REPI- 17 (modified)

Residential Electric-Ready (Space Heating)

*Add new text as follows:*

**R404.4.6 Combustion space heating.** All fossil fuel space heating systems shall comply with the requirements of Sections 404.4.6.1 and 404.4.6.2

**Exceptions:**

**1.** Where an electrical circuit in compliance with IRC Section E3702.11 exists for space cooling equipment.

2. Space heaters in a centralized space heating system serving multiple dwelling units in a R-2 occupancy that comply with C40X.X.

R404.4.6.1 Space heaters.

An individual branch circuit outlet in compliance with IRC Section E3702.11 based on heat pump space heating equipment sized in accordance with R403.7 shall be installed and terminate within three feet of each fossil fuel space heater.

R404.4.6.2 Condensate drainage.

A space that allows for natural drainage for condensate from cooling equipment operation or a condensate drain shall be located within 3 feet (914 mm) of the installed space heater.

**REPI-86-21 (modification replaces the monograph)**

**IECC®: R403.3.6, TABLE R405.2**

**Proponents:**

David Springer, representing on behalf of the California Statewide Utility Codes and Standards Team ([iecc-ducts2@2050partners.com](about:blank)); Mark Lyles, representing New Buildings Institute (markl@newbuildings.org); Kevin Rose, representing Northwest Energy Efficiency Alliance (NEEA) ([krose@neea.org](about:blank))

**2021 International Energy Conservation Code**

**CHAPTER 2 [RE] DEFINITIONS**

**No change (shown for context only):**

**DUCT**. A tube or conduit utilized for conveying air. The air passages of self-contained systems are not to be construed as air ducts.

**DUCT SYSTEM**. A continuous passageway for the transmission of air that, in addition to ducts, includes duct fittings, dampers, plenums, fans and accessory air-handling equipment and appliances.

**Revise as follows:**

**R403.3 Duct~~s~~ Systems.**

**R403.3.5 Duct system testing.** Each ~~D~~*duct*~~s~~ *system* shall be ~~pressure~~ tested for air leakage in accordance with ANSI/RESNET/ICC 380 or ASTM E1554 ~~to determine air leakage~~. Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the system. Registers shall be ~~taped or otherwise~~ sealed during the test. A written report of the test results ~~of the test~~ shall be signed by the party conducting the test and provided to the *code official.* *Duct system* leakage testing at either rough-in or post-construction shall be permitted.. ~~by one of the following methods:~~

~~1. Rough-in test: Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the system, including the manufacturer’s air handler enclosure if installed at the time of the test. Registers shall be taped or otherwise sealed during the test.~~

~~2. Postconstruction test: Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the entire system, including the manufacturer’s air handler enclosure. Registers shall be taped or otherwise sealed during the test.~~

**Exception**: ~~A duct air-leakage test shall not be required for ducts serving ventilation systems that are not integrated with ducts serving heating or cooling systems.~~

*~~Duct system~~* ~~t~~Testing shall not be required for *~~ducts~~*~~or~~ *duct systems* serving ~~heat or energy recovery ventilators or~~ ventilation systems that are not integrated with *~~ducts~~*~~or~~ *duct systems* serving heating or cooling systems.

**R403.3.6 Duct system leakage.** ~~The total leakage of the ducts, where measured in accordance with Section R403.3.5, shall be as follows:~~

~~1. Rough-in test: The total leakage shall be less than or equal to 4.0 cubic feet per minute (113.3 L/min) per 100 square feet (9.29 m2) of~~ *~~conditioned floor~~**~~area~~* ~~where the air handler is installed at the time of the test. Where the air handler is not installed at the time of the test, the total leakage shall be less than or equal to 3.0 cubic feet per minute (85 L/min) per 100 square feet (9.29 m2) of~~ *~~conditioned~~**~~floor area~~*~~.~~

~~2. Postconstruction test: Total leakage shall be less than or equal to 4.0 cubic feet per minute (113.3 L/min) per 100 square feet (9.29 m2) of~~ *~~conditioned~~**~~floor area~~*~~.~~

~~3. Test for ducts within thermal envelope: Where all ducts and air handlers are located entirely within the~~ *~~building thermal envelope~~*~~, total leakage shall be less than or equal to 8.0 cubic feet per minute (226.6 L/min) per 100 square feet (9.29 m2) of~~ *~~conditioned floor area~~*~~.~~

The total measured *duct system* leakage shall not ~~exceed~~ be greater than the values in Table R403.3.6. For buildings complying with Section R405 or R406, where *duct system* leakage to outside is tested in accordance with ANSI/ RESNET/ICC 380 or ASTM E1554, the ~~duct~~ leakage to outside value shall not be used for compliance with this s~~S~~ection, but shall be permitted to be used in the calculation procedures of Section R405 and R406.

**TABLE R403.3.6**

**MAXIMUM TOTAL DUCT SYSTEM LEAKAGE**

|  |  |  |
| --- | --- | --- |
|  | **Rough In** | **Post Construction** |
| **Duct Systems Serving more than 1,000 ft2 of Conditioned Floor Area** | **cfm/100 ft2 (LPM/9.29 m2)** | **cfm/100 ft2**  **(LPM/9.29 m2)** |
| Air handler is not installed | 3 (85) | NA |
| Air handler is installed | 4 (113.3) | 4 (113.3) |
| Duct Systems Located in Conditioned Space, with air handler installed | 8 (226.6) | 8 (226.6) |
| **Duct Systems Serving less than or equal to 1,000 ft2 of Conditioned Floor Area** | **cfm (LPM)** | **cfm (LPM)** |
| Air handler is not installed | 30 (849.5) | NA |
| Air handler is installed | 40 (1132.7) | 40 (1132.7) |
| Duct Systems Located in Conditioned Space, with air handler installed | 80 (2265.4) | 80 (2265.4) |

**Revise as follows:**

**SECTION R405**

**TOTAL BUILDING PERFORMANCE**

**Table R405.2**

**REQUIREMENTS FOR TOTAL BUILDING PERFORMANCE**

**Portions of table not shown remain unchanged.**

|  |  |
| --- | --- |
| **Mechanical** | |
| R403.3~~, including R403.3.1, except Sections R403.3.2, R403.3.3 and R403.3.6~~ | Duct~~s~~ Systems |

**Revise as follows:**

**Portions of table not shown remain unchanged.**

**TABLE R405.4.2(1)**

**SPECIFICATIONS FOR THE STANDARD REFERENCE AND PROPOSED DESIGNS**

|  |  |  |
| --- | --- | --- |
| **BUILDING COMPONENT** | **STANDARD REFERENCE DESIGN** | **PROPOSED DESIGN** |
| Thermal distribution  systems | Duct insulation:  in accordance with Section R403.3.1. | Duct insulation:  as proposed. |
| Duct location:  same as proposed design. | Duct location:  as proposed. |
| Duct System Leakage to Outside:  For duct systems serving ≤ 1,000ft2 of *conditioned floor area*, the duct leakage to outside rate shall be 40 cfm (1132.7 L/min).  For duct systems serving > 1,000ft2 of *conditioned floor area*, the duct leakage to outside rate shall be 4 cfm (113.3 L/min) per 100 ft2 (9.29 m2) of *conditioned floor area.* | Duct System Leakage to Outside:  The measured total duct system leakage rate shall be entered into the software as the duct system leakage to outside rate.  **Exceptions:**   1. ~~When~~ Where duct system leakage to outside is tested in accordance ANSI/ RESNET/ICC 380 or ASTM E1554, the measured value shall be permitted to be entered. 2. ~~When~~ Where total duct system leakage is measured without the air handler installed, the simulation value shall be 4 cfm (113.3 L/min) per 100 ft2 (9.29 m2) of *conditioned floor area.* |
| Distribution System Efficiency (DSE):  ~~For all systems other than tested duct systems, a~~ For hydronic systems and ductless systems, a~~A~~ thermal distribution system efficiency (DSE) of 0.88 shall  be applied to both the heating and cooling system efficiencies. ~~for all systems other than tested duct systems~~.  ~~Duct location:~~  ~~same as proposed design.~~  **~~Exception:~~** ~~For nonducted heating and cooling systems that do not have a fan, the standard reference design thermal distribution system efficiency (DSE) shall be 1~~.  ~~For tested duct systems, the leakage rate shall be 4 cfm (113.3 L/min) per 100 ft~~~~2~~ ~~(9.29 m~~~~2~~~~) of~~ *~~conditioned floor area~~* ~~at a pressure of differential of 0.1 inch w.g. (25 Pa).~~ | Distribution System Efficiency (DSE):  ~~As tested or, where not tested,~~ For hydronic systems and ductless systems as specified in Table R405.4.2(2). |

