unoccupied periods.

A.3.12.2 Code Requirement

IECC			ASHRAE 90.1		
2009	2012	2015	2007	2010	2013
503.2.4.3.2	C403.2.4.3.2	C403.2.4.2.2	6.4.3.3.1	6.4.3.3.1	6.4.3.3.1

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.3.12.3 Plan Review

1. Locate a sequence of operations (SOO) for HVAC equipment.
    a. Review SOO for fan operations during unoccupied periods.
        i. Where no information can be found, assume fan operation is “On.”
    b. Review SOO for fan operations during system warm up.
        i. Where no information can be found, assume fan operation is “On.”
2. Locate fan schedule.
    a. Determine the airflow (cfm) for each supply fan.
    b. Add cfm of all fans in the zone to record the total affected airflow.

A.3.12.4 Field Inspection

1. For each thermostat or building automation system (BAS) in the sample, review the settings in the field to determine programmed fan cycles.
2. Verify count of fans matches expectations from plan review.
    a. Where a difference in fan count is noted, go back to plans to confirm and provide updates in notes.

A.3.12.5 QA and Data Transfer

For applicability of this measure: Measure will apply to all thermostats, except thermostats requiring manual changeover between heating and cooling modes.
Code requirement will be:

1. IECC 2012, IECC 2015, and all versions of ASHRAE 90.1 select: Fan Cycles during Unoccp and warmup by Schedule or sensor; or DOAS with fan always cycling.
2. IECC 2009 select: Fan Cycles during Unoccp by Schedule; but fan "ON" during warmup.

Determine plan review condition from field data collection form:

1. Record condition from the drop down:
    a. If no SOO can be located, select code requirement.
    b. Select: “Fan Cycles during Unoccp and warmup by Schedule or sensor; or DOAS with fan always cycling” if SOO indicates that the fan is scheduled to cycle off during unoccupied periods AND during building warm up.
    c. Select: “Fan Cycles during Unoccp and warmup by Schedule or sensor; or DOAS with fan always cycling” if SOO indicates that the fan is interlocked with DOAS control to cycle on/off as required.
    d. Select: “Fan Cycles during Unoccp by Schedule; but fan "ON" during warmup” if SOO indicates that the fan is scheduled to cycle off during unoccupied periods AND fan is on building warm up, or lists nothing about fan function at warm up (likely 2 different lines in SOO).
    e. Select: “Fan ON Unoccp; or ON/AUTO switch only” if there is no indication of the fan turning off during unoccupied periods.

Determine field inspection condition.

1. Record condition from the drop down:
    a. If no settings can be located, select code requirement.
    b. If the thermostat being inspected is a standard programmable type thermostat, select: “Fan ON Unoccp; or ON/AUTO switch only”
    c. If settings indicate the fan is scheduled to cycle off during unoccupied periods AND during building warm up select: “Fan Cycles during Unoccp and warmup by Schedule or sensor; or DOAS with fan always cycling”
    d. If settings indicate the fan is interlocked with DOAS control to cycle on/off as required, select: “Fan Cycles during Unoccp and warmup by Schedule or sensor; or DOAS with fan always cycling”.
    e. Select: “Fan Cycles during Unoccp by Schedule; but fan "ON" during warmup” if settings indicate that the fan is scheduled to cycle off during unoccupied periods AND fan is on building warm up, or lists nothing about fan function at warm up.
    f. If there is no indication of the fan turning off during unoccupied periods, select: “Fan ON Unoccp; or ON/AUTO switch only”

A.3.13 6023 Optimal Start Controls

A.3.13.1 Measure Description

HVAC systems shall have automatic (optimal) start controls. The controls shall be capable of automatically adjusting the daily start time of the HVAC system to bring each space up to the desired temperature by the time of scheduled occupancy.

A.3.13.2 Code Requirement

IECC			ASHRAE 90.1		
2009	2012	2015	2007	2010	2013
N/A	C403.2.4.3.3	C403.2.4.2.3	6.4.3.3.3	6.4.3.3.3	6.4.3.3

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.3.13.3 Plan Review

1. Determine if plans show an outdoor air temperature (OA) sensor
    a. Review Mechanical symbols for an outdoor air temperature sensor.
    b. Locate OA sensor on mechanical plans. Note location to verify in field.
2. Locate and review sequence of operations for HVAC equipment
    a. Review SOO for information on system start up.

A.3.13.4 Field Inspection

1. If OA sensor was indicated on plans, verify location in field.
2. Verify SOO with thermostat controls:
    a. If controls are individual thermostats, it may be necessary to access contractor settings. Look up instructions on how to access these settings on manufacturer's website.
    b. If controls are BAS, a building operator with access to the controls will be necessary to assist.

A.3.13.5 QA and Data Transfer

For applicability of this measure: This measure will not apply to buildings using IECC 2009. Code requirement will be based on code and year:

1. ASHRAE 90.1-2013 select: Optimum Start; with OA sensor
2. All other codes select: Optimum Start; no OA sensor

For plan review and field inspection, select condition that best meets the information from data collection form.

Affected quantity will be the gross floor area that is heated and cooled.

A.3.14 6026p Snow and Ice-Melting System Control

A.3.14.1 Measure Description

Snow and ice-melting systems must have automatic controls that are capable of shutting off the system when the pavement temperature is above 50°F temperature, no precipitation is falling, and the outdoor air temperature is above 40°F.

1. Snow and ice-melting systems are not required. These controls are mandatory only if these systems are installed.

A.3.14.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
503.2.4.5	C403.2.4.5	C403.2.4.5	6.4.3.8	6.4.3.8	6.4.3.7

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.3.14.3 Plan Review

1. Determine if plans include a snow or ice melt system. This system would likely be indicated in mechanical or electrical drawings at the exterior of the building(s).
2. If snow melt system exists, review mechanical or electrical notes for sensors or locate SOO for system. On the Additional Mechanical Measures Tab record the following:
    a. Select the type of temperature sensor used
    b. Select the temperature sensor setting specified in degrees Fahrenheit.
3. Record the ground/floor area covered by the system(s).
4. Note location of systems and sensors for field inspection.

A.3.14.4 Field Inspection

1. Locate and verify installation of sensors.
2. Check the set points on controller or BAS. Record set points.

A.3.14.5 QA and Data Transfer

For applicability of this measure: This measure will not apply if system is not present.

Code requirement will be: Snow Melt only if OA <40F or readily accessible manual; and Pavement <50F; and Precipitation sensor

For plan review and field inspection, select condition that best meets the information from data collection form.

A.3.15 6029 Demand Control Ventilation

A.3.15.1 Measure Description

Demand-control ventilation (DCV) must be provided for spaces larger than 500 sq. ft. and with an average occupant load of 25 people per 1000 sq. ft. of floor area (as established in Table 403.3 of the International Mechanical Code) and served by systems with one or more of the following:

1. An air-side economizer
2. Automatic modulating control of the outdoor air damper
3. A design outdoor airflow greater than 3,000 cfm.

A.3.15.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
503.2.5.1	C403.2.5.1	C403.2.6.1	6.4.3.9	6.4.3.9	6.4.3.8

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.3.15.3 Plan Review

Find the mechanical plans and specifications. DCV will be indicated if installed as one of the following:

1. Mentioned in the SOO for ventilation controls
2. CO_2 sensors located in high occupancy room types (example conference or meeting rooms).

Where DCV is indicated, mark DCV as “installed” under Ventilation controls.

1. Check the location of the sensors (typically CO_2 sensors) and verify at least one sensor is located in each space (or return air for single zone system) where DCV is required.
2. Note required rooms/locations for field inspection.

A.3.15.4 Field Inspection

Verify that a sensor (typically CO_2 sensor) is located in each space where DCV was noted from plan review.

1. Access the BAS and check and record the DCV related setpoints:
    a. CO_2 level
    b. Airflow
2. For a sample of zones, breathe on the sensor and verify the outdoor air damper responds. Alternately, modify the CO_2 setpoint at the BAS to see if damper opens. Record all observations in the data collection form.

A.3.15.5 QA and Data Transfer

For applicability of this measure: Where there are no spaces that meet the thresholds in the measure description and code references, demand control ventilation is not required. Specifically the following spaces and systems are exempt:

1. Systems with energy recovery complying with Section C403.2.6 of the 2012 IECC.

2. Multiple-zone systems without direct digital control of individual zones communicating with a central control panel.
3. System with a design outdoor airflow less than 1,200 cfm (600 liters per second (L/s)).
4. Spaces where the supply airflow rate minus any makeup or outgoing transfer air requirement is less than 1,200 cfm (600 L/s).
5. Ventilation provided for process loads only.

Verify applicability of measure and enter plan review and as found condition information.

A.3.16 6030 Energy-Recovery Ventilation System

A.3.16.1 Measure Description

Fan systems with large supply airflow and outdoor airflow rates that exceed the values specified in code must include an energy-recovery ventilation (ERV) system.

A.3.16.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
503.2.6	C403.2.6	C403.2.7	6.5.6	6.5.6	6.5.6

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.3.16.3 Plan Review

Find the mechanical plans and SOO. An ERV will most often be included in SOO and airflow schematic drawings for mechanical ventilation. Where an ERV is shown on the plans:

1. Record ERV as yes under the associated system in the HVAC Log.
2. Review SOO to determine the amount of outdoor air (OA) entering the system.
3. Review the SOO or specifications to find the recovery ratio, or the “efficiency” of the ERV system. This will be indicated as a percentage.
4. Review the SOO for the presence of bypass controls for the ERV in the system or otherwise control the economizer so that energy is not recovered during economizer operation. This may be accomplished by one of the following:
    a. A physical bypass with dampers and ducting that avoids the ERV during economizer
    b. The physical rotation of an ERV wheel in the airstream so that it is not functioning
    c. The stopping of the rotation of the ERV wheel.

A.3.16.4 Field Inspection

Verify that the ERV is installed in the expected systems.

1. Verify economizer bypass or control by completing the following:
    a. Check for a physical bypass.
    b. Use the BAS (if available) to exercise the ERV to see if there is a strategy to control or bypass during economizer operation.
    c. If there is no BAS, trigger the economizer sequence to verify the ERV is controlled or bypassed.
2. Record the make and model number from the equipment nameplate in the ERV section of the data collection form and verify it matches the plans. Record any discrepancies.

A.3.16.5 QA and Data Transfer

For applicability of this measure: Verify the supply airflow and outdoor airflow rates in code either require or do not require the installation of an ERV system.

Review plan review and “as found” conditions to select the condition most accurately reflecting the ERV and controls:

1. ERV installed; Energy Recovery Ratio ≥ 60%; Full bypass OA & EA when in Econo
2. ERV installed; Energy Recovery Ratio ≥ 60%; Bypass OA or control in Econo.
3. ERV installed; Energy Recovery Ratio ≥ 50%; Bypass OA or control in Econo.
4. ERV installed; Energy Recovery ≥ 50%; No bypass or control in Econo.
5. ERV installed; Energy Recovery Ratio > 35% but < 50%; Bypass OA or control in Econo.
6. ERV installed; Energy Recovery Ratio > 35% but < 50%; No bypass or control in Econo.
7. ERV Not Used; or Egy Recvy Ratio <35%

A.3.17 6033p Duct Insulation

A.3.17.1 Measure Description

Supply and return air ducts and plenums must be insulated with a minimum of R-6 insulation where located in unconditioned spaces and a minimum of R-8 insulation where located outside the building.

1. This measure will only apply to ductwork located outside of the building or in unconditioned spaces such as vented attic, crawlspace, etc.

A.3.17.2 Code Requirement

IECC	ASHRAE 90.1

2009	2012	2015	2007	2010	2013
503.2.7	C403.2.7	C403.2.9	6.4.4.1.2	6.4.4.1.2	6.4.4.1.2

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.3.17.3 Plan Review

Find the mechanical plans and determine if any ductwork is located outside of conditioned space.

1. Record the following information per the building plans in the Additional Mechanical Controls section of the data collection form:
    a. Insulation R-value
    b. Insulation thickness in inches
    c. Insulation type
2. Complete basic plan take offs to determine the square footage of exterior surface area of ductwork.

A.3.17.4 Field Inspection

Walk around the exterior of the building and check ductwork in any unconditioned areas.

1. Verify applicable ducts are insulated.
2. Record the following information for insulation, as installed, in the Mechanical – Insulation section of the data collection form:
    a. Insulation R-value
    b. Insulation thickness in inches
    c. Insulation type
    d. Insulation condition
3. Record all findings in the data collection form.

A.3.18 6035 Duct Leakage

A.3.18.1 Measure Description

Duct joints, seams, and connections must be fastened and sealed.

A.3.18.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
503.2.7.1	C403.2.7.1	C403.2.9.1	6.4.4.2	6.4.4.2	6.4.4.2

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.3.18.3 Plan Review

Use the mechanical plans or specifications to determine the type of sealant proposed for the ductwork:

1. Determine the airflow (cfm) delivered by the specified ducts and note it in the data collection form.
2. Estimate the quality of sealing based on notes in plan review:
    a. Tested – if testing is indicated.
    b. Properly required – if sealing is indicated with SMACNA Seal Class A.
    c. Poorly sealed – if sealing is indicated with SMACNA Seal Class B or C.
    d. Multiple branch disconnections – will not be used at plan review.

