DENVER AMENDMENT PROPOSAL FORM FOR CPD
INTERNAL PROPOSALS TO THE 2016 DENVER BUILDING CODE AMENDMENTS AND THE 2018 INTERNATIONAL CODES

2018 CODE DEVELOPMENT CYCLE

1) Name: Robby Schwarz Date: 3/25/2019

Click or tap here to enter text.

2) Proposals should be drafted in Word with the only formatting that is needed being BOLDING, STRIKEOUT AND UNDERLINING. Please do not provide additional formatting such as tabs, columns, etc.

Please use a separate form for each proposal submitted.

Is separate graphic file provided (Yes or No):

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AMENDMENT PROPOSAL  Please provide all of the following items in your amendment proposal.  **Code Sections/Tables/Figures Proposed for Revision:** R402.4.2 Testing and new definition

*Note: If the proposal is for a new section, indicate (new). Proposal:

**Definition:**

**Dwelling Unit Enclosure Area:** The sum of the area of ceiling, floors, and walls separating a dwelling unit’s conditioned space from the exterior or from adjacent conditioned or unconditioned spaces. Wall height shall be measured from the finished floor of the *dwelling unit* to the underside of the floor above.

**R402.4.1.2 Testing.** The *building* or dwelling unit shall be tested and verified as having an air leakage rate not exceeding five air changes per hour or 0.28 cubic feet per minute (CFM) per square foot (ft²) of *dwelling unit enclosure area* in *Climate Zones 1 and 2*, and three air changes per hour or 0.17 CFM per (ft²) of *dwelling unit enclosure area* in *Climate Zones 5 through 8*. Testing shall be conducted in accordance with RESNET/ICC 380, ASTM E779 or ASTM E1827 and reported at a pressure of 0.2 inch w.g. (50 Pascals). Where required by the *code official*, testing shall be conducted by an *approved* third party. A written report of the results of the test shall be signed by the party conducting the test and provided to the *code official*. Testing shall be performed after all penetrations of the *building thermal envelope are in place*.

**Exception:**

When testing individual dwelling units an air leakage rate not exceeding four air changes per hour or 0.30 CFM per ft² of the *dwelling unit enclosure area*, tested in accordance with RESNET/ICC 380, ASTM E779 or ASTM E1827 and reported at a pressure of 0.2 inch w.g. (50 Pascals) shall be permitted in all *climate zones* for:

1. Attached single and multifamily building dwelling units.
2. Buildings or dwelling units that are 750 square feet or smaller.

Mechanical ventilation shall be provided in accordance with Section M1505 of the International Residential Code or Section 403.3.2 of the
International Mechanical Code, as applicable, or with other approved means of ventilation.

1. Exterior windows and doors, fireplace and stove doors shall be closed, but not sealed, beyond the intended weather stripping or other infiltration control measures. 2. Dampers including exhaust, intake, makeup air, backdraft and flue dampers shall be closed, but not sealed beyond intended infiltration control measures. 3. Interior doors, if installed at the time of the test, shall be open. 4. Exterior doors for continuous ventilation systems and heat recovery ventilators shall be closed and sealed. 5. Heating and cooling systems, if installed at the time of the test, shall be turned off. 6. Supply and return registers, if installed at the time of the test, shall be fully open.

Additional Code changes:

IRC Change **R303.4 Mechanical ventilation.**

Where the air infiltration rate of a *dwelling unit* is 5 air changes per hour or less where tested with a blower door at a pressure of 0.2 inch w.c (50 Pa) in accordance with Section N1102.4.1.2, the *dwelling unit* shall be provided with whole-house mechanical ventilation in accordance with Section M1505.4.

*Note: Show the proposal using strikeout, underline format. At the beginning of each section, one of the following instruction lines are also needed:*
  *Revise as follows*
  *Add new text as follows*
  *Delete and substitute as follows*
  *Delete without substitution*

*Supporting Information:*

Air changes per hour (ACH) is a volumetric metric that is useful for air quality measurements in buildings but is not the correct expression of air leakage from an energy or building durability perspective. This proposal introduces the ability to use an alternative cubic foot per minute (CFM) per square foot (ft^2) of dwelling unit enclosure area metric for
measuring air leakage in a building. In this way, the air leakage measured at 50 Pascals divided by the building surface area is used to assess the airtightness of the construction and building envelope. Unlike ACH, a CFM/ft² of dwelling unit enclosure area metric normalizes the building air leakage per unit of building envelope surface area; the actual location where air is infiltrating or exfiltrating the building. To this end, the proposal also defines “Dwelling Unit Enclosure Area” as the sum of the area of ceiling, floors, and walls separating a dwelling unit’s conditioned space from the exterior or from adjacent conditioned or unconditioned spaces. In addition, the definition offers guidance to further understand the measurement that must take place to calculate the dwelling unit enclosure area. This guidance states that the wall height shall be measured from the finished floor of the dwelling unit to the underside of the floor above. Lastly, the proposal ensures that the intent of the code, to ensure that the structure is built tight and ventilated correctly with mechanical ventilation, is maintained. If an additional option is adopted into the code, as proposed, then ventilation must also be ensured regardless of how air tightness of the structure is expressed.