**TABLE R405.4.2(2)**

**DEFAULT DISTRIBUTION SYSTEM EFFICIENCIES FOR**

**PROPOSED DESIGNSa**

**Revise as follows:**

|  |  |  |
| --- | --- | --- |
| **DISTRIBUTION SYSTEM CONFIGURATION AND CONDITION** | **FORCED AIR**  **SYSTEMS** | **HYDRONIC**  **SYSTEMSb** |
| Distribution system components located in unconditioned space | NA | 0.95 |
| ~~Untested d~~Distribution system components entirely located in conditioned space c | ~~0.88~~  NA | 1 |
| “Ductless” systemsd | 1 | NA |

a. Default values in this table are for untested distribution systems, which must still meet minimum requirements for duct system insulation.

b. Hydronic systems shall mean those systems that distribute heating and cooling energy directly to individual spaces using liquids pumped through closed-loop piping and that do not depend on ducted, forced airflow to maintain space temperatures.

c. Entire system in conditioned space shall mean that no component of the distribution system, ~~including the air-handler unit,~~ is located outside of the conditioned space.

d. Ductless systems shall be allowed to have forced airflow across a coil but shall not have any ducted airflow external to the manufacturer’s air-handler enclosure.

**Revise as follows:**

**SECTION R406**

**ENERGY RATING INDEX COMPLIANCE**

**ALTERNATIVE**

**Table R406.2**

**REQUIREMENTS FOR ENERGY RATING INDEX**

**Portions of table not shown remain unchanged.**

|  |  |
| --- | --- |
| **Mechanical** | |
| R403.3~~, except Sections R403.3.2, R403.3.3 and R403.3.6~~ | Duct~~s~~ Systems |

**REPI-89-21  
IECC®: R403.5.2, TABLE C403.12.3, TABLE R405.2, TABLE R406.2**

**Proponents:** Gary Klein, representing on behalf of the California Statewide Utility Codes and Standards Team ([iecc-pipe-insulation@2050partners.com](mailto:iecc-pipe-insulation@2050partners.com)); Mark Lyles, representing New Buildings Institute ([markl@newbuildings.org](mailto:markl@newbuildings.org)); Kevin Rose, representing Northwest Energy Efficiency Alliance (NEEA) ([krose@neea.org](mailto:krose@neea.org))

**From the Monograph:**

**Revise as follows:**

**R403.5.2 Hot water pipe insulation.**

~~Insulation for e~~Service hot water piping ~~with a thermal resistance, R-value, of~~ ~~not less than R-3~~ shall be thermally insulated in accordance with Table R403.5.2 and be applied to the following:

1. Piping ¾ inch (19.1 mm) and larger in nominal diameter located inside the *conditioned space*.

~~2. Piping serving more than one dwelling units.~~

2~~3~~. Piping located outside the *conditioned space*.

3~~4~~. Piping from the water heater to a distribution manifold.

4~~5~~. Piping located under a floor slab.

5~~6~~. Buried piping.

6~~7~~. Supply and return piping in ~~circulation~~ ~~and recirculation systems~~ *circulating hot water systems* ~~other than cold water pipe return demand recirculation systems.~~

Exception: Cold water pipe returns in *demand recirculation water systems*.

TABLE R403.5.2 MINIMUM PIPE INSULATION THICKNESS (in inches)

|  |  |  |  |
| --- | --- | --- | --- |
| FLUID OPERATING TEMPERATURE RANGE AND USAGE (°F) | INSULATION CONDUCTIVITY | | MINIMUM PIPE INSULATION THICKNESS |
|  | Conductivity  Btu x in./(h x ft2 x °F)a | Mean Rating Temperature, °F |  |
| 141-200 | 0.25 - 0.29 | 125 | 1 |
| 105-140 | 0.21 - 0.28 | 100 | 1 |

* 1. For insulation outside the stated conductivity range listed in Table R403.5.2, the minimum thickness (T) shall be determined as follows:

T= r[(1 + t/r)K/k - 1]

where

T = Minimum insulation thickness.

r = Actual outside radius of pipe.

t = Insulation thickness requirement; 1 inch.

K = Conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature; [Btu x in/(h x ft2 x °F)].

k = The upper value of the conductivity range listed in Table R403.5.2 for the applicable fluid temperature; [Btu x in/(h x ft2 x °F)].

**TABLE R405.2 REQUIREMENTES FOR TOTAL BUILDING PERFORMANCE**

|  |  |
| --- | --- |
| **SECTION** | **TITLE** |
| **Mechanical** | |
| R403.5.1 | Heated water circulation and temperature maintenance systems |
| R403.5.2 | Hot water pipe insulation |
| R403.5.3 | Drain water heat recovery units |

**TABLE R406.2 REQUIREMENTES FOR ENERGY RATING INDEX**

|  |  |
| --- | --- |
| **SECTION** | **TITLE** |
| **Mechanical** | |
| R403.5.1 | Heated water circulation and temperature maintenance systems |
| R403.5.2 | Hot water pipe insulation |
| R403.5.3 | Drain water heat recovery units |

**As modified by the proponents:**

**R403.5.2 Hot water pipe insulation.**

Insulation for service hot water piping with a thermal resistance, R-value, of not less than R-3 shall be be applied to the following:

1. Piping ¾ inch (19.1 mm) and larger in nominal diameter located inside the *conditioned space*.

~~2. Piping serving more than one dwelling units.~~

2~~3~~. Piping located outside the *conditioned space*.

3~~4~~. Piping from the water heater to a distribution manifold.

4~~5~~. Piping located under a floor slab.

5~~6~~. Buried piping.

6~~7~~. Supply and return piping in ~~circulation~~ ~~and recirculation systems~~ *circulating hot water systems* ~~other than cold water pipe return demand recirculation systems.~~

Exception: Cold water ~~pipe~~ returns in *demand recirculation water systems*.