A.3.18.4 Field Inspection

Review any ductwork exposed during site visit. Where visits occur after occupancy or later in construction, determine if any ductwork can be seen by looking up under ceiling tiles.

1. Verify proper support and sealant has been used.
    a. If Underwriters Laboratory (UL) listed and labeled tape or mastic is used, ensure tape is permitted by code.
2. Check the flex duct to boot attachment is complete with screws and zip ties.
3. Look over top or underneath of ductwork to ensure seals go the entire way around transverse joints.
4. Evaluate the quality of sealing using the designations provided in the data collection form:
    a. Tested – if testing was performed, log test results in Notes.
    b. Properly required – if all longitudinal and transverse joints and seams are sealed and all connections.
    c. Poorly sealed – if all transverse joints and connections are sealed, but longitudinal joints are unsealed.
    d. Multiple branch disconnections – if connection points are loose or unstable.

A.3.19 6042B Hydronic Heating Piping Insulation

A.3.19.1 Measure Description

Piping in a heating system must be insulated.

A.3.19.2 Code Requirement

IECC	ASHRAE 90.1

2009	2012	2015	2007	2010	2013
503.2.8	C403.2.8	C403.2.10	6.4.4.1.3	6.4.4.1.3	6.4.4.1.3

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.3.19.3 Plan Review

Use the mechanical plans or specifications to identify any hydronic heating equipment and piping.

1. Record the following information in the Additional Mechanical Measures tab of the data collection form:
    a. Insulation R-value
    b. Insulation thickness
    c. Insulation type
2. Determine the length (ft.) of the supply and return piping.

A.3.19.4 Field Inspection

Review any piping exposed during site visit. Where visits occur after occupancy or later in construction, determine if any piping can be seen by looking up under ceiling tiles.

1. Verify applicable piping is insulated.
2. Record the following information for insulation, as installed, in the Mechanical – Duct & Piping Insulation section of the data collection form:
3. Insulation R-value
4. Insulation thickness
5. Insulation type

A.3.20 6045p Mechanical Commissioning

A.3.20.1 Measure Description

Mechanical systems must be commissioned in accordance with code requirements.

A.3.20.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
N/A	C408.2	C408.2	6.7.2.4	6.7.2.4	6.7.2.4

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.3.20.3 Plan Review

Use the mechanical specifications to determine any commissioning (Cx) requirements for the building.

1. If commissioning is noted, verify that a Cx plan has been submitted with the plans and specifications.
2. Where Commissioning is specified and Cx plan provided, indicate Commissioned: Satisfactory Quality.

A.3.20.4 Field Inspection

Review any piping exposed during site visit. Where visits occur after occupancy or later in construction, determine if any piping can be seen by looking up under ceiling tiles.

1. Verify that a preliminary Cx report has been submitted to demonstrate Cx occurred on the project and indicates the status of each piece of equipment that has been commissioned.
2. If a Cx report is not available, inquire about Cx and a Cx report with building contact.
3. Assess the quality of the Cx and rate in accordance with the designations provided in the data collection form:
    a. Commissioned: High Quality
    b. Commissioned: Satisfactory Quality
    c. Commissioned: Poor Quality
    d. Not Commissioned

A.3.20.5 QA and Data Transfer

Review applicability based on code exemptions:

1. Mechanical systems in buildings where the total mechanical equipment capacity is less than 480,000 Btu/h cooling capacity and 600,000 Btu/h heating capacity.
2. Systems included in Section C403.3 that serve dwelling units and sleeping units in hotels, motels, boarding houses or similar units.

Code condition is always: Commissioned: Satisfactory Quality

A.3.21 6046A Fan power limit for packaged air conditioners

Measure Name	Measure Number	Code Section
6046A Fan power limit for packaged air conditioners		IECC 2012: C403.2.10
Measure Description		
HVAC systems with total fan system motor nameplate horsepower (hp) greater than 5 hp must be properly sized. Total fan system motor nameplate hp exceeding 5 hp must meet the provisions of Sections C403.2.10.1 through C403.2.10.2 of the 2012 IECC.		
Plan Review		

1) Determine and record the minimum code requirement based on energy code documentation. If there is no documentation or the documentation does not specify the selected compliance path for the project, assume prescriptive requirements are followed.
2) Use the mechanical plans to determine the maximum horsepower allowed based on the supply airflow for each system.
3) Check the mechanical schedule for compliance with the motor nameplate hp limit and record findings in the *Mechanical—Airside* section of the data collection form.
    a. If the system is not compliant, check the mechanical schedule and code compliance forms for brake horsepower (bhp) allowance and compliance. Limits include supply, return, exhaust, and series fan power terminal units (FPTU) fans. Include any "device" credits available to system when using the bhp approach.

Note: While this requirement applies to any system with a total nameplate hp exceeding 5 hp (sum of supply, return, and exhaust fan motors), typically it is easily met by systems less than 15 tons. Relief fan motors that operate only during economizer operation are not counted against the limit.

Field Inspection

1) For each system, verify the nameplate hp for each fan matches those shown in the plans.
2) For all fans, verify that the fan motors installed in the field match the nameplate hp that is indicated on the plans.
    a) If the installed equipment does not match what is called for on the plans:
        i) Record the make and model number off the unit nameplate on each piece of equipment.
        ii) Record the fan nameplate motor hp after the completion of the on-site data collection effort.
3) If brake hp approach for compliance was used, verify that any devices claimed for pressure drop credit in the calculations (e.g., fully ducted return, filtration greater than MERV 8, ERV, etc.,) are installed.
4) Record all findings in the *Mechanical—Airside* section of the data collection form.

A.3.22 6046B Fan power limit for VAV

Measure Name	Measure Number	Code Section
6046B Fan power limit for VAV		IECC 2012: C403.2.10

Measure Description

HVAC systems with total fan system motor nameplate horsepower (hp) greater than 5 hp must be properly sized.

Plan Review

1) Determine and record the minimum code requirement based on energy code documentation. If there is no documentation or the documentation does not specify the selected compliance path for the project, assume prescriptive requirements are followed.

2) Use the mechanical plans to determine the maximum horsepower allowed based on the supply and return airflow for each system.
3) Check the mechanical schedule for compliance with the motor nameplate hp limit and record findings in the *Mechanical – Airside* section of the data collection form.
    a. If the system is not compliant, check the mechanical schedule and code compliance forms for brake horsepower (bhp) allowance and compliance. Limits include supply, return, exhaust, and series fan power terminal units (FPTU) fans. Include any "device" credits available to system when using the bhp approach.

Note: While this requirement applies to any system with a total nameplate hp exceeding 5 hp (sum of supply, return, exhaust, and FPTU fan motors), typically it is easily met by systems less than 15 tons. Relief fan motors that operate only during economizer operation are not counted against the limit.

Field Inspection

1) For each system, verify the nameplate hp for each fan matches those shown in the plans.
2) For all fans, verify that the fan motors installed in the field match the nameplate hp that was indicated on the plans.
    a) If the installed equipment does not match what was called for on the plans:
        i) Record the make and model number off the unit nameplate on each piece of equipment
        ii) Record the fan nameplate motor hp after the completion of the onsite data collection effort.
3) If brake hp approach for compliance was used, verify that any devices claimed for pressure drop credit in the calculations (e.g., fully ducted return, filtration greater than MERV 8, ERV, etc.,) are installed.
4) Record all findings in the *Mechanical – Fan Power VAV* section of the data collection form.

A.3.23 6051 Outdoor heating

A.3.23.1 Measure Description

Outdoor heating systems are not required; however, systems installed to provide heat outside of a building must be radiant systems.

A.3.23.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
503.2.11	C403.2.11	C403.2.13	6.5.8	6.5.8.1	6.5.8.1

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.3.23.3 Plan Review

Use the mechanical plans to identify any outside or covered exterior areas with heating. Where a building has outdoor heating:

1. Determine the type of control on the heating system (occupancy sensor, timer, or no automatic controls).

2. Verify that the heating source is a radiant system.
3. Record heating capacity in MBh.
4. Record all findings in the Additional Mechanical Measures Tab of the data collection form.

A.3.23.4 Field Inspection

Look for outside heating, particularly at exterior entries, check-out counters, or any outdoor patio space.

1. Determine the type of control on the heating system (occupancy sensor, timer, or no automatic controls).
2. Verify that the heating source is a radiant system.
3. Record heating capacity in MBh.
4. Record all findings in the Additional Mechanical Measures Tab of the data collection form.

A.3.24 6056 Economizer

A.3.25 6066P Water Economizer

A.3.25.1 Measure Description

Cooling systems with fans must include an air or water economizer. Air economizer systems must be capable of modulating outdoor air and return air dampers to provide up to 100 percent of the design supply air quantity as outdoor air for cooling.

Water economizers must provide 100% of the cooling load at specified temperature and humidity.

A.3.25.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
503.3.1	C403.3.1.1.1	C403.3	6.5.1.1	6.5.1.1.1	6.5.1.1.1
503.4.1	C403.4.1.1	C403.3	6.5.1.2	6.5.1.2.1	6.5.1.2.1

This item can be traded off in the performance pathway:

1. **Prescriptive:** Projects using the prescriptive path that have cooling systems over 33,000 btu/h will be required to have an economizer.
2. **Performance:** Projects using the performance path can trade off economizers for efficiency gains in other areas. Where an economizer is indicated on the energy model, it will be required to have an economizer.

A.3.25.3 Plan Review

Use the mechanical plans, specifications and sequence of operations (SOO) to determine which cooling systems are equipped with an economizer. Where an economizer is indicated:

1. Log economizer information on the HVAC log under the associated cooling system.
2. Indicate if it is an air or water economizer.
3. Determine the percentage of outdoor air (OA) or tons of water processed by the economizer.

A.3.25.4 Field Inspection

Verify each cooling system that included an economizer on the plans.

1. Confirm the cooling capacity for the economizer unit matches the plans.
2. For air economizers, verify return air damper is fully closed during economizer operation.
3. Look for and note the results of any reports that show a functional performance test has been conducted on the economizer(s).

A.3.25.5 QA and Data Transfer

To determine applicability:

1. Projects using the performance path can trade off economizers for efficiency gains in other areas. Energy model documentation should be reviewed to determine applicability.
2. Various efficiency exemptions are in place across the codes and code years. Cooling systems should be evaluated to determine if efficiency exemptions were taken.

Figure 6066P.1 Outside Air Ductwork for Air Economizer[1]

[1] U.S. Department of Energy

A.3.26 6070 Multi-zone reheat systems

Measure Name	Measure Number	Code Section
6070 Multi-zone reheat systems		IECC 2012: C403.4.2

Measure Description

VAV fans with motors 7.5 hp or larger must have variable speed, variable pitch axial, or fan demand reduction. Zone dampers must reduce airflow before reheating.

Plan Review

1) Determine and record the minimum code requirement based on energy code documentation. If there is no documentation or the documentation does not specify the selected compliance path for the project, assume prescriptive requirements are followed.
2) Use the plans to identify any multi-zone reheat systems.
3) If this measure applies to the building, verify that multi-zone fan systems with simultaneous heating and cooling systems, at a minimum, have dampers in place and specified to reduce individual zone airflow as required by code (varies by code).
4) Verify that the VAV system is specified with either a variable speed drive (VSD), variable pitch axial fan, or fan demand reduction.
    a. Fans with hp greater than or equal to the code requirement must have a VSD.
5) Check the HVAC equipment schedule or equipment specifications to determine which option has been selected.
6) Zone air for reheat systems shall be limited to 30% or 20% with dual max, or have a documented ventilation exception.
7) Identify and record the speed control and fan nameplate hp in accordance with the designations provided in the data collection form:
    a) Variable flow fan with ~33% turndown; VSD
    b) Variable flow fan with ≤50% turndown; VSD
    c) Variable flow fan with ~66% turndown; VSD or two-speed
    d) Variable air flow; Outlet damper; no VSD
    e) Constant volume fan; Constant airflow
8) Record all findings in the *Mechanical – MZ VAV* section of the data collection form.

Field Inspection

1) Verify that the test and balance (TAB) or Cx report shows that box minimums have been properly set to match plan documents.
2) Verify that VSD is in place if required and that the fan is operating at reduced speed.
3) Confirm speed control and fan nameplate hp and record in accordance with the designations provided in the data collection form:
   a) Variable flow fan with ~33% turndown; VSD
   b) Variable flow fan with ≤50% turndown; VSD
   c) Variable flow fan with ~66% turndown; VSD or two-speed
   d) Variable air flow; Outlet damper; no VSD
   e) Constant volume fan; Constant airflow
4) Record all observations in the *Mechanical – MZ VAV* section of the data collection form.

A.3.27 6071 Static pressure sensors

Measure Name	Measure Number	Code Section
6071 Static pressure sensors		IECC 2012: C403.4.2.1

Measure Description

Static pressure sensors used to control VAV fans must be placed in a position such that the controller set point is no greater than one-third of the total design fan static pressure (or 1.2 inches w.c.), except for systems with zone static reset control complying with Section C403.4.2.2 of the 2012 IECC.
Note: ASHRAE 90.1–2013 and the 2015 IECC require both when direct digital controls (DDC) are present.