This proposal also introduces an exception to using ACH to quantify air leakage in attached and small volume dwelling units because ACH is biased against small volume and attached dwellings. Although it is not difficult to get a single-family median size home to pass 3 or 5 ACH as required by the IECC, it is significantly difficult to get a small volume and or an attached home to pass. The alternative metric more accurately reflects leakage through the exterior enclosure area which removes built in volumetric bias while continuing to ensure a tight structure. The alternative metric uses a cubic foot per minute (CFM) per square foot (ft²) of dwelling unit enclosure area metric to demonstrate compliance with the IECC. This metric allows the air leakage measured at 50 Pascals divided by the building surface area to be used to assess the air tightness of the building enclosure. Unlike ACH, a CFM/ft² of dwelling unit enclosure area normalizes the building air leakage per unit of building envelope surface area, the actual location where air is infiltrating or exfiltrating the dwelling regardless of where the air is coming from, which removes the volumetric bias that is causing small volume and attached dwellings units to fail the code require blower door test. In addition, it is not possible to only measure air leakage to the ambient outdoors in attached dwellings which is what ACH assumes. The
air leakage measurement is actually quantifying the leakage that is coming from attached dwellings, stairs, elevator shafts or other parts of the building that may be connected to the living space of the tested unit. Air leakage from a conditioned space to any other space, as well as, two the ambient outdoors continues to be an energy efficiency issue, but it also is a health issue from an indoor air quality perspective, as well as, a building durability issue from a building science perspective. Reducing air leakage from all surfaces of the building enclosure promotes the IECC’s intent while providing a metric that makes better sense for the building type in question.

The use of a more accurate reflection of air leakage that better represents the distribution of holes that are occurring in the building enclosure has begun to be adopted in programs such as EnergyStar, LEED, and Passive House and by standards created by the US Army Corp of Engineers and ASHRAE. Largely this is happening in multifamily construction

as looking at the CFM/ft2 of building enclosure area better represents leakage that is occurring in an attached dwelling unit. However, small volume is also a significant issue which this proposal addresses. The CFM/ft2 of enclosure area will allow both small volume and attached dwellings to be more successful at meeting the intent and requirements of the code.

The proposal also defines “Dwelling Unit Enclosure Area” as the sum of the area of ceiling, floors, and walls separating a dwelling unit’s conditioned space from the exterior or from adjacent conditioned or unconditioned spaces. In addition, the definition offers a small piece of defined guidance in order to further understand the measurement that must take place to calculate the dwelling unit enclosure area. This guidance states that the wall height shall be measured from the finished floor of the dwelling unit to the underside of the floor above. Lastly, the proposal ensures that the intent of the code, to ensure that the structure is built tight and ventilated correctly with mechanical ventilation, is maintained. If this exception is adopted into the code, as proposed, then ventilation must also be ensured regardless of how air tightness of the structure is expressed. Since 1980, The Energy Conservatory, has not only been a leader in

November 15, 2005
air leakage science, but also one of the prominent manufacturers of the blower door air measurement tool. In their article, “Which Is A Better Metric For Measuring Airtightness: ACH @ 50 Pa Or CFM/ Ft2 Of Surface Area @ 50 Pa?”, which is adapted and added to in this reason statement, we get the basis of the argument for the introduction of a new metric into the International Energy Conservation Code for the measurement of air leakage.

To paraphrase, when measuring the airtightness of a building the objective is to learn how much leakage is occurring across the building’s enclosure area. It is analogous to moisture permeability or the measurement of moisture across the building’s enclosure area and thermal transmittance, the rate at which heat is transferred across the building enclosure area. The rate of air leakage or tightness does not depend on the volume of the structure as defined by the building’s enclosure area but does depend on the holes associated with the surface area of the structure. Air permeability of a material is typically measured as the flow per area at a given pressure difference across the material. U value measurements are similar. If we want a metric to use to measure the airtightness quality of construction of the exterior enclosure of buildings it makes sense to use a metric that equates flow to the size and number of holes in the building’s thermal enclosure.