TABLE R405.2 REQUIREMENTES FOR TOTAL BUILDING PERFORMANCE

|  |  |
| --- | --- |
| **SECTION** | **TITLE** |
| **Mechanical** | |
| R403.5 | Service hot water systems |
| ~~R403.5.1~~ | ~~Heated water circulation and temperature maintenance systems~~ |
| ~~R403.5.3~~ | ~~Drain water heat recovery units~~ |

TABLE R406.2 REQUIREMENTES FOR ENERGY RATING INDEX

|  |  |
| --- | --- |
| **SECTION** | **TITLE** |
| **Mechanical** | |
| R403.5 | Service hot water systems |
| ~~R403.5.1~~ | ~~Heated water circulation and temperature maintenance systems~~ |
| ~~R403.5.3~~ | ~~Drain water heat recovery units~~ |

**Reasons:**

1. **First paragraph**. We are proposing to remove the change to wall thickness and k-value and retain the R-value designation in the existing section. We are also proposing to retain the R-value not less than R-3. While the supporting analysis done for the original proposal shows that a 1-inch wall thickness is economically justified, it is only true if the pipe insulation material is changed from foam to fiberglass or mineral wool. This results in an increase of R-1 over the current requirements, a very small change for a big change in common practice. Getting R-3 pipe insulation (1/2-inch foam) done well is more important than having 1-inch wall thickness installed poorly. **We recommend moving the proposal to increase pipe insulation R-value to Section R408 as part of an efficient SHW distribution system measure.**
2. **Piping serving multiple dwelling units.** Currently text in both IEEC sections R403.5.2 and R403.8 imply applicability for piping serving “more than one dwelling unit” (or “multiple dwelling units”). This apparent conflict raises concerns that two-dwelling unit buildings covered by the IRC will now be directed to the commercial sections. **We recommend deleting the confusing language from this section.**
3. **Supply and Return piping**. The language in the existing code is confusing. This modification uses the same changes as in the original proposal. This new language improves the clarity of the code by using defined terms and by creating an exception to this one clause which was previously part of a convoluted sentence. **We recommend accepting these proposed revisions.**
4. **Tables 405.2 and Table 406.2**. The original proposal added a line for hot water pipe insulation. This makes sense because pipe insulation should be required for the Total Building Performance and Energy Rating Index compliance paths. During discussions, it was pointed out that adding the line for pipe insulation meant that the entire section was now required. With that in mind, we are proposing to have only one line in each of the tables, instead of three. **We recommend accepting this modification to streamline the code, albeit by only one line in each table.**

REPl-91-21

**IECC®: R403.5.4 (New), R403.5.4.1 (New)**

**Proponents:**

Dan Wildenhaus, representing Northwest Energy Efficiency Alliance (dwildenhaus@trccompanies.com); Kevin Rose, representing Northwest Energy Efficiency Alliance (NEEA) (krose@neea.org)

**2021 International Energy Conservation Code**

**Add new text as follows:**

~~R403 .5.4 Compact Hot Water Distribution systems /C HWD).~~

~~Where installed, CHWD systems shall comply with the provisions of section R403 .5.4.1.~~

~~R403 .5.4.1 Water Volume in Pipe Method.~~

~~The hot water distribution system shall store not more than 0.5 gallons (1.9 liters) of water in any piping/manifold between the hot water source and any hot water fixture when calculated using approved engineering calculations. These calculations will use the nominal diameter and length of the piping or tubing, and the longest pipe run from water heater, including both horizontal and vertical run of pipe, shall not be more than 20 feet.~~

R403.5.4.1 Water Volume Determination

The water volume in the piping shall be calculated in accordance with this section. Water heaters, circulating water systems and heat trace temperature maintenance systems shall be considered to be sources of heated water. The volume shall be the sum of the internal volumes of pipe, fittings, valves, meters and manifolds between the nearest source of heated water and the termination of the fixture supply pipe. The volume in the piping shall be determined from Table R403.5.4. The volume contained within fixture shutoff valves, within flexible water supply connectors to a fixture fitting and within a fixture fitting shall not be included in the water volume determination. Where heated water is supplied by a recirculating system or heat-traced piping, the volume shall include the portion of the fitting on the branch pipe that supplies water to the fixture.

[Table](https://up.codes/viewer/colorado/iecc-2021/chapter/CE_4/ce-commercial-energy-efficiency#table_C404.5.2.1) R403.5.4.~~1~~

INTERNAL VOLUME OF VARIOUS WATER DISTRIBUTION TUBING

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| OUNCES OF WATER PER FOOT OF TUBE | | | | | | | | | |
| Nominal Size (inches) | Copper Type M | Copper Type L | Copper Type K | CPVC CTS SDR 11 | CPVC SCH 40 | CPVC SCH 80 | PE-RT SDR 9 | Composite ASTM F1281 | PEX CTS SDR 9 |
| 3/8 | 1.06 | 0.97 | 0.84 | N/A | 1.17 | — | 0.64 | 0.63 | 0.64 |
| 1/2 | 1.69 | 1.55 | 1.45 | 1.25 | 1.89 | 1.46 | 1.18 | 1.31 | 1.18 |
| 3/4 | 3.43 | 3.22 | 2.90 | 2.67 | 3.38 | 2.74 | 2.35 | 3.39 | 2.35 |
| 1 | 5.81 | 5.49 | 5.17 | 4.43 | 5.53 | 4.57 | 3.91 | 5.56 | 3.91 |
| 11/4 | 8.70 | 8.36 | 8.09 | 6.61 | 9.66 | 8.24 | 5.81 | 8.49 | 5.81 |
| 11/2 | 12.18 | 11.83 | 11.45 | 9.22 | 13.20 | 11.38 | 8.09 | 13.88 | 8.09 |
| 2 | 21.08 | 20.58 | 20.04 | 15.79 | 21.88 | 19.11 | 13.86 | 21.48 | 13.86 |

For SI: 1 foot = 304.8 mm, 1 inch = 25.4 mm, 1 liquid ounce = 0.030 L, 1 oz/ft2= 305.15 g/m2.

N/A = Not Available.

**Reason Statement:**

***This new section uses the same Water Volume Determination that already exists in the IECC Commercial Code in section C404.5.2.1. This update has been provided to most easily align residential and commercial hot water service volume calculations in piping.*** *Language needs to be introduced into the prescriptive portion of the code's Systems section to be referenced in new R408 Additional Efficiency Package Options (REPI-142-21).*

Inefficient hot water distribution systems have been recognized as a problem for many years as they result in energy and water waste, and result in long hot water delay times that are the cause of a significant number of complaints by new home buyers. Recirculation systems are a solution to two of the three problems (water and wait time), but the thermal energy impact of different recirculation system options has already been addressed in section R403.5.1.1 Circulation system.1

In all non-recirculation distribution options, water heater energy consumption and hot water waste are correlated. A decrease in water heater energy consumption follows a reduction in wasted water; therefore, improving insulation and reducing the piping length and/or pipe diameter have equal benefits for energy and water waste. In recirculation systems, water heater energy consumption and wasted

hot water are independent, and often have an inverse effect (when recirculation is not demand based).2 This distribution system problem exists for a variety of factors including:

* An outdated pipe sizing methodology in the plumbing code that results in oversized hot water distribution systems since the assumed fixture flow rates are much higher than current requirements.
* Municipalities with design recommendations that force plumbers and designers to assume low supply water pressure , resulting in larger distribution piping, which waste more water and energy.
* Increasing efforts to conserve water has resulted in the realization of water savings due to improvements in showerhead and lavatory maximum flow rates; however, reduced flow rates often result in increased wait times if the hot water distribution system is not designed to accommodate lower flows.
* Increasing popularity of gas instantaneous water heaters, which offer improved operating efficiency, but can result in increased water waste when starting from a "cold start up" situation.
* Inefficient plumbing installations that are not focused on minimizing pipe length or pipe diameters.

The IECC has already addressed pipe insulation and Circulation systems in the 2021 IECC Residential provisions.

*Residential Compact Domestic Hot Water Distribution Design: Balancing Energy Savings, Water Savings, and Architectural Flexibility*

Farhad Farahmand, TRC Companies Yanda Zhang, ZYD Energy

2*Evaluating Domestic Hot Water Distribution System Options With Validated Analysis Models* E. Weitzel and M. Hoeschele Alliance for Residential Building Innovation

https ://energy.cdpaccess.com/proposal/445/976/files/download /134/ https ://energy.cdpaccess.com/proposal /445/976/files/download /133 / https ://energy.cdpaccess.com/proposal /445/976/files/download /132 / https://energy.cdpaccess.com/proposal /445/976/files/download /131 / https ://energy.cdpaccess.com/proposal /445/976/files/download /130 /

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*Evaluating Domestic Hot Water Distribution System Options With Validated Analysis Models* E. Weitzel and M. Hoeschele Alliance for Residential Building Innovation

California Energy Codes & Standards Case Report for *Compact Hot Water Distribution ;* Measure Number: 2019-RES-DHW1 -F, Residential Plumbing

Home Innovation Research Labs Annual Builder Practices Survey, 2021

Department of Energy Zero Energy Ready Home National Program Requirements (Rev. 07) [footnote 15] Efficient hot water distribution system - USBGC LEED BD+C: Homes v4 - LEED v4

Residential Hot Water Distribution Systems: Roundtable Session; JD Lutz, Lawrence Berkely National Laboratory; G Klein, California Energy Commission; D Springer, Davis Energy Group; BO Howard, Building Environmental Science & Technology

**Cost Impact:**

The code change proposal will neither increase nor decrease the cost of construction.

Incremental first costs to builders, designers, and plumbers are design based and each builder will need to determine potential cost impacts based on existing designs and measures in use. Depending on current practices and paths taken for IECC compliance this measure may result in small incremental cost increases or decreases. These potential cost differences relative to standard practices are likely to be:

Reduced cost of PEX or copper tubing due to less material installed. Reduced cost to pipe insulation due to smaller plumbing layout.

Reduced or neutral cost in labor hours for plumber.

Increased water heating venting costs, if a gas water heater or electric heat pump water heater is centrally located.

Increased venting labor costs, if a gas water heater or electric heat pump water heater is located is centrally located and not on a garage wall.

This measure should not have maintenance costs associated with it compared to standard practices. REPl-91-21

REPl-142-21

**IECC®: 408.2.6 (N1108.2.6) (New), 403.5.4 (N1103.5.4) (New), 403.5.4.1 (N1103.5.4.1) (New)**

**Proponents:**

Dan Wildenhaus, representing Northwest Energy Efficiency Alliance (dwildenhaus@trccompanies.com); Kevin Rose, representing Northwest Energy Efficiency Alliance (NEEA) (krose@neea.org)

**2021 International Energy Conservation Code**

**Add new text as follows:**

~~408.2.6 (N1108.2.6) Improved Domestic Hot Water Distribution.~~

~~The hot water distribution system shall meet Section R403 .5.4 and shall be paired with a drain water heat~~ *~~recover~~* ~~system per Section R403 .5.3. The storage limit specified by R403 .5.4 shall be measured from the water heating source to the fixture itself. In addition, no more than 0.6 gallons (2.3 liters) of water shall be collected from the hot water fixture before hot water is delivered. The~~

~~fixture with the greatest stored volume between the fixture and the hot water source (or recirculation loop) will need to be tested. To field verify that the system meets the 0.6 gallon (2.3 liter) limit, verifiers shall first initiate operation of on-demand recirculation systems, if present, and let such systems run for at least 40 seconds. In accordance with Department of Energy's Zero Energy Ready Home National Specification (Rev. 07). Next, a bucket or flow measuring bag (pre-marked for 0.6 gallons) shall be placed under the hot water fixture. The hot water shall be turned on completely and a digital temperature sensor used to record the initial temperature of the water flow. Once the water reaches the pre-marked line at 0.6 gallons (approximately 24 seconds for a lavatory faucet), the water shall be turned off and the ending temperature of the water flow (not the collection bucket) shall be recorded. The temperature of the water flow must increase by not less than 10 °F (5.6QC).~~

* + 1. ~~(N1103.5.4) Compact Hot Water Distribution systems (CHWD).~~

~~Where installed, CHWD systems shall comply with the provisions of section R403.5 .4.1.~~

* + - 1. ~~(N1103 .5.4.1) Water Volume in Pipe Method.~~

~~The hot water distribution system shall store not more than 0.5 gallons (1.9 liters) of water in any piping /manifold between the hot water source and any hot water fixture when calculated using approved engineering calculations. These calculations will use the nominal diameter and length of the piping or tubing, and the longest pipe run from water heater, including both horizontal and vertical run of pipe, shall not be more than 20 feet (6.1ml.~~

408.2.6 (N1108.2.6) Compact Hot Water Distribution

For Compact Hot Water Distribution system credit, the volume shall store not more than 16 ounces of water between the nearest source of heated water and the termination of the fixture supply pipe where calculated using section R403.5.4 *Construction documents* shall indicate the ounces of water in piping between the hot water source and the termination of the fixture supply.

**Reason Statement:**

This section is being re-submitted to better align with credit provided for compact hot water distribution outlined in section R405.4 and Table R405.4.2(1), building component “service water heating,” utilizing HWDS or the factor for the compactness of the hot water distribution system. Inefficient hot water distribution systems have been recognized as a problem for many years as they result in energy and water waste, and result in long hot water delay times that are the cause of a significant number of complaints by new home buyers. Recirculation systems are a solution to two of the three problems (water and wait time), but the thermal energy impact of different recirculation system options has already been addressed in section R403.5.1.1 Circulation system.1

In all non-recirculation distribution options, water heater energy consumption and hot water waste are correlated. A decrease in water heater energy consumption follows a reduction in wasted water; therefore, improving insulation and reducing the piping length and/or pipe diameter have equal benefits for energy and water waste. In recirculation systems, water heater energy consumption and wasted hot water are independent, and often have an inverse effect (when recirculation is not demand based).2

This distribution system problem exists for a variety of factors including:

* + - * + An outdated pipe sizing methodology in the plumbing code that results in oversized hot water distribution systems since the assumed fixture flow rates are much higher than current requirements.
        + Municipalities with design recommendations that force plumbers and designers to assume low supply water pressure, resulting in larger distribution piping, which waste more water and energy.
        + Increasing efforts to conserve water has resulted in the realization of water savings due to improvements in showerhead and lavatory maximum flow rates; however, reduced flow rates often result in increased wait times if the hot water distribution system is not designed to accommodate lower flows.
        + Increasing popularity of gas instantaneous water heaters, which offer improved operating efficiency, but can result in increased water waste when starting from a “cold start up” situation.
        + Inefficient plumbing installations that are not focused on minimizing pipe length or pipe diameters.

The IECC has already addressed pipe insulation and Circulation systems in the 2021 IECC Residential provisions.

*1Residential Compact Domestic Hot Water Distribution Design: Balancing Energy Savings, Water Savings, and Architectural Flexibility*

Farhad Farahmand, TRC Companies and Yanda Zhang, ZYD Energy

*2 Evaluating Domestic Hot Water Distribution System Options With Validated Analysis Models* E. Weitzel and M. Hoeschele, Alliance for Residential Building Innovation

**Savings:**

The following savings have been calculated for compact domestic hot water distribution only, as Drain Water Heat Recovery has already been included in the 2021 IECC. The California Energy Codes & Standards Case Report for *Compact Hot Water Distribution.*

Measure Number: 2019-RES-DHW1-F, Residential Plumbing 3 performed savings analysis using 16 California climate zones. This analysis focused on Therm and Water Savings as it's estimated that over 75% of Residential New Construction Water Heaters installed are gas tankless systems. Nationally, ~68% of Residential New Construction Domestic Hot Water systems are gas fueled, according to

the *Home Innovation Research Lab 's Annual Builder Practices Survey, 20214.* California's climate zones correlate approximately to IECC Climate Zones 2, 3b, 3c, 4c, 5b, and 6. Savings estimated should be conservative for climate zones 4c and higher as ground

temperatures and therefore incoming water temperatures in California homes may be 1 to 3°F higher than in these cooler climates.

Energy Savings Compact Hot Water Distribution Design: ln climate zones 3b and lower, first year weighted average residential energy savings (translated from Therms/yr to Mmbtu/yr) are estimated to be per Single Family Home: Climate Zone Savings in Therms Savings in Mmbtu2 are estimated to be per Single Family Home:

|  |  |  |
| --- | --- | --- |
| Climate Zone | Savings in Therms | Savings in Mmbtu |
| 2 and 3b | 4.48 | 0.448 |
| 3c and higher | 5.57 | 0.557 |

These estimates come from assumption of a 2,430 sq ft home with 3.5 bedrooms.

3California Energy Codes & Standards Case Report for *Compact Hot Water Distribution;* Measure Number: 2019-RES-DHW1-F, Residential Plumbing

4Home Innovation Research Labs Annual Builder Practices Survey, 2021

**Water Savings**

Estimated impacts on water use are presented in the table below. Water use savings estimates are challenging given that hot water usage behaviors among individuals and households are highly variable and can depend strongly on the demographics of the household (Parker, D.; Fairey, P.; and Lutz, J.; 2015). In addition, the proposed compliance option approach ensures that compliant hot water distribution systems will be smaller than a conventional non-compact system but cannot precisely specify the design and configuration and hence the impacts on water waste. To provide a best approximation of water savings impacts, the Statewide CASE Team relied on detailed distribution simulation study completed under the U.S. Department of Energy's Building America program (Weitzel, E.; Hoeschele, M. 2014). In these estimates, it was assumed that all water savings occur indoors.

**Impacts on Water Use Table**

|  |  |
| --- | --- |
|  | **On-Site Indoor Water Savings (gal/yr)** |
| Per Dwelling Unit Impacts (single family) | 962 |
| Per Dwelling Unit Impacts (multifamily) | 321 |

**Drain Water Heat Recovery Savings:**

Using the most conservative Department of Energy savings estimates of 800kWh per year, with an U.S. Energy Information Agency hybrid electricity rate for the nation of 13.5 cents per kWh show an annual savings estimate for electric water heating at: $108/yr

https ://energy.cdpaccess.com/proposal /446/975/files/download /139/ https ://energy.cdpaccess.com/proposal /446/975/files/download /138/ https ://energy.cdpaccess.com/proposal /446/975/files/download /137/ https ://energy.cdpaccess.com/proposal /446/975/files/download /136/ https ://energy.cdpaccess.com/proposal /446/975/files/download /135/

**Bibliography:**

* + - * + *Residential Compact Domestic Hot Water Distribution Design: Balancing Energy Savings, Water Savings, and Architectural Flexibility* Farhad Farahmand, TRC Companie; Yanda Zhang, ZYD Energy
        + *Evaluating Domestic Hot Water Distribution System Options With Validated Analysis Models* **E.** Weitzel and M. Hoeschele Alliance for Residential Building Innovation
        + California Energy Codes & Standards Case Report for *Compact Hot Water Distribution;* Measure Number: 2019-RES-DHW1-F, Residential Plumbing
        + Home Innovation Research Labs Annual Builder Practices Survey, 2021
        + Department of Energy Zero Energy Ready Home National Program Requirements (Rev. 07) [footnote 15)
        + Efficient hot water distribution system - USBGC **LEED** BD+C: Homes *v4-* **LEED** *v4*
        + Residential Hot Water Distribution Systems: Roundtable Session; JD Lutz, Lawrence Berkely National Laboratory; G Klein, California Energy Commission; D Springer, Davis Energy Group; BO Howard, Building Environmental Science & Technology
        + Code Changes and Implications of Residential Low-Flow Hot Water Fixtures – CEC-500-2021-043. Gary Klein, Jim Lutz, Yanda Zhang, John Koeller.
        + Time-to-Tap and Volume-until-Hot – Water, Energy, and Time Efficient Hot Water Systems. 2020 Educational Institute, March 2020, Gary Klein presentation.

**Cost Impact:**

The code change proposal will neither increase nor decrease the cost of construction.

Incremental first costs to builders, designers, and plumbers are design based and each builder will need to determine potential cost impacts based on existing designs and measures in use. Depending on current practices and paths taken for IECC compliance this measure may result in small incremental cost increases or decreases. These potential cost differences relative to standard practices are likely to be:

* + - * + Reduced cost of PEX or copper tubing due to less material installed.
        + Reduced cost to pipe insulation due to smaller plumbing layout.
        + Reduced or neutral cost in labor hours for plumber.
        + Increased water heating venting costs, if a gas water heater or electric heat pump water heater is centrally located.
        + Increased venting labor costs, if a gas water heater or electric heat pump water heater is located is centrally located and not on a garage wall.

This measure should not have maintenance costs associated with it compared to standard practices.

Energy Savings and Cost Impact for Drain Water Heat Recovery: Using the most conservative Department of Energy savings estimates of 800kWh per year savings, with an U.S. Energy Information Agency hybrid electricity rate for the nation of 13.5 cents per kWh, and an increased cost of $1,000 per unit due to increase copper prices; these systems provide an 11 year simple payback.

REPl-142-21

REPI-155 (modified)

**Add new definitions in R202 as follows:**

**ALL-ELECTRIC BUILDING.**A *building* that contains no *combustion equipment*, or plumbing for *combustion equipment,* installed within the *building* or *building site.*

**APPLIANCE.**A device or apparatus that is manufactured and designed to utilize energy and for which this code provides specific requirements.

**COMBUSTION EQUIPMENT.**Any*equipment* or *appliance* used for space heating, *service water heating*, cooking, clothes drying and/or lighting that uses *fuel gas* or *fuel oil*.

**EQUIPMENT.**Piping, ducts, vents, control devices and other components of systems

other than appliances that are permanently installed and integrated to provide control of environmental conditions for buildings. This definition shall also include other systems specifically regulated in this code.

**FUEL GAS.**A natural gas, manufactured gas, liquified petroleum gas or a mixture of these.

**FUEL OIL.** Kerosene or any hydrocarbon oil having a flash point not less than 100°F (38°C).

**MIXED-FUEL BUILDING.**A *building* that contains *combustion equipment* or includes piping for such *equipment*.

**Add new Appendix as follows:**

**APPENDIX RX ALL-ELECTRIC RESIDENTIAL BUILDINGS**

**About this appendix:** *Appendix RX requires the installation of all-electric equipment and appliances in new construction in order to reduce carbon emissions and improve the safety and health of residential buildings. Where adopted as a requirement, Section RX102.1 is intended to replace R401.2.*

**Section RX101**

**GENERAL**

**RX101.1 Intent.** The intent of this Appendix is to amend the *International Energy Conservation Code* to reduce greenhouse gas emissions and improve the safety and health of buildings by not permitting *combustion equipment* in buildings.

**RX101.2 Scope.** This appendix applies to new residential buildings.

**Section RX102**

**ALL-ELECTRIC RESIDENTIAL BUILDINGS**

RX102.1 Application. Residential buildings shall be *all-electric buildings* and comply with Section R401.2.5 and either Sections R401.2.1, R401.2.2, R401.2.3 or R401.2.4.

**REPI-75-21**

**IECC®: R403.3, R403.3.1, R403.3.2, R403.3.3, R403.3.3.1**

**Proponents:**

Robby Schwarz, BUILDTank, Inc., representing Colorado Chapter of the ICC (robby@btankinc.com)

**Revise as follows:**

R403.3 Ducts and air handlers.

Ducts and air handlers shall be installed in accordance with Sections R403.3.1 through R403.3.7.

R403.3.1 Ducts and air handlers located outside conditioned space.

Air handlers shall not be installed outside conditioned space. Supply and return ducts located outside conditioned space shall be insulated to an R-value of not less than R-8 and shall comply with Section R403.3.3. within ceiling insulation. ~~for ducts 3 inches (76 mm) in diameter and larger and not less than R-6 for ducts smaller than 3 inches (76 mm) in diameter. Ducts buried beneath a building shall be insulated as required per this section or have an equivalent thermal distribution efficiency. Underground ducts utilizing the thermal distribution efficiency method shall be listed and labeled to indicate the R-value equivalency.~~

R403.3.2 Ducts and air handlers located in conditioned space.

For ductwork and air handlers to be considered inside a conditioned space, they it shall comply with one of the following:

1. The duct and air handler systems shall be located completely within the continuous air barrier and within the building thermal envelope.
2. Ductwork in ventilated attic spaces shall be buried within ceiling insulation in accordance with Section R403.3.3 and all of the following conditions shall exist:
   1. The air handler is located completely within the continuous air barrier and within the building thermal envelope.
   2. The duct leakage, as measured either by a rough-in test of the ducts or a post-construction total system leakage test to outside the building thermal envelope in accordance with Section R403.3.6, is less than or equal to 1.5 cubic feet per minute (42.5 L/min) per 100 square feet (9.29 m2) of conditioned floor area served by the duct system.
   3. ~~The ceiling insulation R-value installed against and above the insulated duct is greater than or equal to the proposed ceiling insulation R-value, less the R-value of the insulation on the duct.~~
3. Ductwork in floor cavities located over unconditioned space shall comply with all of the following:
   1. A continuous air barrier installed between unconditioned space and the duct.
   2. Insulation installed in accordance with Section R402.2.7.
   3. A minimum R-19 insulation installed in the cavity width separating the duct from unconditioned space.
4. Ductwork located within exterior walls of the building thermal envelope shall comply with the following:
   1. A continuous air barrier installed between unconditioned space and the duct.
   2. Minimum R-10 insulation installed in the cavity width separating the duct from the outside sheathing.
   3. The remainder of the cavity insulation shall be fully insulated to the drywall side.

R403.3.3 Ducts ~~buried~~ within ceiling insulation.

~~Where~~ Supply and return air ducts located in unconditioned attic or ceiling spaces ~~are partially or completely buried in ceiling insulation, such ducts~~ shall comply with all of the following:

1. The supply and return ducts shall have an insulation R-value not less than R-8.
2. The duct shall be installed on the truss bottom cord or ceiling joist closest to the finished material separating conditioned space from unconditioned space and ~~At all points along each duct,~~ the sum of the ceiling insulation R-value ~~against and~~ above the top of the duct, and against ~~and below the bottom of~~ the sides of the duct, shall be equal to that required in table R402.1.3 for ceilings. ~~not less than R-19, excluding the R-value of the duct insulation.~~
3. ~~In Climate Zones 0A, 1A, 2A and 3A, the supply ducts shall be completely buried within ceiling insulation, insulated to an R-value of not less than R-13 and in compliance with the vapor retarder requirements of Section 604.11 of the International Mechanical Code or Section M1601.4.6 of the International Residential Code, as applicable.~~

**~~Exception:~~** ~~Sections of the supply duct that are less than 3 feet (914 mm) from the supply outlet shall not be required to comply with these requirements.~~

R403.3.3.1 Effective R-value of deeply buried ducts.

Where using the Total Building Performance or Energy Rating Index Compliance Option in accordance with Section R401.2.2, ~~sections of ducts~~ that are installed in accordance with Section R403.3.3~~, located directly on or within 5.5 inches (140 mm) of the ceiling, surrounded with blown-in attic insulation having an R-value of R-30 or greater and located such that the top of the duct is not less than 3.5 inches (89 mm) below the top of the insulation,~~ shall be considered as having an effective duct insulation R-value of R-25.

**Reason Statement:**

It has been confirmed through numerous studies that locating ductwork and air handler equipment outside the buildings thermal envelope significantly impact their operational efficiency and delivered efficiency. This proposal begins by tackling half of the efficiency issue by requiring that all air handlers be installed within the building thermal envelope. In Colorado’s Climate Zone 5 this has proven not to be an issue for house that have single or multiple systems. The mechanical heating and cooling system is removed from the harsh exterior environment, often a ventilated attic space, and performs significantly better and closer to its rated efficiency. This proposal does not change the allowance to install duct work in unconditioned spaces but does change some of the requirements

to determine if the builder and inspector can consider the duct and air handler to be inside conditioned space. In other words, how do you install ducts outside the building envelope in such a way that achieves delivered performance that is equivalent to being installed within the conditioned space. This section now only allows the duct work to be installed in unconditioned spaces not the air handler. It continues to require less duct leakage and insulation to be mounded over the duct. Ducts within ceiling insulation addresses a more defined way to install duct in an unconditioned space to ensure that it will perform as if it is inside conditioned space and for the performance compliance paths of R405 and R406 to model the duct with additional R-value. The Duct insulation R-value has been assigned at R8 because only ducts that are 3” of smaller were allowed something less. This is a small upgrade as the majority of HVAC duct work that supplies air to a home is bigger than 3”. **Cost Impact:** The code change proposal will increase the cost of construction. In some climate zone and in some housing types, this proposal will increase the cost of construction due to the requirement that the air handing equipment be installed inside conditioned space of a home. The upside to the cost is significant improvement in achieving the rated efficiency of the mechanical equipment that no longer has to overcome extreme temperature swings. Al other proposed changes to this section of code better define the installation of ducts and air handlers in conditioned space. It is still an option to install duct outside in a manner that impact its performance and therefore cost is not impacted.

**Working Group Recommendation: Reject.**

**Working Group Remarks: The concept of this proposal requires further study and collaboration with other affected stakeholders. Some areas of the country wouldn’t have a problem with these proposed changes in terms of relocating the air handler to be inside conditioned space. In other areas this is not the case. Therefore, this practice must undergo increased use in the field and acceptance in those areas of the country before it can be considered part of a national code.**

**REPI-76-21**

**IECC®: R403.3, R403.3.2, R403.7, R403.7.1 (New)**

**Proponents:**

Nicholas O'Neil, representing NEEA (noneil@energy350.com); Kevin Rose, representing Northwest Energy Efficiency Alliance (NEEA) (krose@neea.org)

**Revise as follows:**

R403.3 Ducts and air handlers.

Ducts and air handlers shall be installed in accordance with Sections R403.3.1 through R403.3.7.

R403.3.2 Ducts and air handlers located in conditioned space.

The air handler shall be located completely within the continuous air barrier and within the building thermal envelope. For ductwork to be considered inside a conditioned space, it shall comply with one of the following:

1. The duct system shall be located completely within the continuous air barrier and within the building thermal envelope.
2. Ductwork in ventilated attic spaces shall be buried within ceiling insulation in accordance with Section R403.3.3 and all of the following conditions shall exist:
   1. ~~The air handler is located completely within the continuous air barrier and within the building thermal envelope.~~
   2. 2.1 The duct leakage, as measured either by a rough-in test of the ducts or a post-construction total system leakage test to outside the building thermal envelope in accordance with Section R403.3.6, is less than or equal to 1.5 cubic feet per minute (42.5 L/min) per 100 square feet (9.29 m2) of conditioned floor area served by the duct system.
   3. 2.2 The ceiling insulation R-value installed against and above the insulated duct is greater than or equal to the proposed ceiling insulation R-value, less the R-value of the insulation on the duct.

3. Ductwork in floor cavities located over unconditioned space shall comply with all of the following:

3.1. A continuous air barrier installed between unconditioned space and the duct.

3.2. Insulation installed in accordance with Section R402.2.7.

3.3. A minimum R-19 insulation installed in the cavity width separating the duct from unconditioned space.

4. Ductwork located within exterior walls of the building thermal envelope shall comply with the following:

4.1. A continuous air barrier installed between unconditioned space and the duct.

4.2. Minimum R-10 insulation installed in the cavity width separating the duct from the outside sheathing.

4.3. The remainder of the cavity insulation shall be fully insulated to the drywall side.

R403.7 Equipment sizing, location and efficiency rating.

Heating and cooling equipment shall be sized in accordance with ACCA Manual S based on building loads calculated in accordance with ACCA Manual J or other approved heating and cooling calculation methodologies. New or replacement heating and cooling equipment shall have an efficiency rating equal to or greater than the minimum required by federal law for the geographic location where the equipment is installed.

**Add new text as follows:**

R403.7.1 Air handler location.

Air handlers shall be located completely within the continuous air barrier and within the building thermal envelope.

**Exception:** Replacement heating and cooling equipment.

**Reason Statement:** This has been a commonly used compliance option in the past under the ducts-inside requirement. This proposal now mandates theair handler should be located inside the thermal envelope and continuous air barrier, both under the ducts in conditioned space areaas well as a new section under equipment sizing. There are energy savings based on building pressure balancing and the highestpriority leaks are now located inside the thermal envelope, allowing any remaining leaks to contribute to the space conditioning.Numerous studies have shown that the highest-pressure leaks are closest to the air handler and that these matter the most in terms

of wasted energy. By locating the air handler inside the thermal envelope and continuous air barrier the wasted energy is minimized. This proposal also adds a clarification to the charging language of R403.3 that it applies to ducts and air handlers, and not just ducts. **Cost Impact:** The code change proposal will neither increase nor decrease the cost of construction. A 2013 report from US DOE Building America shows that while home configurations can vary depending on the location of the air handler and ductwork, the average cost to include ducts inside (of which a small portion of the cost would include the air handler) was less than $500 total, or about $0.40 per square foot of floor area for an average size home. That cost includes the redesign costs of locating ducts and air handling equipment inside, the additional drywall and framing for the duct chases, or additional louvers and enclosures for the air handler closet. More information can be found in the reports here:

[https://www.energy.wsu.edu/documents/aht\_aceee%20ducts%20inside[1].pdf](https://www.energy.wsu.edu/documents/aht_aceee%20ducts%20inside%5b1%5d.pdf)

<https://www.energy.gov/sites/prod/files/2014/01/f6/1_1g_ba_innov_ductsconditionedspace_011713.pdf>

This proposal focuses solely on the air handler and as such the cost of mandating it to be located inside the conditioned space is a small fraction of the total cost for locating all ducts inside. In addition, as a builder still has the alternate option to locate ducts outside of the thermal envelope and conditioned space, this provision reduces the cost of requiring R-8 insulation on ducts, thereby reducing the net cost to locate them inside.

**Working Group Recommendation: Reject.**

**Working Group Remarks: The concept of this proposal requires further study and collaboration with other affected stakeholders. Some areas of the country wouldn’t have a problem with these proposed changes in terms of relocating the air handler to be inside conditioned space. In other areas this is not the case. Therefore, this practice must undergo increased use in the field and acceptance in those areas of the country before it can be considered part of a national code.**

**This recommendation should be considered in conjunction with REPI-75 which is similar in nature.**

**REPI-80-21**

**IECC®: R403.3.2**

**Proponents:**

Vladimir Kochkin, NAHB, representing NAHB (vkochkin@nahb.org)

**Revise as follows:**

R403.3.2 Ducts located in conditioned space.

For ductwork to be considered inside a conditioned space, it shall comply with one of the following:

1. The duct system shall be located completely within the continuous air barrier and within the building thermal envelope.
2. Ductwork in ventilated attic spaces shall be buried within ceiling insulation in accordance with Section R403.3.3 and all of the following conditions shall exist:
   1. The air handler is located completely within the continuous air barrier and within the building thermal envelope.
   2. The duct leakage, as measured either by a rough-in test of the ducts or a post-construction total system leakage test to outside the building thermal envelope in accordance with Section R403.3.6, is less than or equal to 1.5 cubic feet per minute (42.5 L/min) per 100 square feet (9.29 m2) of conditioned floor area served by the duct system.
   3. The ceiling insulation R-value installed against and above the insulated duct is greater than or equal to the proposed ceiling insulation R-value, less the R-value of the insulation on the duct.
3. Ductwork in floor cavities located over unconditioned space shall comply with all of the following:
   1. A continuous air barrier installed between unconditioned space and the duct.
   2. Insulation installed in accordance with Section R402.2.7.
   3. A minimum ~~R-19~~ R-10 insulation installed in the cavity width separating the duct from unconditioned space.
4. Ductwork located within exterior walls of the building thermal envelope shall comply with the following:
   1. A continuous air barrier installed between unconditioned space and the duct.
   2. Minimum R-10 insulation installed in the cavity width separating the duct from the outside sheathing.
   3. The remainder of the cavity insulation shall be fully insulated to the drywall side.

**Reason Statement:**

The provision for R19 insulation was added in the 2021 IECC without justification. Apparently, the requirement was copied from a drawing intended for CZ 3 applications where R-19 floor insulation is a requirement. There is no basis for having a separate requirement for insulation at duct locations in floor cavities that is more restrictive than the floor insulation R-value requirement (CZ 0, 1, 2 require R13 floor insulation). Furthermore, duct insulation requirement for ducts in unconditioned space is R6 or R8 depending on the duct diameter. The proposed modification aligns the requirement for ducts in floors with a similar requirement for ducts in exterior walls where ducts must be separated by R-10 (see R403.3.2(4) of 2021 IECC). It is noted that floor insulation installation is always required to be in compliance with Section R402.2.7 and the floor is required to include an air barrier between unconditioned space and the duct. There are no energy use implications associated with this change. The R19 requirement can add cost for constructing a bulkhead to accommodate the added insulation in the floor. **Cost Impact:** The code change proposal will decrease the cost of construction.In certain floor assembly configurations in Climate Zones 0, 1, and 2, this change will reduce costs by avoiding the need for bulkheadconstruction.

**Working Group Recommendation: Accept proposal and further modify as follows:**

**R403.3.2 Ducts located in conditioned space.**

For ductwork to be considered inside a conditioned space, it shall comply with one of the following:

1. The duct system shall be located completely within the continuous air barrier and within the building thermal envelope.
2. Ductwork in ventilated attic spaces shall be buried within ceiling insulation in accordance with Section R403.3.3 and all of the following conditions shall exist:
   1. The air handler is located completely within the continuous air barrier and within the building thermal envelope.
   2. The duct leakage, as measured either by a rough-in test of the ducts or a post-construction total system leakage test to outside the building thermal envelope in accordance with Section R403.3.6, is less than or equal to 1.5 cubic feet per minute (42.5 L/min) per 100 square feet (9.29 m2) of conditioned floor area served by the duct system.
   3. The ceiling insulation R-value installed against and above the insulated duct is greater than or equal to the proposed ceiling insulation R-value, less the R-value of the insulation on the duct.
3. ~~Ductwork in floor cavities located over unconditioned space shall comply with all of the following:~~
   1. ~~A continuous air barrier installed between unconditioned space and the duct.~~
   2. ~~Insulation installed in accordance with Section R402.2.7.~~
   3. ~~A minimum R-19 R-10 insulation installed in the cavity width separating the duct from unconditioned space.~~
4. ~~Ductwork located within exterior walls of the building thermal envelope shall comply with the following:~~
   1. ~~A continuous air barrier installed between unconditioned space and the duct.~~
   2. ~~Minimum R-10 insulation installed in the cavity width separating the duct from the outside sheathing.~~
   3. ~~The remainder of the cavity insulation shall be fully insulated to the drywall side.~~
5. Ductwork located in wall or floor building assemblies separating unconditioned from conditioned space shall comply with the following:
   1. A *continuous air barrier* shall be installed as part of the building assembly between the *duct* and the *unconditioned space*.
   2. *Ducts* shall be installed in accordance with Section R403.3.1.

Exception: Where the building assembly cavities containing *ducts* have been air sealed in accordance with Section R402.4.1, *duct* insulation is not required.

* 1. At least 50 percent of the design R-value of the assembly, not less than R-10, shall be located between the *duct* and the *unconditioned space*.
  2. For *ducts* in these building assemblies to be considered within *conditioned space*, the air handling equipment shall be installed within *conditioned space*.

**Working Group Remarks: The original proposal to revise the minimum insulation value for 3.3 was accepted, and further modified to combine Items 3 and 4 as a single Item 3. The proponent participated in the working group’s development of these modifications.**

**REPI-81-21**

**IECC®: R403.3.3**

**Proponents:**

Craig Conner, representing self (craig.conner@mac.com); Joseph Lstiburek, representing Building Science Corporation (joe@buildingscience.com)

**Revise as follows:**

R403.3.3 (N1103.3.3) Ducts buried within ceiling insulation.

Where supply and return air ducts are ~~partially~~ or completely buried in ceiling insulation, such ducts shall comply with all of the following:

1. The supply and return ducts shall have an insulation R-value not less than R-8.
2. At all points along each duct, the sum of the ceiling insulation R-value against and above the top of the duct, and against and below the bottom of the duct, shall be not less than R-19, excluding the R-value of the duct insulation.
3. In Climate Zones 0A, 1A, 2A and 3A, the supply ducts shall be completely buried within ceiling insulation, insulated to an R-value of not less than R-13 and in compliance with the vapor retarder requirements of Section 604.11 of the International Mechanical Code or Section M1601.4.6 of the International Residential Code, as applicable.

**Exception:** Sections of the supply duct that are less than 3 feet (914 mm) from the supply outlet shall not be required to comply with these requirements.

**Reason Statement:**

This language makes it clear that the buried duct language does not apply for partially buried ducts. **Cost Impact:** The code change proposal will neither increase nor decrease the cost of construction. This corrects the code. It does not increase costs.

**Working Group Recommendation: Reject. Section R403.3.3 is poorly worded and requires further study and additional revisions regarding requirements buried ducts. Deleting “partially” may create further confusion in the field. This topic needs to addressed as part of the next code revision cycle.**

**REPI-84-21**

**IECC®: R403.3.5, R403.3.6**

**Proponents:**

Robby Schwarz, BUILDTank, Inc., representing Colorado Chapter of the ICC (robby@btankinc.com)

**Revise as follows:**

**R403.3.5 Duct testing.**

Ducts shall be pressure tested in accordance with ANSI/RESNET/ICC 380 or ASTM E1554 to determine air leakage by one of the following methods:

1. Rough-in test: Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the system, including the manufacturer’s air handler enclosure if installed at the time of the test. ~~Registers shall be taped or otherwise sealed during the~~ All portions of the Duct system, including air handler, filter box, supply and return boots, shall be tested.
2. Postconstruction test: Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the entire system, including the manufacturer’s air handler enclosure. ~~Registers shall be taped or otherwise sealed during the test.~~ All portions of the Duct system, including air handler, filter box, supply and return boots, shall be tested.

A written report of the results of the test shall be signed by the party conducting the test and provided to the code official.

**Exception:** A duct air-leakage test shall not be required for ducts serving ventilation systems that are not integrated with ducts serving heating or cooling systems.

**R403.3.6 Duct leakage.**

The total leakage of the duct~~s,~~ system, where measured in accordance with Section R403.3.5, shall be as follows:

1. Rough-in test: The total leakage shall be less than or equal to 4.0 cubic feet per minute (113.3 L/min) per 100 square feet (9.29 m2) of conditioned floor area where the air handler is installed at the time of the test. ~~Where the air handler is not installed at the time of the test, the total leakage shall be less than or equal to 3.0 cubic feet per minute (85 L/min) per 100 square feet (9.29 m2) of conditioned floor area.~~

**Exceptions:**

1. Where the air handler is not installed at the time of the test, the total leakage shall be less than or equal to 3.0 cubic feet per minute (85 L/min) per 100 square feet (9.29 m2) of conditioned floor area.
2. If the HVAC duct system is serving less than or equal to 1,200 square feet of conditioned floor area, the allowable duct leakage shall be 50 cubic feet per minute or less.
3. Postconstruction test: Total leakage shall be less than or equal to 4.0 cubic feet per minute (113.3 L/min) per 100 square feet (9.29 m2) of conditioned floor area.

**Exception:** If the HVAC duct system is serving less than or equal to 1,200 square feet of conditioned floor area, the allowable duct leakage shall be 50 cubic feet per minute or less.

1. ~~Test for ducts within thermal envelope: Where all ducts and air handlers are located entirely within the building thermal envelope, total leakage shall be less than or equal to 8.0 cubic feet per minute (226.6 L/min) per 100 square feet (9.29 m2) of conditioned floor area.~~

**Reason Statement:** This code change proposal begins by defining a duct leakage test of the entire system, including the duct, the air handler, filter box andsupply and return boots. The entire system is what is tested and what needs to pass the requirements of the IECC. This is important tomake clear as we are seeing significant leakage at duct boots for example, that many feel are exempt as they are not specifically calledout. In addition, although manufacturers are supposed to be delivering tight air handler boxes the reality that they either are not orwhen they are installed, they continue to leak. Testing the entirety of the HVAC system as installed leads to better efficiency andperformance.

An allowance to have ducts that leak as much as 8 CFM per 100 sqft of conditioned floor area has been removed by this proposal as this allowance does not take into consideration the inefficiencies that arise from ductwork that leaks within the building thermal envelope. First, since the code does not require a duct leakage to outside test it is unable to quantify how much of the leakage that is supposed to be leaking inside the envelope is actually leaking outside. Second, duct leakage as high as 8 CFM means that rooms with specific design flows are not being heated or cooled to the design parameters. This causes the occupant to adjust the thermostat to try to compensate for comfort issues associated with duct leakage. This causes more leakage and potential increased stratification of temperature in the home, building durability and potential safety problems in the house. Sticking with efficiency of the system, the

thermostat adjustment leads to short cycling as the system that was design to specific set point temperatures tries to achieve arbitrary set points. A consistent duct leakage allowance requirement of 4CFM across the board regardless of duct location simplifies things for contractors and ensure better performance of ducts locating both inside and outside the building. The duct leakage section of the proposal restructures the requirement with exceptions, one of which is currently awkwardly in the body of the code and one of which is being proposed. For duct work servicing small square footages it become unreasonable to require the duct to be tighter than 50 CFM. At 1200 sqft the 4 CFM duct leakage target would be 48 CFM, so this appeared to be the perfect starting point for this exception.

**Cost Impact:** This proposal may increase cost in jurisdiction that have not concentrated on total system duct leakage and that have allowed ducts toleak more if they are within the building envelope. The increased cost comes down quickly as installers better understand installationtechniques that ensure tighter systems and are also mitigated by better system performance, efficiency, and fewer call backs.

**Working Group Recommendation: The Working Group could not reach a consensus on a direction regarding this proposal. The main issue of contention is what defines the entirety of the duct system, and if the entire duct system needs to be tested at final for compliance.**

**Apart of the above issue, several of the proposed changes are included under REPI-86.**