Plan Review

1) Determine and record the minimum code requirement based on energy code documentation. If there is no documentation or the documentation does not specify the selected compliance path for the project, assume prescriptive requirements are followed.
2) Use specifications, plans, or control drawings to identify static pressure (SP) sensor placement.
   a. For buildings with DDC controls, check sequence of operations (SOO) to verify set point is being reduced (reset) based on zone cooling demand.
3) Note sensor location and total fan CFM per the data collection form:
   - Static pressure reset with max setpoint 1/3 of design pressure or 1.2" w.c.; and reset is at least 0.5" w.c.
   - Static pressure reset at least 0.5" w.c; or the max setpoint ≤1/3 of design pressure
   - No static pressure reset; or the max setpoint >1/3 of design pressure
4) Record all findings in the *Mechanical – Airside* section of the data collection form.

Field Inspection

1) Confirm static pressure placement matches plan review findings.
2) If pressure sensor cannot be located, verify location on control drawings or contact the HVAC contractor to determine the location of the SP sensor.
3) Observe setpoint and reset in BAS, if possible.
4) Record all observations in the *Mechanical – Airside* section of the data collection form.

A.3.28 6089 Water-source heat pump power

Measure Name	Measure Number	Code Section
6089 Water-source heat pump power		IECC 2012: C403.4.3.3.3

Measure Description

Each hydronic heat pump on the hydronic system having a total pump system power exceeding 10 hp shall have a two-position valve and VSD on circulation pump.

Plan Review

1) Determine and record the minimum code requirement based on energy code documentation. If there is no documentation or the documentation does not specify the selected compliance path for the project, assume prescriptive requirements are followed.
2) Document heat pump nameplate horsepower.
3) Use the plans or specifications to verify water source heat pump (WSHP) loop pump size
    a. Verify that when total pump system power >10 hp, each WSHP has a two-position valve.
4) Verify VSD control of pump.
5) Indicate in the *Mechanical – Plant* section of the data collection form which of the following options pertains to the system:
    - Individual WSHP valves; VSD on pumps
    - Individual WSHP valves; pump rides pump curve
    - No individual WSHP valves; pump is constant flow.
6) Record all findings in the *Mechanical – Plant* section of the data collection form.

Field Inspection

1) Confirm for at least 3 and at least 10% of the WSHP units that there is a 2-position water loop shutoff valve if required (total of all hydronic heat pump units >10 hp).
   Note: A small number of units may have no valve to avoid pump deadheading.
2) Verify VSD is installed on the pump.
3) Verify pump nameplate hp matches design.
4) If the system is operational, check that the pump is operating at reduced speed.
5) Record all observations in the *Mechanical – Plant* section of the data collection form.

A.3.29 6091P Multiple chiller controls

Measure Name	Measure Number	Code Section
6091P Multiple chiller controls		IECC 2012: C403.4.3.5

Measure Description

Chilled water plants with more than one chiller must reduce flow through the chiller plant when a chiller is shut down.

Plan Review

1) Determine and record the minimum code requirement based on energy code documentation. If there is no documentation or the documentation does not specify the selected compliance path for the project, assume prescriptive requirements are followed.
2) Use the plans to identify chillers.
3) If this measure applies to the building, verify each chiller has an isolation valve or a check valve combined with a dedicated primary pump.
4) Review the mechanical plans showing the hydronic piping layout and the pump schedule to verify that a VSD motor(s) has been installed.
5) Note the appropriate designation for the system per the *Mechanical – Plant* section of the data collection form:
   a) VSD primary chiller pump with variable flow chiller.
   b) Individual chiller valves and separate pumps for each chiller or VSD on common pump.
   c) Individual chiller valves, but not separate pumps for each chiller or VSD.
   d) No individual chiller valves and primary pumps are constant flow.
6) Check SOO for flow through chiller only when chiller is operational.
7) Record all findings in the *Mechanical – Chiller* section of the data collection form

Field Inspection

1) Verify that installed equipment matches plan review findings.
2) Verify each chiller has an isolation valve or a check valve combined with a dedicated primary pump.
3) Verify VSD is installed on all the chiller pumps.
4) If the system is operational, verify that each pump can operate at reduced speed and that the flow valve to non-operational chillers is closed.
5) Record all observations in the *Mechanical – Chiller* section of the data collection form.

A.3.30 6101 Multiple zone reset controls

Measure Name	Measure Number	Code Section
6101 Multiple zone reset controls		IECC 2012: C403.4.5.4

Measure Description

Multiple zone HVAC systems must include controls that automatically reset the supply air temperature in response to representative building loads or to outdoor air temperature. Temperature shall be reset at least 25% of the difference between design supply air temperature and cooling design room air temperature.

Plan Review

1) Determine and record the minimum code requirement based on energy code documentation. If there is no documentation or the documentation does not specify the selected compliance path for the project, assume prescriptive requirements are followed.
2) Verify sequence of operations (SOO) or specifications have SAT reset controls meeting code requirements.
3) Note design SAT and reset SAT per the designations provided in the *Mechanical – Controls* section of the data collection form:
   - SAT is reset: ≥ 25% des SA to space reset
   - SAT is reset; < 25% des SA to space reset; or core zones not sized for reset
   - No SAT reset
4) Record all findings in the *Mechanical – MZ Reset Controls* section of the data collection form.

Field Inspection

1) Observe SAT reset in operation, trends of the SAT setpoint, or programming in field.
   Note: This will likely require assistance from a controls contractor or building operator; the system must be operational.
2) Alternatively, verify SAT reset sequence on control drawings.
3) Record all observations in the *Mechanical – MZ Reset Controls* section of the data collection form.

A.3.31 6106AS VAV Ventilation Optimization

Measure Name	Measure Number	Code Section
6106AS VAV Ventilation Optimization		ASHRAE 90.1-2010: 6.5.3.3

Measure Description

Multi-zone VAV systems with DDC-to-zone (Direct Digital Control) must dynamically reset outside air intake in response to ventilation system efficiency. They must automatically reduce outdoor air intake flow below design rates in response to changes in system ventilation efficiency.
Note: This requirement does not apply when an energy model has been submitted for compliance.

Plan Review

1) Determine and record the minimum code requirement based on energy code documentation. If there is no documentation or the documentation does not specify the selected compliance path for the project, assume prescriptive requirements are followed.
2) Verify sequence of operations (SOO) or specifications have a dynamic ventilation reset for multi-zone systems.
3) Record flow of outside air (cfm).
4) Select best description of system:
   - VAV ventilation optimization; with zone DCV (Apx B, 62.1-2010 UM)
   - VAV ventilation optimization
   - No VAV ventilation optimization
5) Record all findings in the *Mechanical – VAV Ventilation Controls* section of the data collection form.

Field Inspection

1) Observe dynamic ventilation reset in operation, trends of outside air setpoint, or programming in field.
   Note: This will likely require assistance from a controls contractor and the system be operational.
2) Alternatively, verify dynamic ventilation reset sequence on control drawings.
3) Record observations in the *Mechanical – VAV Ventilation Control*s section of the data collection form.

A.3.32 6108AS Single-zone VAV

Measure Name	Measure Number	Code Section
6108AS Single-zone VAV		ASHRAE 90.1-2010: 6.4.3.10

Measure Description

Single-zone air handling units (AHUs) and fan coil units (FCUs) with fan motors 5 hp or larger and chilled water coils must be 2 speed or VAV with variable speed drives (VSD). Fan speed is limited at 50% cooling to the greater of 50% flow or minimum outside air (OA) requirements. Single-zone systems with dx cooling, 110,000 Btu/h or greater, must also be 2 speed or variable frequency drive (VFD) with fan speed limited to 2/3 full speed at 50% cooling demand.

Plan Review

1) Determine and record the minimum code requirement based on energy code documentation. If there is no documentation or the documentation does not specify the selected compliance path for the project, assume prescriptive requirements are followed.
2) Use the HVAC equipment schedule or equipment specifications to verify that AHUs and FCUs are specified with variable or multi-speed fans if they have fan motors 5 hp or greater and chilled water coils.
    a. Note minimum speed and verify system is controlled to run at minimum speed at low or no load.
3) Record all findings in the *Mechanical – Single Zone VAV* section of the data collection form and note equipment details in the *HVAC Log*.

Field Inspection

1) Verify that the installed equipment matches what is specified on the plans and/ or in the specifications and the code requirements.
2) If the installed equipment is different than what is shown in the mechanical plans, check the fan motor nameplate for the horse power rating and for the presence of a VFD control or two speed motor.
3) Verify that the installed equipment model number is for equipment with variable or multi-speed fan capability.
4) Alternatively, contact the HVAC contractor to determine the specifications for the installed system.
5) Verify that fan is running at low speed during low- or no load conditions.
6) Record all observations in the *Mechanical – Single Zone VAV* section of the data collection form and note equipment details in the *HVAC Log*.

A.3.33 6109PAS Parking Garage Fan Controls

A.3.33.1 Measure Description

Enclosed parking garage ventilation systems shall automatically detect contaminant levels and stage fans or modulate fan airflow rates to 50% or less of design capacity provided acceptable contaminant levels are maintained.

A.3.33.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
N/A	N/A	C403.2.6.2	6.4.3.4.5	6.4.3.4.5	6.4.3.4.5

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.3.33.3 Plan Review

Where buildings contain a parking garage, review mechanical plans, sequence of operations (SOO) or specifications for information on CO sensors and ventilation controls.

1. Record exhaust fan setting
2. Control type
3. Reduction in fan flow
4. Total exhaust fan HP in garage

A.3.33.4 Field Inspection

Verify exhaust fans and controls match expectations from plan review, including:

1. Variable speed drives (VSD) or constant volume fans
2. CO sensors are in place
3. Fans are operating at reduced speed based on contaminate level.

Where installed, ask to review BAS system controlling fans.

A.3.33.5 QA and Data Transfer

To determine plan review and as found conditions, combine information from data collection sheet to select the most appropriate condition from Pacific Northwest National Laboratory (PNNL) analysis form.

Figure 6109PAS.1 EMS Screenshot Showing Garage Fan Control Based on Contaminant Level

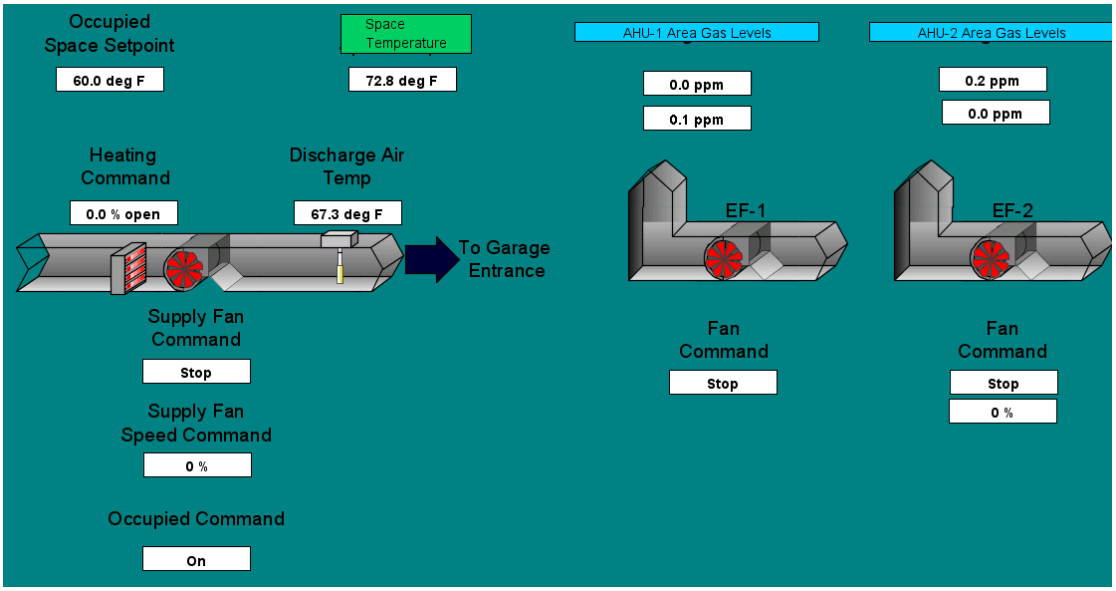


Figure 6109PAS.2 Garage Exhaust Fans

Figure 6109PAS.3 Garage Fan VFD

A.3.34 6110PAS Zone Isolation

Measure Name	Measure Number	Code Section GG
6110PAS Zone Isolation		ASHRAE 90.1-2010: 6.4.3.5

Measure Description

HVAC systems serving zones that are not intended to operate or be occupied at the same time must be able to automatically shut off the supply of conditioned air, outdoor air, and exhaust air to any zone that is not occupied. Zones that do operate and are occupied simultaneously can be grouped into a single isolation zone ≤25,000 sq. ft. and not more than one floor.

Plan Review

1) Determine and record the minimum code requirement based on energy code documentation. If there is no documentation or the documentation does not specify the selected compliance path for the project, assume prescriptive requirements are followed.
2) Use the mechanical plans or specifications to verify that isolation devices, such as dampers, are present where zones are required to be isolated and that isolation areas are below required area thresholds.
3) Verify that the sequence of operations (SOO) in the mechanical plans or specifications have required zone isolation controls for spaces that operate for extended hours.
4) Record all findings in the *Mechanical – Zone Isolation section* of the data collection form.

Field Inspection

1) For multiple zones on a single fan system with various occupied times, confirm the schedules are programmed for each zone and isolation devices (dampers) shut off airflow to spaces that are not occupied.
2) Verify with the HVAC contractor or building operator that the controls are set up correctly.
   a) Alternatively, control functionality may be verified by exercising the BAS.
3) Record all observations in the *Mechanical – Zone Isolation section* of the data collection form.

A.3.35 7006 SWH Pipe Insulation

A.3.35.1 Measure Description

For automatic circulating hot water and heat-traced systems, piping shall be insulated with not less than 1 inch of insulation having a conductivity not exceeding 0.27 Btu per inch/h × sq. ft. × °F, which is equivalent to an R-value of 3.7.

A.3.35.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
504.5	C404.5	C404.4	7.4.3	7.4.3	7.4.3

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.3.35.3 Plan Review

Locate plumbing plans and specifications.

1. Use the plans to verify that insulation is specified for piping in recirculating hot water systems or systems that show heat tracing.
2. Verify the R-value of the insulation, the type of insulation, and insulation thickness.
3. Determine the linear feet of the HW piping.
4. Log information under Additional Mechanical Measures.

A.3.35.4 Field Inspection

Walk site to view exposed HW piping where possible. It may be possible in a more finished building to move a few ceiling tiles if piping is running at ceiling locations.

1. Verify piping is insulated as required in the plans.
2. Document pipe insulation type and thickness.

A.4 Lighting/Electrical Measures

A.4.1 9003 Manual Lighting Control

A.4.1.1 Measure Description

Each enclosed area (space) shall have at least one manual control for the lighting in that area, as well as controls allowing reasonably uniform lighting reduction between 30% and 70% (varies by code). The controls shall be located within the area or be a remote switch that identifies the lights served and indicates their status.

A.4.1.2 Code Requirement

IECC			ASHRAE 90.1		
2009	2012	2015	2007	2010	2013
505.2.1	C405.2.1	C405.2.2.3	9.4.1.2	9.4.1.2	9.4.1.1

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.4.1.3 Plan Review

Locate lighting plans and control schedule in electrical drawings. Control details may be found in drawing set floor plans, one-line controls diagram, specifications, or not at all. On the Controls tab of the data collection form, log all controls for the project, including interior and exterior and indicate their functionality. For manual controls:

1. Verify the design for each space includes a switch for manual control. This can typically be found on the lighting floor plan with the switch indicated by a $ symbol. The symbol can be verified in the symbol legend, which is typically within the first few pages of a drawing set. See Figure 9003.1.
    a. Note any spaces not requiring manual controls.
    b. Document spaces that do not have a switch on the plans for onsite verification, these may be controlled by a remote switch.
2. Verify the design includes lighting reduction controls per code in each space, unless not required, based on number of luminaries in the space, rated power of lighting within the space, space type, or alternate lighting controls in the space as required by code.
    a. Approved lighting reduction controls include strategies such as dimming (^{D} or similar on plans), dual switching lamps or luminaires ($$ - multiple switches on plans), or others. These strategies may be called out in a note on the plans as well.
3. Begin to log what spaces are controlled manually on the Lighting System tab. Plan review will go back and forth between the Fixtures, Controls, and Lighting Systems tab for the lighting review documentation.
4. Note that emergency lighting and exit or egress lighting is not required to be controlled.
    a. Emergency lighting may be indicated on plans by a diagonal fill in fixture or letter indicator and the circuit may be labeled ‘E’ or ‘EM’  .
    b. Several symbols are used to indicate exit or egress lighting. Examples include: 

A.4.1.4 Field Inspection

Using the Controls tab and Lighting System tab, walk the property and verify expectations of controlled lighting from plan review. For manual controls specifically, field inspection can be sampled to include five or 10% of spaces, whichever is greater. Sampling of spaces should include a distribution of space types, for example if a building includes private offices and open offices, each should be sampled to five or 10% of that space type.

1. Verify each space includes a manual control unless noted during the plan review that one is not required.
2. If the control is remote, verify it identifies the lights served and indicates their status.
3. Verify required lighting reduction controls are present for each space by observing a second switch, button, or a dimmer that uniformly reduces the lighting by at least 50% (unless noted during the plan review that they are not required).
4. Verify maximum controlled area for each manual control as required by the specific code.
5. If any aspect of the onsite lighting does not match the plan design for a space, determine which exceptions may apply for the as-constructed space.
6. Record all findings in the data collection form.

A.4.1.5 QA and Data Transfer

Record code requirement based on code and year:

1. If IECC, as “Manual 2-step controls; w/reduction to ≤50% in each room”
2. If ASHRAE 2010 or 2013, as “Manual 2-step controls; w/reduction to ≤70% in each room”
3. If ASHRAE 2007, as “Manual 1-step room controls for 100% off only”

Select plan review condition based on information from data collection form:

1. If plans show manual controls with dimmer, as “Manual 3-step or dimmer controls; w/reduction to ≤33%”
2. If plans show manual controls with dual switching, as “Manual 2-step controls; w/reduction to ≤50% in each room”
3. If plans show manual switch only, as “Manual 1-step room controls for 100% off only”
4. If plans show no manual switching, as “No local manual controls”. Before logging this condition, verify that remote switching is not allowed. Remote switching can be used for corridors, public lobbies, and other areas as allowed by code.

Figure 9003.1 Example Lighting Symbol Legend

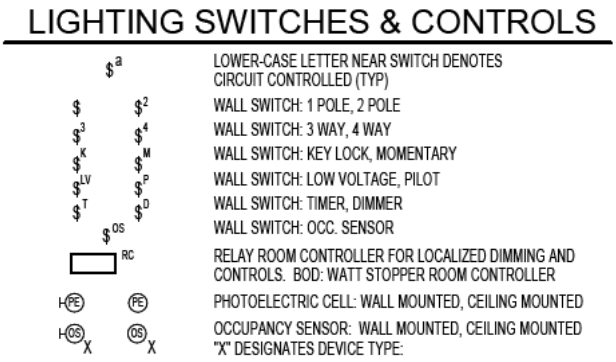


Figure 9003.2 Example Lighting Floor Plan Switch Identification

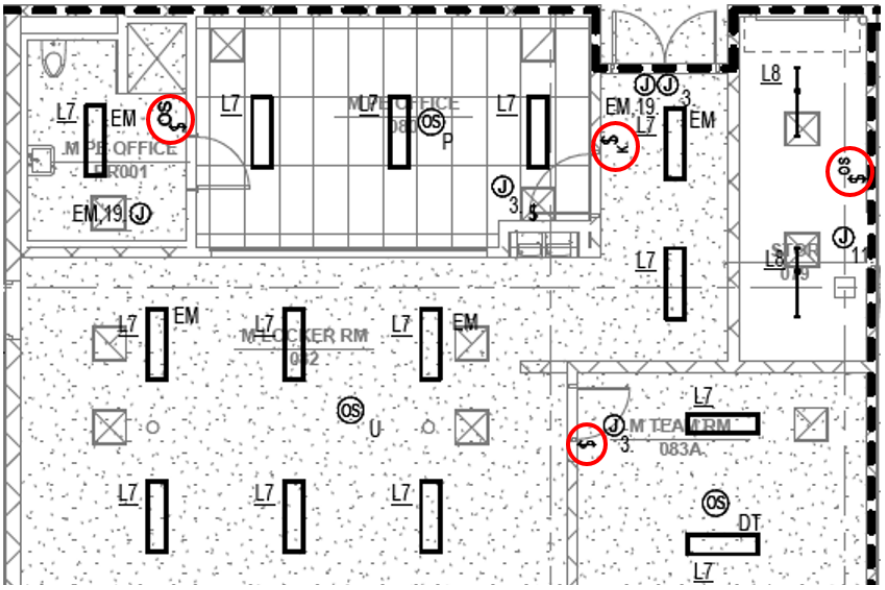
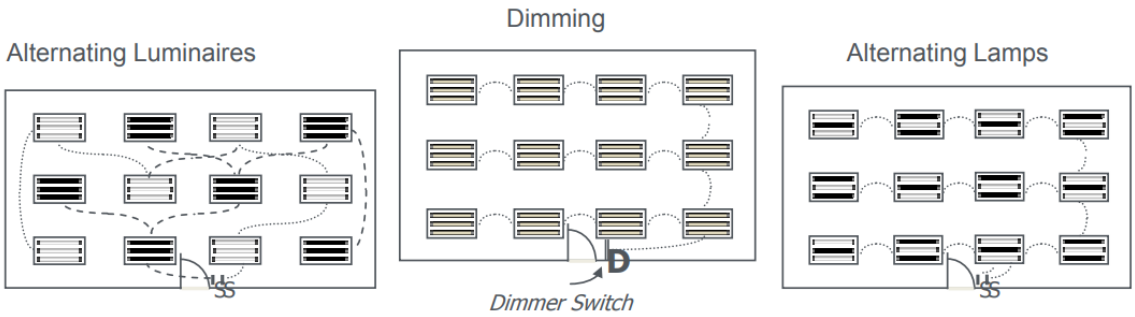


Figure 9003.3 Example Uniform Lighting Reduction Strategies[1]

[1] https://www.energycodes.gov/sites/default/files/becu/2012iecc_commercial_lighting_BECU.pdf



A.4.2 9009 Automatic Time Switch Control

A.4.2.1 Measure Description

Lighting within all areas of a building must have automatic time switch controls unless it is controlled by an occupancy sensor. A means for override also must be provided. Emergency egress lighting may be exempt, depending on code.

A.4.2.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
505.2.2.2	C405.2.2.1	C405.2.2	9.4.1.1	9.4.1.1	9.4.1.1

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.4.2.3 Plan Review

Locate lighting plans and control schedule in electrical drawings. Control details may be found in drawing set floor plans, one-line controls diagram, specifications, or not at all. On the Controls tab of the data collection form, log all controls for the project, including interior and exterior and indicate their functionality. For time switch controls:

1. The automatic time switch control is often within a lighting control system panel for all the building lights. If details of system settings (including automatic time switching) are not included on the plans, note to verify controls on site.
2. Confirm override switching devices in rooms with automatic time switch control. This control may be the same switch or device that is utilized to provide the manual lighting control and lighting level reduction control.

A.4.2.4 Field Inspection

Using the Controls tab and Lighting System tab, walk the property and verify expectations of controlled lighting from plan review. For automatic time switches specifically, data collectors may need to ask the facility contact person what controls the automatic time switch and where the device is located. If this is unknown, check mechanical rooms, electrical rooms, and other facilities closets.

1. For a stand-alone time clock, verify there are times set for on and off operation and confirm it controls the lighting circuits as expected from plans.
2. For a control system, ask to be shown the schedules for the automatic on/off. Confirm the spaces controlled align with those required and determined during the plan review.
3. Note the square footage of any spaces not meeting the code requirement for automatic time switch controls.
4. Record all findings in the data collection form.

A.4.2.5 QA and Data Transfer

Record code requirement based on code and year:

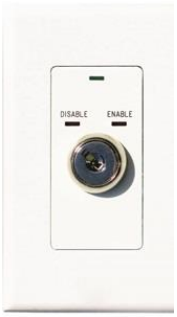
- Automatic time controls ; Control zones ≤25k sq. ft./1 floor; Any override limited to 5000 sq. ft. & 2 hours
- Automatic time controls ; Control zones ≤25k sq. ft./1 floor; and override limited to 5000 sq. ft. & 2 hours
- Automatic time controls ; Control zones >25k sq. ft./1 floor; or override >5000 sq. ft. or > 2 hours
- No automatic controls

Figure 9009.1 Lighting Control Panels [1]

Figure 9009.2 Digital/Electronic Programmable Clock [2]

Figure 9009.3 Captive Key Switch[3]

[1] http://www.nexlight.com/nexlight/products.asp?mc=18, http://ali-and-co.com/Lighting%20Control%20Panels.html, and https://www.legrand.us/wattstopper/lighting-control-panel-systems/contractor-panels/lp8.aspx
[2] https://www.intermatic.com/en/timer-controls/electronic-controls/et90215c
[3] http://www.acuitybrands.com/products/detail/336774/Lighting-Controls-and-Design/Key-Enabled-DigitalSwitch/Key-Enabled-DigitalSwitch



A.4.3 9011 Occupancy Sensor Control

A.4.3.1 Measure Description

Occupancy sensors are required in certain specific space types, varying by code. Occupancy sensors must turn lights off automatically within a certain time period of occupants leaving the space. These controls are required to either turn on automatically to no more than 50% power or turn on manually, depending on space type.

A.4.3.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
505.2.2.2	C405.2.2.2	C405.2.1	9.4.1.2a	9.4.1.2b	9.4.1.1gh

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.4.3.3 Plan Review

Locate lighting plans and control schedule in electrical drawings. Control details may be found in drawing set floor plans, one-line controls diagram, specifications, or not at all. On the Controls tab of the data collection form, log all controls for the project, including interior and exterior and indicate their functionality. For time-switch controls:

1. Verify the design for each space type required by the code includes an occupancy sensor control – typically indicated by OS.
2. Identify the intended control method and the delay off time in the plans, specifications, or control diagrams, as available.

A.4.3.4 Field Inspection

Using the Controls tab and Lighting System tab, walk the property and verify expectations of controlled lighting from plan review.

1. Locate occupancy sensors in each space as required. Examples of sensors are shown below.
2. If the lights are on before you enter the space, be sure the space is unoccupied and wait for the lights to turn off. Wait at least an additional 30 seconds before entering the space and note whether they come on automatically or require manual switching. If they come on automatically, note whether they came on to 50% power or less and whether there is a method to turn them to 100%. Determine approximate percentages using a light-level meter.
3. Verify how long the occupancy sensors are set to wait before switching off the lights. If the sensors do not have an adjustable control that the time can be determined from, document the make and model to look up the default settings later.
4. If the lighting is controlled by a lighting control system or panel, ask to see the settings to verify the wait time.
5. Verify that the lights are not turned on by movement in adjacent spaces.

A.4.3.5 QA and Data Transfer

Record code requirement based on code and year:

- Occupancy sensors ; Manual ON; time off ≤ req'd
- Occupancy sensors ; Auto on 50%; time off ≤ req'd
- Occupancy sensors ; Auto on 100%; time off ≤ req'd
- Occupancy sensors ; Manual ON; time off > req'd
- Occupancy sensors ; Auto on 50%; time off > req'd
- Occupancy sensors ; Auto on 100%; time off > req'd
- No occupancy sensors

Figure 9011.1 Ceiling Mount and Wall Switch Occupancy Sensors[1]

[1] http://www.mcwonginc.com/c11599/c12300.asp *and* http://www.homecontrols.com/Leviton-Occupancy-Sensor-Wall-Switch-with-LED-Nightlight-LVOSSNLIDx

A.4.4 9014A Daylight Zone Control

A.4.4.1 Measure Description

For enclosed spaces with more than two fixtures, lighting in daylight zones must be controlled independently (either manually or automatically) of general lighting. Each daylight control zone may not exceed 2,500 sq. ft. Contiguous daylight zones along vertical fenestrations may be controlled together provided they do not contain zones facing more than two adjacent cardinal directions. Daylight zones under skylights more than 15 ft. from the perimeter must be controlled separately from the perimeter daylight zones. Automatic daylighting controls requirements can either be “stepped” dimming or continuous, depending on code and application.

A.4.4.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
505.2.2.3	C405.2.2.3	C405.2.3	N/A	9.4.1.5	9.4.1.1.ef

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.4.4.3 Plan Review

Locate lighting plans and control schedule in electrical drawings. Control details may be found in drawing set floor plans, one-line controls diagram, specifications, or not at all. On the Controls tab of the data collection form, log all controls for the project, including interior and exterior and indicate their functionality. For daylight controls:

1. Identify daylight zones using floor plans. Daylight zones can be determined as follows (see diagram and examples of daylight zone calculations shown below):
    a. **Under skylights**: The area under skylights whose horizontal dimension, in each direction, is equal to the skylight dimension in that direction plus either the floor-to-ceiling height or the dimension to a ceiling-height opaque partition, or 0.5 the distance to adjacent skylights or vertical fenestration, whichever is least. For the 2015 IECC this is equal to the skylight dimension in that direction plus either 0.7 X the floor-to-ceiling height or the dimension to

an opaque partition equal to 0.7 X the ceiling height, or one-half the distance to adjacent skylights or vertical fenestration, whichever is least.

b. **Adjacent to vertical fenestration**: The area adjacent to the vertical fenestration with a depth of 15 ft. or to the nearest ceiling-height opaque partition, whichever is less. For the 2015 IECC, the area adjacent to the vertical fenestration with a depth of height of the top of the window or to the nearest ceiling height opaque partition, whichever is less. The zone width is assumed to be the window width plus: 2 ft on each side, the distance to an opaque partition, or one half the distance to adjacent skylight or vertical fenestration, whichever is least.

2. Determine if fixtures in each daylight zone are controlled manually, by automatic stepped dimming, or by continuous dimming.
3. Determine if fixtures in each daylight zone (either partially or completely) are on a separate circuit from the other general lighting and controlled manually, or if the daylight controls are automated. Automated controls will include a photocell, which is often indicated by a Ⓟ symbol on the plans.
    a. Note: Fixtures in the daylight zone may be on the same electrical circuit; if this is the case, the fixtures must operate on an independently switched or controlled branch of that circuit.
4. If automated controls details are on the plans, determine if requirements are met by:
    a. Continuous dimming that must reduce power continuously down to less than 35% the rated value, or
    b. Stepped dimming requires at least two steps, one to 50%–70% of rated power, and one to 35% or less.
5. Daylight zones in spaces where multi-level lighting controls are required must be controlled separately. Lighting must be capable of being reduced to 35% or less of rated power.

A.4.4.4 Field Inspection

Using the Controls tab and Lighting System tab, walk the property and verify expectations of controlled lighting from plan review.

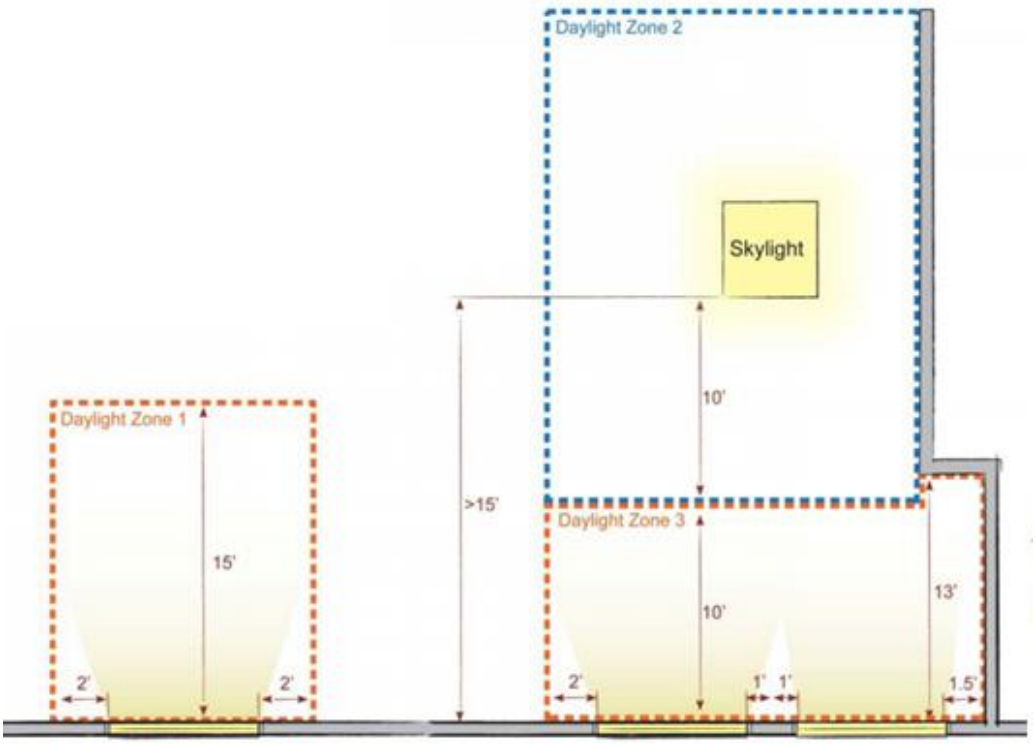
1. Locate fixtures within each daylight zone identified during plan review.
2. For manually controlled fixtures, determine if these fixtures are switched separately from the other general lighting.
3. For automatically controlled fixtures, locate the photocell and, if possible, cover it or shine a flashlight on it (depending on current conditions). Wait a few minutes and note whether lights automatically adjust.
4. Note whether control is stepped or continuous.
5. Verify that calibration and setpoint controls are readily accessible and separate from the light sensor.
6. Record all findings in the data collection form.

A.4.4.5 QA and Data Transfer

In certain cases, daylight zones are required to be controlled automatically. Those requirements are specific to each code and, in the case of the IECC, specific to window-to-wall ratio.

Figure 9014A.1 Photocell Sensors[1]

Figure 9014A.2 Daylight Zone Calculation (Plan View) Examples for the 2012 IECC[2]



[1] https://www.legrand.us/wattstopper/daylighting-controls/daylighting-controls/lmls-400.aspx and https://www.legrand.us/wattstopper/legacy-products/commercial-products-legacy/daylighting-controls-legacy/ls-101.aspx

[2] http://kenergy.us/files/6613/6370/9460/2012_IECC_commercial_lighting_BECU.pdf

A.4.5 9014B Daylighting High-Bay Spaces

A.4.5.1 Measure Description

An enclosed space greater than 10,000 sq. ft. (varies by code) with a ceiling height greater than 15 ft. and designated for certain uses specified by code, must have a total daylight zone under skylights of at least half the floor area.

A.4.5.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
N/A	C402.3.2	C402.4.2	N/A	5.5.4.2.3	5.5.4.2.3

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.4.5.3 Plan Review

Under the lighting system tab, for each space log the ceiling height of the space. To do this, log all spaces and find section cuts or interior elevations of each space or room and complete plan review take offs to verify distance from floor to ceiling.

A.4.5.4 Field Inspection

Verify ceiling heights in spaces that are indicated on the Lighting System tab as having ceilings of 15 ft. or more. For these spaces, make particular note of the existence of skylights to match plan review expectations.

A.4.5.5 QA and Data Transfer

Applicability of this section will be determined by the existence of a “high-bay” space, a space greater than 10,000 sq. ft. (varies by code) with a ceiling height greater than 15 ft. and designated for certain uses specified by code. Where applicable, verify that the spaces include a daylighting control.

A.4.6 9025 Display Lighting Control

A.4.6.1 Measure Description

Display lighting requires dedicated, independent controls from other general lighting in the space. Controls are required for:

1. Display and accent lighting
2. Lighting in display cases
3. Lighting installed to highlight retail merchandise or art exhibits

Display lighting is installed to highlight specific merchandise in addition to lighting equipment and is not considered as part of the general overhead lighting.

1. This measure will not apply to Office Occupancies.
2. This measure will not apply to buildings complying under IECC 2009.

A.4.6.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
N/A	C405.2.3(2)	C405.2.4(1)	9.4.1.4	9.4.1.6	9.4.1.3.a

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.4.6.3 Plan Review

Locate lighting plans and control schedule in electrical drawings. Control details may be found in drawing set floor plans, one-line controls diagram, specifications, or not at all. On the Controls tab of the data collection form, log all controls for the project, including interior and exterior and indicate their functionality. For display controls:

1. Identify display lighting in the lighting plans that show lighting controls. If more lighting is needed than allowed using the Allowed Interior Lighting Power calculation, display lighting is often identified in the compliance documentation.
2. Verify any lighting dedicated for display purposes is controlled independently from other lighting, and record condition:
    a. Display lighting controlled separately
    b. Display lighting not controlled separately
3. Verify dedicated circuit for display lighting.
4. Calculate total wattage of display lighting.

A.4.6.4 Field Inspection

Using the Controls tab and Lighting System tab, walk the property and verify expectations of controlled lighting from plan review.

1. Identify the switch locations for display lighting using the lighting controls plans, if available. Lighting controls are often located at the display cases or switched from a circuit breaker box.
2. Switch off/on display lighting to verify it is controlled independently from other lighting and record findings in the data collection form.
3. Verify amount of display lighting matches expectations from plan review. Note any change in total display wattage.

A.4.6.5 QA and Data Transfer

1. Measure will only be applicable with the presence of display lighting controls.
2. Record code requirement as “Display lighting controlled separately.”

Figure 9025.1 Display and Accent Lighting and Display Case Lighting Examples[1]

A.4.7 9029 Non-Visual Lighting Control

A.4.7.1 Measure Description

Lighting for non-visual applications must be controlled independently of other lighting in the space. Examples of non-visual applications include plant growth, food warming, or lighting for sale.

1. This measure will ONLY apply with the occurrence of non-visual lighting applications.
2. This measure will not apply to Office Occupancies.
3. This measure will not apply to Core and Shell construction.

A.4.7.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
N/A	405.2.3(5)	405.2.4(5)	9.4.1.4	9.4.1.6	

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.4.7.3 Plan Review

Locate lighting plans and control schedule in electrical drawings. Control details may be found in drawing set floor plans, one-line controls diagram, specifications, or not at all. On the Controls tab of the data collection form, log all controls for the project, including interior and exterior and indicate their functionality. For non-visual controls:

1. Review lighting plans for any non-visual lighting indicated. This information may also be located on a COMcheck calculation.
2. Verify lighting dedicated for non-visual purposes is controlled independently from other lighting; it should have a dedicated circuit on the plans.

[1] *http://usaledsolutions.com/applications/accent-lighting/, http://www.gelighting.com/LightingWeb/la_en/north/products/industry/retail/overview/, and http://www.showcases-smart.com/wp-content/uploads/2010/04/black-museum-showcase-display-case-lights-bktr411.jpg*

3. Confirm controls, and select condition closest to plans:
    a. Select “Occupancy sensor controlled” if controlled by an OS that is independent from the general lighting in the area.
    b. Select “Accessible separate control device” if another type of independent control is indicated. This can be a manual switch.
    c. Select “No separate control device” if no independent control can be located.
4. Determine the total wattage of all non-visual lighting.

A.4.7.4 Field Inspection

Use the lighting control plans, to help locate the lighting controls for non-visual lighting.

1. Switch off/on non-visual lighting to verify it is controlled independently from other lighting and record findings in the data collection form.
2. Verify amount of lighting matches what was expected based on plan review.

A.4.7.5 QA and Data Transfer

1. Applicability:
    a. Measure will only be applicable with the presence of display lighting controls.
    b. This measure will not apply to buildings complying under IECC 2009.
2. When applicable, code condition is “Accessible separate control device”

Figure 9029.1 Non-Visual Application Lighting Examples[1]

A.4.8 9031 Exterior Lighting Control

A.4.8.1 Measure Description

Exterior lighting must be automatically controlled: lighting designated for dusk-to-dawn operation shall be controlled by an astronomical time switch[2] or a photocell. Lighting not designated for dusk-to-dawn operation shall be controlled by an astronomical time switch or a combination of a photocell and a time switch.

[1] http://thegreatestgarden.com/2014/12/the-grow-lights-for-indoor-plants.html *and* http://commercialkitchendesign.net/category/food-warming/

[2] An astronomical time switch will calculate the rise of the sun and set times based on location. It will also automatically adjust for daylight savings. Look for a zip code or other location input.

1. This measure will not apply to tenant fit-outs (exterior lighting will most likely have been installed under Core and Shell construction).

A.4.8.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
505.2.4	405.2.4	405.2.5	9.4.1.3	9.4.1.7	

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.4.8.3 Plan Review

Locate lighting plans and control schedule in electrical drawings. Exterior lighting control information may be on site lighting/power plans, electrical notes/symbols, lighting fixture schedule. On the Controls tab of the data collection form, log all controls for the project, including interior and exterior and indicate their functionality. For exterior controls:

1. Identify any exterior lighting controls on the plans.
2. Exterior lighting controls may be indicated either in a note or showing the sensor and/or timeclock on the floor plans.
    a. A photocell is often shown as a Ⓟ symbol.
    b. The time switch or time clock may also be denoted on the plans using a symbol; verify symbol with electrical notes.
3. Check lighting controls or sequence of operations (SOO) for after-hours reduction of exterior lighting as required.

A.4.8.4 Field Inspection

Walk the site exterior to verify locations of photocells and (assuming all site visits are completed during daylight hours) that all exterior lights are off.

1. Verify from the facility contact person if the exterior lighting is scheduled for dusk-to-dawn operation or not.
    a. If dusk-to-dawn operation is in use, request to see the astronomical time switch or photocell.
    b. If dusk-to-dawn operation is not in use, request to see the astronomical time switch or both the photocell and time switch.
2. Verify the following for each device on site:
    a. Astronomical Time Switch – Appropriate location must be input. Current time indicated by switch must match actual time.
    b. Time Switch – Current time indicated by switch must match actual time.
    c. Photocell – Must be outdoors with access to receive sunlight (direct sunlight not necessary). Should not be covered or blocked. It may be possible to

temporarily block the device and wait to see if the lighting turns on. However, if the photocell is used in conjunction with a time clock, no change may occur.

3. If required, check lighting controller or BAS to see if a portion of exterior lighting is deenergized after hours or if occupancy sensors are present as required. Record all findings in the data collection form.

A.4.8.5 QA and Data Transfer

Code requirement:

1. For ASHRAE 90.1-2010 or 2013, select “Photocell or Astro time switch; with additional nighttime turn off (12 am–6 am)”
2. For all other codes, select “Photocell or Astro time switch”

Select condition that best fits the exterior controls for plan review and as found:

1. Select “Photocell or Astro time switch; with additional nighttime turn off (12 am–6 am)” if a photocell or astronomical time switch is indicated to turn lights ON at dark, and notes verify that additional nighttime turn OFF is from midnight to 6 am.
2. Select “Photocell or Astro time switch” if a photocell or astronomical time switch is indicated.
3. Select “Time switch but no seasonal correction” if project includes a time switch only, that is not an astronomical time switch.
4. Select “No exterior lighting controls” if no exterior controls can be located.

Figure 9031.1 Exterior Photocell and Time Switch Examples[1]

[1] http://www.superiorlighting.com/70_Watt_LED_Dusk_to_Dawn_Yard_Lights_p/7101caal068.htm, https://www.grainger.com/product/6P008&AL!2966!3!166591460085!!!s!81032115957, and https://www.1000bulbs.com/product/3419/ELEC-T101.html

Figure 9031.2 Astronomical Time Switch Examples[1]

A.4.9 9037 Interior Lighting Power Allowance

A.4.9.1 Measure Description

Total connected lighting power (the sum of all interior lighting equipment power not including exempt lighting) must be not greater than the allowed interior lighting power.

1. This measure will not apply to Core and Shell projects without permanently installed interior lighting.

A.4.9.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
505.5.2	C405.5.2	C405.4.2	9.5.1	9.5.1	9.5.1

A.4.9.3 Plan Review

Locate electrical drawings, lighting plans, and fixture schedules. For all fixtures, log information on the Fixtures tab, including:

1. Fixture ID from plans,
2. a short description,
3. fixture type (from drop down list),
4. lamp type (from drop down list),
5. lamp length where applicable (in feet),
6. number of lamps, and
7. watts/lamp.

Total watts/fixture will be calculated in data collection sheet.

After logging fixtures, the Lighting System tab can be completed.

[1] https://www.zoro.com/tork-electronic-timer-astro-365-days-spdt-dzs200bp/i/G2802371/ and http://www.directindustry.com/prod/general-industrial-controls-p-ltd/product-61204-556346.html

1. Reviewing the lighting plans, provide information on each space that is lit.
2. Select fixture ID from drop down list for each fixture present in a space.
    a. Each space with multiple fixtures will require more than one line to provide information about multiple light fixtures in the space.
3. Provide a count of each fixture in each space.
4. Watts/Fixture and Total Watts will be automatically calculated.
5. Each fixture should be assigned a corresponding control ID.

A.4.9.4 Field Inspection

If the site is larger than 10,000 sq. ft., select about 10% of rooms of each space type to verify while on site. No less than five of any space type should be verified.

1. Before walking the site, ask to see where the spare bulbs and ballasts are stored. This is the easiest way to confirm wattages on different fixture and lamp types. Take photos of the lamps to reference later and confirm wattage on each lamp type listed in the fixture schedule or on the data collection form provided.
2. Using the data collection form, conduct a fixture count of each space and record the results.
    a. Be sure to confirm the fixture types match the plans and make a note if they do not.
    b. Number of lamps per fixture should also be verified and noted.
    c. If available, collect make and model of the fixtures to confirm specifications after the visit.
        i. This is especially helpful with LEDs since they do not fit into standard wattage categories.
        ii. Also note screw-base fixtures must be recorded as the maximum labeled wattage rather than the rated wattage of the bulb.
    d. For low-voltage or track lighting, confirm length of track, circuit breaker wattage, transformer wattage, or circuit breaker wattage as necessary.
3. If some lighting is not counted here because it is considered retail display lighting, verify that it is separately controlled from general lighting and highlighting retail displays.
4. If site-verified data varies more than 10% from the design and plan reviewed information, verify another 10% of spaces.

A.4.9.5 QA and Data Transfer

Determine the allowed interior lighting power.

1. Performance path projects: Determine LPD from energy model report.
2. Prescriptive or Trade Off path projects:
    a. If project has provided COMcheck, determine allowed watts from report.
    b. If not, calculate watts allowance based on Building Area Method.

c. If the high efficiency lighting additional efficiency package option is selected, verify adjusted values based on C406.

If COMcheck documentation is provided:

1. Verify fixture counts match the number of fixtures shown on the floor plans, verify fixture wattages match those in the lighting fixture schedule, and confirm space types and floor areas.
2. For low-voltage lighting the supplying transformer wattage must be used to determine load.
3. For line-voltage track lighting, load is based on wattage of connected fixtures with a minimum of 30W/lf of track the length of track, or the wattage of the systems circuit breaker, or an installed current limiting device.
4. Verify the correct energy code was input into the COMcheck, or other code approved software; it should be listed near the top.

If COMcheck documentation is not provided:

1. It may be easiest to calculate the interior lighting power allowance and designed connected lighting powers using the COMcheck software. COMcheck is free and can be downloaded at: https://www.energycodes.gov/comcheck.
2. If data collection supplemental form is used:
   a. Use the fixture counts, wattages, floor areas, and building or space types shown on the plans to calculate the design connected load and allowed load.
   b. Where no calculation is provided, project should be evaluated using Building Area Method. When using the building area method, retail display lighting is included.

A.4.10 9047 Additional Retail Lighting Power Allowance

A.4.10.1 Measure Description

Sales area space types qualify for an additional interior lighting power allowance for display lighting beyond the value listed in the space-by-space table, depending on the type of goods for sale.

1. This measure will not apply to Office occupancies.
2. This measure will only apply if the project has demonstrated Lighting Power Density compliance via the space-by-space method.

A.4.10.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
505.5.2	C405.5.2	C405.4.2.2.1	9.6.1	9.6.2	9.6.2

A.4.10.3 Plan Review

Identify any sales areas on the plans and determine the square footage of each retail area type in the space. All data should be logged into the Fixtures and Lighting System tabs using the same process as 9037.

A.4.10.4 Field Inspection

Verify fixture counts and wattages match those called out in design documents, submittals, or O&M documents.

1. If possible, visit the bulb and spare fixture storage location to confirm make and model details as well as bulb wattages.
2. Make note if any fixtures do not appear to match those expected from the plans or the images collected during plan review.
    a. Number of lamps per fixture should also be verified and noted.
    b. If available, collect make and model of the fixtures to confirm specifications after the visit.
3. Collect images of each fixture to reference while on site.

A.4.10.5 QA and Data Transfer

Determine the allowed additional retail lighting power.

1. The additional allowance is determined by the retail area type, which is based on the type of merchandise highlighted by the display lighting.
    a. Select Retail Area Type from drop down.
2. Performance path projects: Determine LPD from energy model report.
3. Prescriptive or Trade Off path projects: calculate watts allowance based on Retail Area Type and square feet of sales area (note sales area may not equal conditioned square footage):
    a. Retail Area 1: 500+(sq. ft. of sales area X 0.6)
    b. Retail Area 2: 500+(sq. ft. of sales area X 0.6)
    c. Retail Area 3: 500+(sq. ft. of sales area X 1.4)
    d. Retail Area 4: 500+(sq. ft. of sales area X 2.5)
    e. For multiple area types: 500+(sq. ft. of sales area R1 X 0.6)+ (sq. ft. of sales area R2 X 0.6)+ (sq. ft. of sales area R3 X 1.4)+ (sq. ft. of sales area R4 X 2.5)

If COMcheck documentation is provided:

1. Verify the correct energy code was input into the COMcheck.
2. Verify fixture counts match the number of fixtures shown on the floor plans.
3. Verify fixture wattages match those in the lighting fixture schedule.
4. Confirm retail area types and floor areas.

If COMcheck documentation is not provided:

1. It may be easiest to calculate the interior lighting power allowance and designed connected lighting powers using the COMcheck software.
2. If data collection supplemental form is used:
    a. Using fixture counts and wattages, calculate the design connected retail display lighting (which should be less than the allowed lighting power calculated above).
    b. For low-voltage lighting, the supplying transformer wattage must be used to determine load.
    c. For line-voltage track lighting, load is based on wattage of connected fixtures with a minimum of 30W/lf of track the length of track, or the wattage of the systems circuit breaker, or and installed current limiting device.
    d. Remember to review the code for special cases; for example, screw-base fixtures must be recorded as the maximum labeled wattage rather than the rated wattage of the bulb and track and low-voltage lighting as described above.

A.4.11 9048 Exterior Lighting Power Allowance

A.4.11.1 Measure Description

Exterior lighting power for fixtures supplied through the building energy service must be less than the allowance specified by code.

1. This measure will not apply to Tenant Fit-Out projects where exterior lighting was installed as part of Core and Shell construction.

A.4.11.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
505.6.2	C405.6.2	C405.5.1	9.4.5	9.4.3	9.4.2

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.4.11.3 Plan Review

Identify all lit exterior areas on the plans and determine the square footage or linear footage of each lit exterior area. Log all data into the Fixtures and Lighting System tabs using the same process as 9037. See Table 9048 for how to measure exterior lit areas.

Table 9048.1 Area Units for Exterior lighting

Area Type	Units	Area Type	Units
Parking Area	Square feet	Driveways	Square feet
Walkways <10 ft. wide	Linear feet	Ramps <10 ft. wide	Linear feet

Area Type	Units	Area Type	Units
Walkways >10 ft. wide	Square feet	Ramps >10 ft. wide	Square feet
Dining areas	Square feet	Stairways	Square feet
Pedestrian Tunnels	Square feet	Landscaping	Square feet
Pedestrian Entrances	Linear feet	Vehicular Entry/Exit	Linear feet
Entry Canopies	Square feet	Loading Docks	Square feet
Sales Canopies	Square feet	Outdoor Sales Area	Square feet
Street Frontage for Sales Area	Linear feet	Building Façade	Square feet
ATM	# of ATMs	Loading areas for emergency service	Square feet
Drive-up windows	# of windows	Parking near 24 hour retail entrances	# main entries

A.4.11.4 Field Inspection

Verify fixture counts and wattages match those called out in design documents, submittals, or O&M documents.

1. If possible, visit the bulb and spare fixture storage location to confirm make and model details as well as bulb wattages.
2. Make note if any fixtures do not appear to match those expected from the plans or the images collected during plan review.
3. Verify illuminated surface areas matched that calculated in accordance with the plans. Record all findings in the data collection form.
4. Collect images of each fixture to reference while on site.

A.4.11.5 QA and Data Transfer

Exterior LPD will need to be calculated based on exterior areas that are lit. Allowed exterior LPD should not include areas that are not planned to be lit.

1. If COMcheck documentation is provided: Record watts allowed under code requirement.
2. If no COMcheck documentation is provided: Calculate allowed exterior wattage along with plan review calculation.
3. Exceptions may include low-voltage landscape lighting and those approved for historical, safety, signage, or emergency considerations but are specific to each code.
4. Certain exterior lighting applications are also exempt from the exterior lighting power allowance requirements. Depending on the code, these may include sports fields, monuments, marinas, temporary lighting, and more.

If COMcheck documentation is provided:

1. Verify the correct energy code was input into the COMcheck.
2. Verify counts and wattage match the fixture schedule.
3. Confirm other inputs, such as dimensions used.

4. Record watts provided under plan review.

If COMcheck documentation is not provided:

1. It may be easiest to calculate the interior lighting power allowance and designed connected lighting powers using the COMcheck software.
2. If data collection supplemental form is used:
    a. Calculate the design connect exterior lighting power by multiplying fixture counts by wattage values.
    b. Determine the appropriate exterior lighting zone type for the site (1–4).
    c. Where design includes lighting for any non-tradable surfaces, calculate the lighting power allowance using the value specified in code and the site dimensions. Calculate the total design power for the surface by multiplying counts and wattages of each fixture to determine if it is less than allowance.
    d. When calculating the area of surface to apply the power density allowance to, consider only the area of the surface that is illuminated.
    e. Sum the base site and tradable surfaces allowances using the values specified in code for the appropriate zone and the site dimensions from the plans.
    f. Calculate the total design power for the tradable surfaces by multiplying counts and wattages of each fixture not included in non-tradable surfaces or exempt. This should be less than the sum of the allowance.
    g. If fixture details such as make and model are provided, confirm wattages on product documentation.

A.4.12 9054AS Parking Garage Lighting Controls

A.4.12.1 Measure Description

Parking garage lighting shall be scheduled to automatically shut off during unoccupied times.

1. This measure will only apply to buildings with a parking garage. This measure does not apply to open air parking lots.
2. This measure will not apply to buildings complying under IECC.
3. This measure will not apply to buildings complying under ASHRAE 90.1-2007.

A.4.12.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
N/A	N/A	N/A	N/A	9.4.1.3	9.4.1.2

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.4.12.3 Plan Review

Locate lighting plans and control schedule in electrical drawings. Parking garage lighting control information may be on lighting plans for parking garage areas, electrical notes/symbols, lighting fixture schedule or sequence of operations. On the Controls tab of the data collection form, log all controls for the project, including interior and exterior and indicate their functionality. For parking garage controls:

1. Determine whether the design includes motion sensors for the lighting zones. These may be indicated as occupancy sensors (OS or similar) or using another symbol. Symbols will be identified on the electrical cover or notes sheet.
2. Sensors may be called out on the lighting fixture schedule as integral to the fixtures.
3. Determine the size of the control zone.
    a. For parking garages, control zones are often indicated with a subscript or superscript number or letter in relationship to the control symbol (OS_1, OS_2 or similar).
    b. Estimate mid points between zones to measure the control zone for each control symbol sub-group.

A.4.12.4 Field Inspections

Look for occupancy sensors throughout the lighting zones. Record all findings in the data collection form.

1. Verify schedule for automated shutoff within a lighting control system or time switch. This should match the hours of operation or occupied times of the garage. Size limits on controlled areas and override requirements should be verified with code.
2. Verify lighting power is reduced when no activity is detected. Lighting levels should increase as someone enters the zone after it has been vacant for a period. Wait-period and zone sizing requirements should be verified with code.

Note: Parking garage lighting may be easiest to inspect during darker hours.

A.4.12.5 QA and Data Transfer

1. Verify control zones are no larger than what is allowed by code (3,600 ft. – ASHRAE 90.1-2013).
2. Select best description of controls:
    a. Occupancy sensor light control; zones ≤ 3.6 ksf; @ fixt off ≥30%; and off in ≤ 30 min
    b. Occupancy sensor light control; overall reduction <30%; or off in > 30 min
    c. Schedule based lighting controls
    d. No automatic lighting controls
3. Lighting power must be reduced by at least 30% when there is no activity detected within 30 minutes in the lighting zone no larger than 3,600 feet.

Figure 9054AS.1 Motion Sensor, Photocells, Time Switch, and Lighting Control System Examples[1]

A.4.13 9055pAS Automatic Receptacle Controls

A.4.13.1 Measure Description

A percentage of receptacles in certain space types and for modular furniture, as specified by the standard used, shall be automatically controlled to turn off. This may be based on a programmed schedule or, when no activity is detected in the area, by using an occupancy sensor or other device.

1. This measure will primarily apply to Office Occupancies.
2. This measure will not apply to buildings complying under IECC.
3. This measure will not apply to buildings complying under ASHRAE 90.1-2007.
4. This measure will not apply to core and shell projects.

A.4.13.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
N/A	N/A	N/A	N/A	8.4.2	8.4.2

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.4.13.3 Plan Review

In building plans, find the electrical power plans.

1. Locate spaces that require automatic controls, including private offices, open offices, and computer classrooms.
2. Complete plan take-offs to determine the floor area that is required to have receptacle controls. This will not be equal to the full building area in any circumstance.
3. Log floor area that meets these requirements under Additional Electrical Measures.

[1] http://www.mcwonginc.com/c11599/c12300.asp, https://www.wholesalecontractorsupply.com/Photocells-Photocontrols-Locking-s/224.htm, https://www.1000bulbs.com/product/3419/ELEC-T101.html, and http://ali-and-co.com/Lighting%20Control%20Panels.html

Verify receptacles are automatically controlled.

1. Verify receptacles in the specified spaces and use types have overlapping circuitry since a percentage of them must be connected to automated controls.
2. The controlled receptacles should be indicated by a different symbol than uncontrolled receptacles; verify with legend on plans.
    a. Occupancy sensors (OS) (or similar) or a time switch may be shown on the plans, or electrical notes may specify requirements for control.
3. Count total receptacles and controlled receptacles and divide.
    a. This measure only applies to 125 volt, 15- and 20-Ampere receptacles.
    b. It is unlikely that a higher voltage or ampere receptacle will be located in an office or classroom condition, but those receptacles are exempt from the count.
4. Log type of control and percentage of outlets controlled under Additional Electrical Measures.

A.4.13.4 Field Inspection

Walk through areas of the site that require controlled receptacles. A field verification sample can be completed as follows: Five private offices or 10%, whichever is greater, should be verified and 1,000 sq. ft. of open office space or 10%, whichever is greater, should be verified.

1. Verify controlled receptacles are permanently marked to visually differentiate them from the uncontrolled ones. (ASHRAE 90.1 – 2013 only)
2. Count the marked and unmarked receptacles to determine the correct percentage was installed.
3. Inspect the time switch to ensure it is programmed correctly, or verify occupancy sensors or another system is in place for the automatic shutoff.

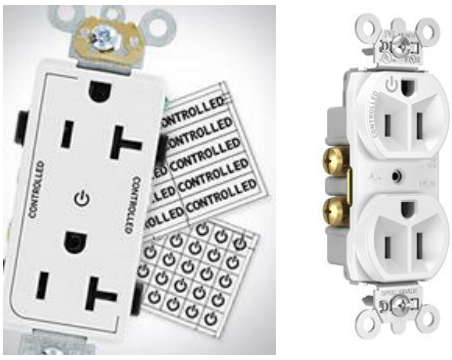
A.4.13.5 QA and Data Transfer

Code condition should be selected as “Automatic plug load control; outlets switched ≥50%; schedule”.

Plan review and as found control conditions should be selected as follows:

1. Select “Automatic plug load control; outlets switched ≥50%; occupant sensor” if 50% are controlled by an occupancy sensor.
2. Select “Automatic plug load control; outlets switched ≥50%; schedule” if 50% are controlled on a schedule.
3. Select “Automatic plug load control; outlets switched <50%; schedule or sensor” if more than 0% but less than 50% are shown as controlled.
4. Select “No automatic plug load controls” if no controls are shown but controls are required.

Figure 9055pAS.1 Marked Controlled Receptacle Examples[1]



A.4.14 9099p Lighting Commissioning or Functional Testing

A.4.14.1 Measure Description

Testing of the lighting controls hardware and software must be conducted to ensure they are operating as designed. Documentation must be issued certifying that installation meets code requirements. All occupant sensors, time switches, programmable schedule controls, and photo-sensors or daylighting controls installations shall be verified for appropriate placement, sensitivity, and programming, as applicable.

1. This measure will not apply to shell buildings with no permanently installed lighting.
2. This measure will not apply to buildings complying under IECC 2009.
3. This measure will not apply to buildings complying under ASHRAE 90.1-2007.

A.4.14.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
N/A	408.3	408.3	N/A	9.4.4	9.4.3

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.4.14.3 Plan Review

Verify construction documents require the commissioning or testing. This information will typically be found on electrical notes, or in specifications.

Assess quality of commissioning or testing and record condition:

1. Select “Commissioned: High Quality” if documents exceed general industry accepted standards.

[1] Sources: http://www.leviton.com/en/solutions/leviton/energy-management/ashrae-901/receptacle-control-solutions and http://www.legrand.us/passandseymour/receptacles/commercial-grade/hard-use-spec-grade/plug-load/half-controlled/15a/5262chw.aspx

2. Select “Commissioned: Satisfactory Quality” if documents indicate general commissioning or functional testing of lighting system.
3. Select “Commissioned: Poor Quality” if documents indicate a lighting testing scope that is less than required by the code or if interview onsite indicates problems with lighting since commissioning.
4. Select “Commissioning not completed or specified” if there is no record of lighting commissioning or testing.

A.4.14.4 Field Inspection

Request to see the commissioning report or certification for the lighting controls system. Ask a facilities team member about the commissioning process and if they have had many issues with the system since it was commissioned.

Assess quality of commissioning based on same information shown under Plan Review above.

A.4.14.5 QA and Data Transfer

Code condition should be selected as “Commissioned: Satisfactory Quality”

Verify the quality of commissioning or testing and record condition based on same information shown under Plan Review above.

A.4.15 15007 Optional On-Site Renewables

A.4.15.1 Measure Description

Renewable energy systems shall provide enough energy to meet code requirements based on peak rated output per square foot of building area or total sum basis, or as a percent of mechanical, water heating, and lighting annual consumption.

1. This measure will only apply to buildings complying under IECC 2015.
2. This measure will only apply to buildings that have selected RE under the options for C406.

A.4.15.2 Code Requirement

IECC			ASHRAE 90.1		
2009	**2012**	**2015**	**2007**	**2010**	**2013**
N/A	N/A	C406.5	N/A	N/A	N/A

This item is mandatory and will be recorded the same way for all of the compliance paths (Prescriptive, Trade Off, or Performance).

A.4.15.3 Plan Review

Locate electrical plans, energy model or other documentation related to on-site renewable energy generation.

1. Find the amount of renewable energy provided and record under Additional Electrical Measures.
2. Record the type of system(s) on site (solar, wind, geothermal, etc.)

A.4.15.4 Field Inspection

Verify rated capacity of the renewable system matched design documents and calculations.

1. Verify it is in operation. Ask the facilities team member if the renewable system has been operating as expected and if they have any records of the production from the system.
2. Ask if the building is meeting energy goals set during the design process and record all findings in the data collection form.

A.4.15.5 QA and Data Transfer

Determine compliance path under C406.5 and record code requirement:

1. If compliance is based on building size of conditioned floor area, code requirement should be entered as conditioned floor area X 0.50 watts under “Rated Watts.”
2. If compliance is based on a percent of mechanical, water heating, and lighting annual consumption, there should be energy model results and generation calculations provided to determine expected annual energy use of these systems. Enter the energy used (for mech, hw, and lighting) X .03 for under Annual kWh.

Appendix B – Code Measure Reference Chart

Measure	Description	Code Sections					
		IECC			90.1		
		2009	2012	2015	2007	2010	2013
5012	Roofs shall be insulated to meet CZ requirements	502.2.1	C402.2.1	C402.2.2	5.5.3.1	5.5.3.1	5.5.3.1
5014	Low slope roofs in CZ 1-3 shall be cool roofs	N/A	C402.2.1.1	C402.3	5.5.3.1.1	5.5.3.1.1	5.5.3.1.1
5018A	Above grade frame walls shall be insulated to meet CZ requirements	502.2.3	C402.2.3	C402.2.3	5.5.3.2	5.5.3.2	5.5.3.2
5018B	Above grade mass walls shall be insulated to meet CZ and density requirements	502.2.3	C402.2.3	C402.2.3	5.5.3.2	5.5.3.2	5.5.3.2
5023A	Exterior frame floors shall meet the insulation requirements	502.2.5	C402.2.5	C402.2.4	5.5.3.4	5.5.3.4	5.5.3.4
5023B	Exterior mass floors shall meet the minimum R-value or U-value by assembly type	502.2.5	C402.2.5	C402.2.4	5.5.3.4	5.5.3.4	5.5.3.4
5029B	Opaque rollup doors shall meet U-factor requirements	502.2.7	C402.2.7	C402.4.4	5.5.3.6	5.5.3.6	5.5.3.6
5034	Window-to-wall ratio shall meet maximum limits	502.3.1	C402.3.1	C402.4.1	5.5.4.2.1	5.5.4.2.1	5.5.4.2.1
5035	Skylight to roof ratio shall meet maximum limits	502.3.1	C402.3.1	C402.4.1	5.5.4.2.2	5.5.4.2.2	5.5.4.2.2
5042A	Windows shall meet U-factor requirements	502.3.2	C402.3.3	C402.4.3	5.5.4.3	5.5.4.3	5.5.4.3
5042B	Windows shall meet SHGC requirements	502.3.2	C402.3.3	C402.4.3	5.5.4.4.1	5.5.4.4.1	5.5.4.4.1
5043A	Skylights shall meet U-factor requirements	502.3.2	C402.3.3	C402.4.3	5.5.4.3	5.5.4.3	5.5.4.3
5043B	Skylights shall meet SHGC requirements	502.3.2	C402.3.3	C402.4.3	5.5.4.4.2	5.5.4.4.2	5.5.4.4.2
5056	Building shall meet continuous air barrier requirements	N/A	C402.4.1	C402.5.1	5.4.3.1	5.4.3.1	5.4.3.1

Measure	Description	Code Sections					
		IECC			90.1		
		2009	2012	2015	2007	2010	2013
5077	Stair and shaft vent leakage	502.4.5	C402.4.5	C402.5.5	6.4.3.4.1	6.4.3.4.1	6.4.3.4.1
5083	Building entrances shall be protected with an enclosed vestibule	502.4.7	C402.4.7	C402.5.7	5.4.3.4	5.4.3.4	5.4.3.4
5089	Fenestration orientation	N/A	N/A	N/A	N/A	5.5.4.5	5.5.4.5
6005A	Packaged air conditioner efficiency	503.2.3	C403.2.3	C403.2.3	6.4.1.1	6.4.1.1	6.4.1.1
6005B	Packaged heat pump efficiency	503.2.3	C403.2.3	C403.2.3	6.4.1.1	6.4.1.1	6.4.1.1
6005C	Gas furnace efficiency	503.2.3	C403.2.3	C403.2.3	6.4.1.1	6.4.1.1	6.4.1.1
6005D	Boiler efficiency	503.2.3	C403.2.3	C403.2.3	6.4.1.1	6.4.1.1	6.4.1.1
6005E	WSHP efficiency	503.2.3	C403.2.3	C403.2.3	6.4.1.1	6.4.1.1	6.4.1.1
6007A	Air-cooled Chiller efficiency	503.2.3	C403.2.3	C403.2.3	6.4.1.1	6.4.1.1	6.4.1.1
6007B	Water-cooled Chiller efficiency	503.2.3	C403.2.3	C403.2.3	6.4.1.1	6.4.1.1	6.4.1.1
6017	Heat pump supplementary heat control	503.2.4.1.1	C403.2.4.1.1	C403.2.4.1.1	6.4.3.5	6.4.3.5	6.4.3.5
6018	Thermostat deadband requirement	503.2.4.2	C403.2.4.2	C403.2.4.1.2	6.4.3.1.2	6.4.3.1.2	6.4.3.1.2
6019A	Thermostat heating setback	503.2.4.3.1	C403.2.4.3.1	C403.2.4.2.1	6.4.3.3.2	6.4.3.3.2	6.4.3.3.2
6019B	Thermostat cooling setback	503.2.4.3.1	C403.2.4.3.1	C403.2.4.2.1	6.4.3.3.2	6.4.3.3.2	6.4.3.3.2
6019C	Night fan control	503.2.4.3.2	C403.2.4.3.2	C403.2.4.2.2	6.4.3.3.1	6.4.3.3.1	6.4.3.3.1
6023	Optimal start controls	N/A	C403.2.4.3.3	C403.2.4.2.3	6.4.3.3.3	6.4.3.3.3	6.4.3.3
6026p	Snow and ice-melting system control	503.2.4.5	C403.2.4.5	C403.2.4.5	6.4.3.8	6.4.3.8	6.4.3.7
6029	Demand control ventilation	503.2.5.1	C403.2.5.1	C403.2.6.1	6.4.3.9	6.4.3.9	6.4.3.8
6030	Energy recovery requirement	503.2.6	C403.2.6	C403.2.7	6.5.6	6.5.6	6.5.6
6033p	Exterior (outside building) Duct insulation	503.2.7	C403.2.7	C403.2.9	6.4.4.1.2	6.4.4.1.2	6.4.4.1.2
6035	Duct leakage requirement	503.2.7.1	C403.2.7.1	C403.2.9.1	6.4.4.2	6.4.4.2	6.4.4.2

Measure	Description	Code Sections					
		IECC			90.1		
		2009	2012	2015	2007	2010	2013
6042B	Hydronic Piping HW Insulation Requirement	503.2.8	C403.2.8	C403.2.10	6.4.4.1.3	6.4.4.1.3	6.4.4.1.3
6045p	Mechanical Commissioning	N/A	C408.2	C408.2	6.7.2.4	6.7.2.4	6.7.2.4
6046A	Fan power limit requirement for PkgAC	503.2.10	C403.2.10	C403.2.12.1	6.5.3.1	6.5.3.1	6.5.3.1
6046B	Fan power limit requirement for VAV	503.2.10	C403.2.10	C403.4.4.4	6.5.3.2	6.5.3.2	6.5.3.2
6051	Outdoor heating: radiant and controlled	503.2.11	C403.2.11	C403.2.13	6.5.8	6.5.8.1	6.5.8.1
6056	Economizer supplies 100% design supply air	503.3.1	C403.3.1.1.1	C403.3	6.5.1.1	6.5.1.1.1	6.5.1.1.1
6066p	Water economizer capacity meets requirements	503.4.1	C403.4.1.1	C403.3	6.5.1.2	6.5.1.2.1	6.5.1.2.1
6070	Multi-zone reheat systems shall be VAV with appropriate zone minimums, and fans with motors ≥threshold hp shall be variable speed or pitch	503.4.2	C403.4.2	C403.4.1.1	6.5.3.2	6.5.3.2	6.5.3.2
6071	Static pressure reset for multi-zone VAV fans	503.4.2	C403.4.2.1	C403.4.1.2	6.5.3.2.2	6.5.3.2.2	6.5.3.2.2
6089	Each WSHP in a system exceeding 10 hp pump shall have a two-position valve	503.4.3.3.3	C403.4.3.3.3	C403.4.2.4	6.5.4.1	6.5.4.1	6.5.4.2
6091p	Multiple chiller shall reduce flow when a chiller is shut down	503.4.3.5	C403.4.3.4	C403.4.3.4	6.5.4.2	6.5.4.3	6.5.4.4
6101	Multiple zone HVAC systems shall have supply-air temperature reset controls	503.4.5.4	C403.4.5.4	C403.4.4.5	6.5.3.4	6.5.3.4	6.5.3.4
6106AS	VAV ventilation optimization	N/A	N/A	C403.4.4.6	N/A	6.5.3.3	6.5.3.3
6108AS	Single zone VAV	N/A	N/A	C403.4.4.1	N/A	6.4.3.10	6.5.3.2.1
6109pAS	Parking garage fan controls	N/A	N/A	C403.2.6.2	6.4.3.4.5	6.4.3.4.5	6.4.3.4.5
6110pAS	Zone Isolation	N/A	N/A	C403.2.4.4	6.4.3.3.4	6.4.3.3.4	6.4.3.3.4
7006	SWH Pipe Insulation - Recirculated	504.5	C404.5	C404.4	7.4.3	7.4.3	7.4.3

Measure	Description	Code Sections					
		IECC			90.1		
		2009	2012	2015	2007	2010	2013
9003	Manual lighting control	505.2.1	C405.2.1	C405.2.2.3	9.4.1.2	9.4.1.2	9.4.1.1.a
9009	Automatic time switch control	505.2.2.2	C405.2.2.1	C405.2.2	9.4.1.1	9.4.1.1	9.4.1.1.i
9011	Occupancy sensor control	505.2.2.2	C405.2.2.2	C405.2.1	9.4.1.2	9.4.1.2b	9.4.1.1.h
9014A	Daylighting control	505.2.2.3	C405.2.2.3	C405.2.3	N/A	9.4.1.5	9.4.1.1.ef
9014B	For large, high-bay spaces total daylight zone under skylights at least 1/2 of floor area	N/A	C402.3.2	C402.4.2	N/A	5.5.4.2.3	5.5.4.2.3
9025	Display lighting control	N/A	C405.2.3(2)	C405.2.4(1)	9.4.1.4	9.4.1.6	9.4.1.3.a
9029	Lighting for nonvisual applications shall be controlled separately	N/A	C405.2.3(5)	C405.2.4(5)	9.4.1.4	9.4.1.6	9.4.1.3.a
9031	Exterior lighting control	505.2.4	C405.2.4	C405.2.5	9.4.1.3	9.4.1.7	9.4.1.4
9037	Interior lighting power allowance	505.5.2	C405.5.2	C405.4.2	9.5.1	9.5.1	9.5.1
9047	Additional retail lighting power allowance	505.5.2	C405.5.2	C405.4.2.2.1	9.6.1	9.6.2	9.6.2
9048	Exterior lighting power allowance	505.6.2	C405.6.2	C405.5.1	9.4.5	9.4.3	9.4.2
9054AS	Occupant based parking garage light control	N/A	N/A	N/A	N/A	9.4.1.3	9.4.1.2
9055pAS	Receptacle controls	N/A	N/A	N/A	N/A	8.4.2	8.4.2
9099p	Lighting Testing or Commissioning	N/A	C408.3	C408.3	N/A	9.4.4	9.4.3
15007	Optional onsite renewable	N/A	N/A	C406.5	N/A	N/A	N/A

Appendix C – Activities and Subcategories

Include in Study?	Building Activity	Subcategory
Y	Mercantile	Vehicle dealership/showroom
Y	Mercantile	Retail store
Y	Mercantile	Other retail
Y	Mercantile	Strip shopping mall
N	Mercantile	Enclosed mall
Y	Office	Administrative/professional office
Y	Office	Bank/other financial
Y	Office	Government office
Y	Office	Medical office (non-diagnostic)
Y	Office	Mixed-use office
Y	Office	Other office
N	Health care – Outpatient	Medical office (diagnostic)
N	Health care – Outpatient	Clinic/other outpatient health
N	Food Sales	Convenience store
N	Food Sales	Convenience store with gas station
N	Food Sales	Grocery store/food market
N	Food Sales	Other food sales
N	Food service	Fast Food
N	Food service	Restaurant/Cafeteria
N	Food service	Bar/Pub/Lounge
N	Food service	Other Food Service
N	Food Sales	Convenience Store (<=5,000sf)
N	Food Sales	Dept. Store w/ Grocery
N	Food Sales	Gas Station with a Convenience Store
N	Food Sales	Grocery (> 5000sf)
N	Food Sales	Other Grocery
Y	Office	Call Center
Y	Office	City Hall or City Center
Y	Office	Contractor's Office (Construction, Plumbing, HVAC, etc.)
Y	Health care – Outpatient	Dental Office
Y	Health care – Outpatient	Medical Clinic / Outpatient Medical

Include in Study?	Building Activity	Subcategory
Y	Health care – Outpatient	Medical Office
Y	Health care – Outpatient	Medical Urgent Care Clinic
Y	Office	Non-Profit or Social Services
Y	Office	Office- Admin, Professional, Government, Financial
Y	Office	Other Office
	Health care – Outpatient	Outpatient Rehab
Y	Office	Religious Office
Y	Office	Retail Banking
Y	Office	Sales Office
Y	Health care – Outpatient	Veterinarian Office/Clinic
N	Food service	Bar, Pub, Lounge
N	Food service	Cafeteria
N	Food service	Catering Service
N	Food service	Coffee, Doughnut, or Bagel Shop
N	Food service	Fast Food Restaurant
N	Food service	Ice Cream or Frozen Yogurt Shop
N	Food service	Other Restaurant
N	Food service	Reception Hall
N	Food service	Sit Down Restaurant
N	Food service	Take-Out Restaurant
N	Food service	Truck Stop
Y	Mercantile	Auto Parts
Y	Mercantile	Auto/Boat Dealer/Showrm
Y	Mercantile	Beauty / Barber
Y	Mercantile	Beer, Wine, or Liquor Store
N	Mercantile	Car Wash
Y	Mercantile	Clothing
Y	Retail	Department Store
N	Mercantile	Dry Cleaner
Y	Mercantile	Elecronics/Appliances
N	Mercantile	Enclosed Mall
Y	Mercantile	Florist, Nursery
Y	Mercantile	Hardware

Include in Study?	Building Activity	Subcategory
Y	Mercantile	Home Improvement
N	Mercantile	Laundromat (Self-Service)
Y	Mercantile	Other Specialty Merchandise
Y	Mercantile	Pharmacy
Y	Mercantile	Post Office
Y	Mercantile	Rental Center
Y	Mercantile	Repair Shop
Y	Mercantile	Strip Shopping Center
Y	Mercantile	Studio/Gallery
N	Mercantile	Vehicle Repair
N	Mercantile	Warehouse Club

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