The article continues with an example to help demonstrate how volume is not proportional to surface area:

Comparison between ACH50 and CFM50/ft2 for a 2000 ft2 home at 3 ACH50 House Is 50 X 40 X 8 Volume = 16,000 ft3

Surface Area = 50 X 40 X 2 + 180 X 8 = 5440 ft2 CFM50 = (3 X 16000)/60 = 800 CFM CFM50/ft2 = 800/5440 = 0.147 CFM50/ft2

Increase height to 2 story at 3 ACH50 House Is 50 X 40 X 16 Volume = 32,000 ft3 Surface area = 50 X 40 X 2 + 180 X 16 = 6880
\[ \text{ft}^2 \text{ CFM50} = \frac{(3 \times 32000)}{60} = 1600 \text{ cfm} \]
\[ \text{CFM50}/\text{ft}^2 = \frac{1600}{6880} = 0.233 \text{ CFM50}/\text{ft}^2 \]

In this example, when the volume is doubled, the surface area increased by 26%. And when the ACH50 stays the same, the CFM/\text{ft}^2 of surface area increased by 58%. I have attached an Excel spreadsheet calculator that further defines the disconnect between ACH and CFM/\text{ft}^2 of surface area to further elaborate the issue. In the attached calculator you can change the ratio of width and length of the building to see the effect on the resulting expressions of air leakage. An independent yet similar calculator can be found at this Residential Energy Dynamic link

http://www.residentialenergydynamics.com/REDCalcFree/Tools/AirLeakageMetrics

The primary purpose of this code change proposal is to introduce the CFM/\text{ft}^2 of surface area metric into the code. Deciding on where to set the minimum allowable leakage rate is difficult largely due to the earlier volume and surface area discussion. Both tests are performed at a pressure differential of 0.2 inch water gauge (50 Pa), which is a the traditional residential testing pressure so an attempt was made to align the introduction of a CFM/\text{ft}2 of surface area metric with the existing ACH50 metric of 3 and 5 air changes per hour. ACH being a volumetric measurement penalized small volume dwelling units so a decision was made to concentrate on a size range of dwellings between 2500 and 5500 square feet. By doing this and using the attached conditioned floor space to shell area calculator we were able to see that little variation occurred between ACH and CFM/\text{ft}2 of surface area metric when changing the size ratio of the modeled house within this house size range. By rounding up, the proposal is using .17 CFM/\text{ft}2 of surface area metric to align with 3 ACH and .28 CFM/\text{ft}2 of surface area metric to align with 5 ACH. By using these numbers, small volume homes, while not having a volumetric penalty, are allowed to be a little more leaky and large volume homes must achieve just about the same level of tightness if not a slight bit more. As the average home size in the United States is approximately just less than 2500 square feet this code change proposals purpose of introducing a better measurement metric without removing the codes traditional measurement methodology,
provid additional flexibility while maintaining similar stringency.

The Energy Conservatory suggests that the use of Air Changes per Hour at 50 Pa (ACH50) started approximately 60 years ago by researchers who were interested in ways to predict the natural infiltration rate of buildings, which at the time was most commonly measured in Air Changes per Hour. At the time air quality in buildings was being studied and the metric made sense. If a pollutant is released in a building, the time for the concentration to decay by a certain percentage depends on the infiltration measured in air changes per hour. The analysis of a tracer gas decay test gives a result in air changes per hour. So, when they started measuring airtightness, for use in estimating natural infiltration in air changes per hour, it made sense to use ACH50 as the metric.

However, as discussed earlier, two homes with the same volume can have very different surface areas and holes associated with the building enclosure area. Value is gained by including a surface area-based metric in that air-sealing varies directly with the amount of surface area not the amount of volume in the dwelling. Two buildings can have surface areas that differs by 15%, but have the same volume and the current metric offers the same leakage allowance. Therefore, if the purpose of measuring air leakage is to determine something about the construction quality, air leakage rate, energy efficiency and building durability the metric should be associated with the flow of air through holes in the enclosure. To quantify these things ACH is the wrong metric. It does not tell you anything about the quantity and air leakage through holes in the building. Conversely, the CFM/ ft2 of surface area metric concretely expresses the quantity of air leakage throught the building’s exterior enclosure. When an enclosure is tight more energy is conserved as well as allowing better control and predictability of air flow, thermal flow, and moisture flow.
Many standards are now using square foot of enclosure area instead of ACH. Examples include EnergyStar, US Army Corp of Engineers, LEED, US Passive House and ASHRAE 62.2. This proposal is the first step to bring this better expression of air leakage into the code. It has been created in such a way that options are maintained allowing jurisdictions and building professionals flexibility in defining air leakage requirements.

Link to Energy Conservatory article from which portions of this reason statement have been added: https://support.energyconservatory.com/hc/en-us/articles/204176240-Which-is-a-better-metric-for-measuring-airtightness-ACH-50-Pa-or-CFM-ft-of-surface-area-50-Pa-

Why the change to R403.6?

November 15, 2005

It was pointed out in the last code cycle, that this metric could have an unintended loophole since it is not used in the IRC. To avoid that, the section was edited to ensure whole house mechanical ventilation continues to be required and installed

Why The change to IRC 303.4?

November 15, 2005

It was pointed out in the last code cycle, that this metric could have an unintended loophole since it is not used in the IRC. To avoid that, the section was edited to ensure whole house mechanical ventilation continues to be required and installed

Cost Statement: This proposal would reduce cost for the following reasons.
• Some jurisdictions nationally allow Guarded testing, an alternative blower door testing method that attempts to only quantify air leakage between conditioned space and the outdoors. This testing method requires multiple individuals and blower doors to be run simultaneously. Using a CFM/ft2 of enclosure area Metric ensures a tight building thermal enclosure in the most cost-effective way by only requiring one tester and piece of equipment per test.

• Air leakage pathways depend on the type of area separation assembly that is used between attached units. Some assemblies such as shaft liner areas separation walls are fairly tight from unit to unit and leak substantially to the outdoors while others promote leakage between units, common spaces, and other defined unconditioned spaces in the building. An enclosure test for attached dwellings allows for identification of the most cost-effective air sealing option per assembly that is chosen.

• Air sealing of exterior walls in mid to large size single family homes has become cost effective, repeatable, and achievable. Small volume homes don’t have the same opportunities for sealing as volume is the primary driver not the number or size of holes to the exterior. Therefore, multiple re-inspections are needed and additional application of air sealing measures to chase down very small reductions in air leakage that still don’t result in passing 3 and in some cases 5 ACH occur. A more reasonable metric for small volume dwelling would result in more passing units and less re-inspections while still meeting the tightness goals of the code.

• In attached housing there is an additional fire and air separation wall, floor, and or ceiling where often only a limited amount of air sealing is allowed. However, with a reasonable metric such a 0.30 CFM/ft2 of enclosure area one is looking at the entire surface area. This creates parity with single family homes as they have the opportunity to address all surfaces of the dwelling when seeking to reduce the infiltration rate to pass the requirements of code.
The value of allowing an exception to use 0.30 CFM/ft² of enclosure area is that air-sealing varies directly with the amount of surface area. Two dwellings can have surface area that differs by 15%, but still have the same volume and the current metric offers the same leakage allowance. If the surface area can be addressed in the measurement than the playing field is leveled and attached and small volume dwelling units would not have the problems passing the IECC. There should be no cost implication associated with the adoption of this proposed language. Dwellings will continue to need to be tested and testing prices will not change due to an additional option for how to express the results of the test.

Note: The following items are required to be included: Purpose: The proponent shall clearly state the purpose of the proposed amendment to physical, environmental and customary characteristics that are specific to the City and County of Denver (e.g., clarify the Code; revise outdated material; substitute new or revised material for physical, environmental and customary characteristics; add new requirements to the Code; delete current requirements, etc.) Reasons: The proponent shall justify changing the current Code provisions, stating why the proposal is necessary to reflect physical, environmental and customary characteristics that are specific to the City and County of Denver. Proposals that add or delete requirements shall be supported by a logical explanation which clearly shows why the current does not reflect physical, environmental and customary characteristics that are specific to the City and County of Denver and explains how such proposals will improve the Code. Substantiation: The proponent shall substantiate the proposed amendment based on technical information and substantiation. Substantiation provided which is reviewed and determined as not germane to the technical issues addressed in the proposed amendment shall be identified as such. Bibliography (as needed): The proponent shall submit a bibliography when substantiating material is associated with the amendment proposal. The proponent shall make the substantiating materials available for review. Referenced Standards:

Click or tap here to enter text.

List any new referenced standards that are proposed to be referenced in the code. Impact: Click or tap here to enter text.

Note: The proponent shall indicate one of the following regarding the impact of the amendment proposal:

- The effect of the amendment proposal on the cost of construction; Increase, Reduce, No Effect:
The effect of the amendment proposal on the cost of design; Increase, Reduce, No Effect:

Is the amendment proposal more- or less-restrictive than the I-Codes; More, Less, Same:

Departmental Impact: Click or tap here to enter text.

Note: Indicate one of the following regarding the impact of the amendment proposal:

The effect of the amendment proposal on the cost of review; Increase, Reduce, No Effect:

The effect of the amendment proposal on the cost of enforcement/inspection; Increase, Reduce, No Effect: