INTRODUCTION

Code Check Plumbing & Mechanical®

By DOUGLAS HANSEN, SKIP WALKER, & REDWOOD KARDON

Illustrations & layout by Paddy Morrisey


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KEY TO USING CODE CHECK

Code Check Plumbing & Mechanical condenses large amounts of code information by using "shorthand" conventions that are explained here. Each text line begins with a checkbox and ends with the code citations. The first code citation is typically from the IRC, and the second from the UPC or UMC. The following example is taken from p.14 under the topic of plumbing vents:

☐ All fixture traps req venting ___________ 3101.2.1 901.2

This line is stating that all fixture traps require venting, and the rule is found in section 3101.2.1 of the IRC and section 901.2 of the UPC.

The actual number in the IRC also includes a letter. Issues pertaining to building start with an R, energy an N, Mechanical an M, fuel gas a G, plumbing a P, and electrical an E. The letters were omitted here to save space. The full IRC section name for the above line would be P3101.2.1.

References to figures and tables are preceded by an F or a T. The following example is from p.7 on the subject of fittings and changes of direction:

☐ Changes in direction req appropriate fittings F11–14.T10 __ 3005.1 706.1

This line is stating that changes of directions must use appropriate fittings, as illustrated in Figures 11 through 14 and also in Table 10.

A change from the previous code edition is shown by a code citation in a different color. The superscript endnote after the code citation refers to the table on the inside back cover (p.49), where more information about the change is found. The following example is from p.27 on the subject of general Mechanical requirements:

☐ Plastic pans not OK under gas water heaters ___________ 2801.6® n/a

This line is saying that gas-fired water heater catch pans cannot be plastic, and that this IRC code change is #28 in T49 on p.49. The “n/a” in the right column means that the UPC does not have this rule.

A line ending in EXC means that an exception to the rule is contained in the line that follows. The following example is from p.36 on the subject of electrical requirements for central heating:

☐ No other equipment on central heating circuit EXC ___________ 3703.1 422.12

• Associated pumps, humidifiers, & AC equipment ___________ 3703.1 422.12X

These lines are stating that central heating equipment requires its own circuit with no other equipment on that circuit. An exception is made for associated pumps, humidifiers, air cleaners, and AC equipment. The “X” at the end of the citation in the right column refers to an exception in the code, i.e., the full citation is section “422.12 Exception”.

Benjamin Franklin was chosen as the main character in our Code Check illustrations for a number of reasons. Franklin’s insatiable curiosity, scientific genius, and civic-mindedness drove him to study fire safety, safe exitting, public sanitation, improved heating methods, and of course, electricity.

In 1752, he brought the first bathtub to America. After designing a more comfortable model, he took it with him on his travels to Europe.

CODE CHECK “YOUR KEY TO THE CODES.”

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www.codecheck.com
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DRAINAGE (CONTINUED)

Drain, waste and vent (DWV) pipe sizes are determined by the number of drainage fixture units that each pipe carries. Begin by drawing an isometric diagram of all the fixtures, and assign each the appropriate number of drainage fixture units from T6. Start at the highest point of the system and work down to the building drain, sizing each pipe per T8 or T9 for the number of DFUs.

**Drain Pipe Size**

<table>
<thead>
<tr>
<th>IRC</th>
<th>15 IRC</th>
<th>15 UPC</th>
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<tr>
<td>Size piping per DFU loads T6–T9</td>
<td>3005.4</td>
<td>703.1</td>
</tr>
<tr>
<td>Branches &amp; building drain max load per T7 &amp; T8</td>
<td>3005.4.1 &amp; 2</td>
<td>703.2</td>
</tr>
<tr>
<td>Kitchen, bath, &amp; laundry group DFUs can be per T9</td>
<td>T3004.1</td>
<td>n/a</td>
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**Table 6: DFUs & Trap Size**

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<tr>
<th>Fixture</th>
<th>IRC</th>
<th>DFUs</th>
<th>Trap Size</th>
<th>UPC</th>
<th>DFUs</th>
<th>Trap Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bar Sink</td>
<td>1</td>
<td>1¼</td>
<td>1</td>
<td>1½</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bathtub (w/o w/o shower)</td>
<td>2</td>
<td>1½</td>
<td>2</td>
<td>1½</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bidet</td>
<td>1</td>
<td>1¼</td>
<td>1</td>
<td>1¼</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bidet (1½ in. outlet)</td>
<td>1</td>
<td>1½</td>
<td>2</td>
<td>1½</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CW Standpipe</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
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<tr>
<td>Dishwasher (independent drain)</td>
<td>2</td>
<td>1½</td>
<td>2</td>
<td>1½</td>
<td></td>
<td></td>
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<tr>
<td>Floor drain</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KS</td>
<td>2²</td>
<td>1½</td>
<td>2</td>
<td>1½</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LT</td>
<td>2</td>
<td>1½</td>
<td>2</td>
<td>1½</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lavatory</td>
<td>1</td>
<td>1¼</td>
<td>1</td>
<td>1¼</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single head shower stall</td>
<td>2</td>
<td>1½</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additional shower heads</td>
<td>2</td>
<td>Note C</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
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<tr>
<td>Water Closet (toilet)</td>
<td>1</td>
<td>1.6 GPF</td>
<td>3</td>
<td>n/a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Closet (toilet)</td>
<td>&gt; 1.6 GPF</td>
<td>4</td>
<td>n/a</td>
<td></td>
<td></td>
<td></td>
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A. UPC: Min. 2 in. drain
B. W/o w/o DW or food waste grinder.
C. The IRC bases the trap size on the flow rate; >6.7 gpm & ≤ 12.3 gpm = 2 in., ≤ 25.8 gpm = 3 in.

**Table 7: Branch Drain Max DFUs**

<table>
<thead>
<tr>
<th>Pipe size</th>
<th>IRC 1/4 in.</th>
<th>1/2 in.</th>
<th>2 in.</th>
<th>2½ in.</th>
<th>3 in.</th>
<th>4 in.</th>
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<tr>
<td>IRC DFUs</td>
<td>Vertical</td>
<td>1</td>
<td>4</td>
<td>10</td>
<td>20</td>
<td>48</td>
</tr>
<tr>
<td>Horizontal</td>
<td>1²</td>
<td>3²</td>
<td>6²</td>
<td>12²</td>
<td>20</td>
<td>160</td>
</tr>
<tr>
<td>UPC DFUs</td>
<td>Vertical</td>
<td>1</td>
<td>2</td>
<td>16</td>
<td>32</td>
<td>48</td>
</tr>
<tr>
<td>Horizontal</td>
<td>1</td>
<td>1</td>
<td>8</td>
<td>14</td>
<td>35</td>
<td>216²</td>
</tr>
</tbody>
</table>

A. Based on ¼ in./ft. slope

**Table 8: IRC Max DFUs on Building Drain, Building Drain Branches, & Building Sewer**

<table>
<thead>
<tr>
<th>Pipe size (in.)</th>
<th>1½</th>
<th>2²</th>
<th>2½²</th>
</tr>
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<td>Slope (in. per ft.)</td>
<td>n/a</td>
<td>Note A</td>
<td>Note A</td>
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<tr>
<td>1½²</td>
<td>n/a</td>
<td>21</td>
<td>27</td>
</tr>
<tr>
<td>2½²</td>
<td>n/a</td>
<td>24</td>
<td>31</td>
</tr>
<tr>
<td>3²</td>
<td>36</td>
<td>42</td>
<td>50</td>
</tr>
<tr>
<td>4²</td>
<td>180</td>
<td>216</td>
<td>250</td>
</tr>
</tbody>
</table>

A. 1½ in. horizontal branches to building drains limited to 1 pumped fixture (included food waste grinder) or 2 non-pumped fixtures.
B. Drains <3 in. may not receive discharge from water closets.

**Table 9: Kitchen, Bath, & Laundry Groups**

<table>
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<th>Group</th>
<th>Description</th>
<th>IRC T3004.1</th>
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<td>Full Bath</td>
<td>1.6 GPF WC, lavy, tub w/o w/o shower</td>
<td>5²</td>
</tr>
<tr>
<td>Half Bath</td>
<td>1.6 GPF WC + lavy</td>
<td>4²</td>
</tr>
<tr>
<td>Laundry</td>
<td>CW standpipe + laundry tray</td>
<td>3</td>
</tr>
<tr>
<td>Kitchen</td>
<td>Separate DW &amp; sink</td>
<td>2</td>
</tr>
<tr>
<td>Multiple Bath Groups</td>
<td>1 full bath + 1 half bath</td>
<td>7²</td>
</tr>
</tbody>
</table>

A. Add 1 DFU if WC is >1.6 gal. per flush.
B. For each additional bath beyond 1½ baths, add 1 DFU per half bath, 2 DFUs per full bath.

**Fittings & Changes of Direction**

<table>
<thead>
<tr>
<th>IRC</th>
<th>15 IRC</th>
<th>15 UPC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changes in direction req appropriate fittings F11–14, T10</td>
<td>3005.1</td>
<td>706.1</td>
</tr>
<tr>
<td>Use double sanitary tees or equivalent (back-to-back fixture fitting) for 2 fixture inlets at same level F11</td>
<td>3005.1.1</td>
<td>706.2</td>
</tr>
<tr>
<td>Double sanitary tee barrel min 2 sizes larger than inlets F11</td>
<td>n/a</td>
<td>706.2</td>
</tr>
<tr>
<td>No horizontal-horizontal fittings within 10 pipe diameters downstream of stack base or horizontal offset F12</td>
<td>3005.5</td>
<td>n/a</td>
</tr>
<tr>
<td>Sanitary tee horizontal to vertical only, not on “back” F12</td>
<td>3005.1</td>
<td>706.1</td>
</tr>
</tbody>
</table>

**Building drain branches are the horizontal pipes that connect directly to the building drain. They can be carrying the drainage from multiple branch drains which are less likely to all be used at the same time. Therefore, the IRC allows these drains, and the building drain and building sewer, a larger number of DFUs than for the upstream branch drains of the same pipe size. The UPC does not have a corresponding system other than in an engineered design approved by the AHJ.**

**Kitchen, bath, and laundry groups can be sized using T9, which allows a smaller number of DFUs than would be calculated if each individual fixture drain were assigned values from T6. UPC appendix C (Alternate Plumbing Systems) provides a similar system and requires approval by the AHJ.**
## Table 10
**APPLICATION OF FITTINGS • IRC T3005.1 & UPC 706**

<table>
<thead>
<tr>
<th>Fitting</th>
<th>Horizontal to Vertical</th>
<th>Vertical to Horizontal</th>
<th>Horizontal to Horizontal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1⁄8 bend</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>1⁄4 bend</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>3⁄8 bend</td>
<td>✓</td>
<td>✓</td>
<td>IRC ✓ • UPC Ø</td>
</tr>
<tr>
<td>1⁄2 bend</td>
<td>✓</td>
<td>IRC ✓ • UPC Ø</td>
<td></td>
</tr>
<tr>
<td>Short sweep (cast iron)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Long sweep</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Sanitary tee</td>
<td>✓ CS</td>
<td>Ø</td>
<td>Ø</td>
</tr>
<tr>
<td>Wye</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Combo wye &amp; 1⁄2 bend</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

A. IRC max. 2 in. diameter.
B. IRC fixture drain max 2 in. diameter, fitting min. 3 in. diameter.
C. Double sanitary tees not to receive discharge from pumped waste or from WCs unless min. 18 in. between WC and fitting.
D. Double sanitary tees in UPC must have barrel 2 pipes sizes larger than inlets.

---

### FIG. 11
**Drains Entering at Same Level**

A back-to-back fixture fitting should be used for fixtures or trap arms entering at the same level. The IRC allows a double sanitary tee to be used for this purpose where they are similar fixtures and both drains are the same size. The UPC only allows it for branch drains entering at the same level and into a barrel that is a min of two pipe sizes larger than the inlets.

---

### FIG. 12
**Sanitary Tees**

OK only for horizontal to vertical

---

### FIG. 13
**DWV Fittings**

- Wye
- Sanitary tee
- 1⁄2 bend
- 1⁄4 bend
- 1⁄8 bend
- 1⁄16 bend
- 60° bend
- 45° bend
- 22.5° bend
- Long sweep

**FIG. 14**
**Application of Fittings**

IRC allows horizontal-to-horizontal 1⁄4 bend up to 2 in. diameter.

- Combo or Wye & 1⁄2 bend
CLEANOUTS

Cleanouts are necessary for clearing drain obstructions and for inspecting the building sewer with a sewer camera. Each code has restrictions on cleanouts in crawlspace. The IRC requires that underfloor cleanouts be no further than 5 ft. from the crawl access opening. The IRC allows cleanouts in crawlspace only where the travel path is a minimum of 24 inches high. When those conditions cannot be met, the cleanouts must be extended to the exterior.

IRC Cleanout Requirements

- CO plugs req raised sq. head or countersunk head or slot 3005.2.6
- Size same as drainpipes up to 4 in. diameter EXC 3005.2.5
  - Removable trap OK 1 size smaller than drain (e.g., kitchen) 3005.2.5X1
  - CO in stacks OK 1 size smaller than stack 3005.2.9X2
- CO to exterior if crawlspace travel path <24 in. in height 3005.2.10
- COs req’d not >100 ft. apart in each horizontal drainline 3005.2.1
  - CO not req’d between nonremovable trap and trap vent 3005.2.1X
- COs below grade must be extended to or above grade 3005.2.10
- Req’d in horizontal drains, building drains, & building sewer for each change of direction >45° F16 3005.2.4
  - First CO may serve up to 40 ft. that contains multiple changes F16 3005.2.4
- COs at base of stacks OK 1 size smaller than stack size 3005.2.5X2.
- CO req’d at (or within 10 ft. developed length upstream of) junction of building drain & building sewer. F10 Toilet not OK as req’d CO 3005.2.3
  - Install COs to allow cleaning in direction of flow 3005.2.8
- Pipes 16 in. req 18 in. clearance to face of closest obstruction 3005.2.9
- Not OK to obstruct CO w/ permanent finishes, etc. 3005.2.10.1
- CO openings not OK for new fixtures w/o new CO 3005.2.11

UPC Cleanout Requirements

- COs liquid & gas tight 707.3
- Plugs brass or plastic w/ raised head or countersunk slot 707.1
- Min plug size for ≤2 in. pipe = 1 ½ in., 2½ in. or 3 in. pipe = 2½ in., ≥4 in. pipe = 3½ in. 707.10
- Req’d at upper terminal of all horizontal runs F15 EXC 707.4
  - Horizontal runs <5 ft. (unless serving sinks or urinals) 707.4X1
  - Horizontal pipes ≤72° from vertical (1/5 bend) 707.4X2
  - Pipes above lowest floor of building 707.4X3
  - No upper terminal CO req’d if 2-way CO at junction of building drain and building sewer F10 707.4X4
- Req’d every 100 ft. length or fraction of developed length 707.4
- Req’d for runs w/ aggregate change of direction >135° F16 707.4
  - Trap arm bends <90° do not req CO 707.14
- Takeoff above flow line unless wye branch or end of line F17 707.5
- Clearance in front of CO min 24 in. exc. ≤2 in. pipe 18 in. OK 707.9
  - Underfloor CO must extend above finished floor or outside building if >5 ft. from access door or if <18 in. vertical clearance or if passageway to CO <30 in. wide 707.9
  - COs must terminate above grade & be readily accessible or under cover plate 707.8

FIG. 15
UPC Cleanouts
Horizontal Distances

- 2-way CO if no upper terminal CO

FIG. 16
Cleanout Bends & Clearances (plan view)

- UPC req’s a CO for an aggregate total bend >135°.
- IRC req’s a CO for every change of direction >45° except only one is req’d each 40 ft.

FIG. 17
Adding Drain at Cleanout

If additional drain is added here, new CO is req’d.

COs may not be used for new fixtures unless new CO added.
Air Admittance Valves (AAVs) operate by gravity, as shown in FIG. 43, and have no metal or rubber parts that could corrode or deform. In the IRC they can be used for individual fixtures or for branches. The UPC does not explicitly allow AAVs. Some jurisdictions may accept them under the provisions for Alternate Materials and Methods found in 301.3. If the UPC is the code in your area, be sure to check with your local building department (AHJ) before installing AAVs.

Air Admittance Valves  15 IRC
☐ Install after DWV leak test  3114.2
☐ OK at individual, branch, circuit & stack vents  3114.3
☐ Individual & branch type AAV to vent only fixtures on same floor level & that connect to a horizontal branch drain  3114.3
☐ Individual fixture & branch AAV ≥4 in. above branch or fixture drain  3114.4
☐ Stack-type AAV min 6 in. above FLR of highest fixture  3114.4
☐ AAV within same max distance as conventional vent  3114.4
☐ AAVs terminating in attic min 6 in. above insulation  3114.4
☐ AAVs must be accessible for service & inspection  3114.5
☐ Space containing air admittance valve must be ventilated  3114.5
☐ Min 1 vent to outdoors (UPC all vents to exterior)  3114.7
☐ Not OK for sewer ejector pump or tanks  3114.8

### AIR ADMITTANCE VALVES

![Air Admittance Valve](image1)

An AAV cannot be located inside a stud cavity or other area where not accessible & open to free air.

When AAVs are placed in attics, they must be at least 6 in. above insulation.

![Air Admittance Valve Operation](image2)

Air above washers is open to air inside vent pipe

Washer seals by gravity after use

Outside openings separated from air in pipe by washer

During operation, negative pressure in pipe lifts the washer & admits air into pipe

### WATER SUPPLY & DISTRIBUTION

Plumbing systems must be designed and maintained to prevent contamination of potable water from cross connections to drains or other contaminated sources. Piping must be protected against movement and against damage during construction. Modern plumbing supply systems typically use plastic pipe or tubing with branch piping originating from a central manifold, rather than a trunk and branch system with a main line with branches. Plastics typically can only tolerate exposure to sunlight for limited periods, and some types of plastics require flushing procedures to remove solvents prior to use.

### Water Supply – General

15 IRC  15 UPC
☐ Non-potable water system outlets to be marked

CAUTION: NONPOTABLE WATER. DO NOT DRINK

☐ Plastic underground water service req #18 tracer blue wire _n/a_  604.10.1
☐ Min pressure 40 psi (UPC: 15 psi)  2903.3  608.1
☐ If pressure insufficient, install booster pump, tanks, etc  2903.3  608.1
☐ Max pressure 80 psi (p.19)  2903.1  608.2
☐ Mechanical ASSE 1010 water hammer arrestors (not air chambers) req’d near quick-close valves (DW or CW)  2903.5  609.10

### TABLE 20 WATER PIPE MATERIALS  15 IRC T2906.4&5 & UPC T604.1

<table>
<thead>
<tr>
<th>Material</th>
<th>Service</th>
<th>Distribution</th>
<th>Service</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABS</td>
<td>✓</td>
<td>ø</td>
<td>ø</td>
<td>✓</td>
</tr>
<tr>
<td>Brass pipe</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>CPVC</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Cu tubing</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Ductile iron</td>
<td>✓</td>
<td>ø</td>
<td>ø</td>
<td>✓</td>
</tr>
<tr>
<td>Galvanized steel</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>PE</td>
<td>✓</td>
<td>ø</td>
<td>ø</td>
<td>✓</td>
</tr>
<tr>
<td>PE-AL-PE</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>PEX</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>PEX-AL-PECA</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>PEX-AL-HDPE</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Polypropylene plastic tubing (PP)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>PVC</td>
<td>✓</td>
<td>ø</td>
<td>ø</td>
<td>✓</td>
</tr>
<tr>
<td>Stainless steel</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

### Materials

15 IRC  15 UPC
☐ All materials must meet NSF 61 & be approved  2906.4&5  604.1
☐ Lead content of pipe & fittings max 8%  2906.2  604.2
☐ Cu alloy fittings & valves >15% Zn by weight & used w/ plastic piping systems req resistance to dezincification per NSF 14 _n/a_  604.1
☐ Flex connectors per ASME A112.18.6/CSA B125.6  2906.7  604.5
☐ Flex connectors accessible (UPC: readily accessible)  2906.7  604.5
☐ Cu pipe markings: K=green, L=blue, M=red  2906.5  604.4
☐ CPVC joints AMI, primer must be orange  2906.9.1.2  605.3.1
☐ One-step cements AMI yellow (IRC: or red)  2906.9.1.2  605.3.1
CROSS-CONNECTION CONTROL

Backflow prevention devices protect water systems from backup and contamination. Protection of the drinking water system is critical. Vacuum breakers prevent contaminants from entering through systems such as lawn sprinklers. An air gap is a physical separation and is used to protect waste receptors, such as sinks.

Protection of Potable Water

15 IRC 15 UPC

- Prevent contamination of potable water supply 2902.1 602.1
- Connections for private to public water supply prohibited 2902.1 602.2
- Reduced pressure principle backflow preventers F45 OK for:
  - Boilers w/ conditioning chemicals 2902.5.1 603.5.10
  - Fire-sprinkler systems w/ additives 2902.5.4.1 603.5.14.2
  - Lawn irrigation systems w/ chemical injectors 2902.5.3 603.5.6.3
  - Solar heating piping w/ additives 2902.5.3 603.5.6.3
  - Pool/spa makeup water n/a 603.5.20
- Atmospheric vacuum breakers OK for:
  - Hose bibbs (not needed for tank drain valves) F47 2902.4.3 603.5.7
  - Pool/spa inlets 6 in. critical level & after last valve 2902.3.2 603.5.6
- Integral air gaps in fixtures to recognized standards OK:
  - Reverse osmosis drinking water treatment units 2909.2 603.4.6
  - DWs (AMI may req air gap if discharge connection low) 2717.1 n/a
  - Pullout spouts and sprayers w/ integral backflow AMI 2902.4.2 603.4.6
  - Pull-out or separate shower spray wands 2902.4.2 603.4.6
  - Flush tank fill w/ critical level 1 in. above overflow 2902.4.1 603.5.2
- Fixture outlet receptor air gaps:
  - Min 2× diameter of outlet and per table F44,T21 2902.3.1 603.3.1

Outdoors & Irrigation Systems

15 IRC 15 UPC

- Irrigation vacuum breakers 6 in. above highest head F46 2902.5.3 603.5.3
- Hose bibb integral backflow or vacuum breaker EXC F47 2902.4.3 603.5.7
- Water heater & boiler drains, clothes washers 2902.4.3X 603.5.7

Vacuum Breakers

Reduced Pressure Backflow Device

Reduced pressure backflow device used for:
- Boilers
- Fire-sprinkler systems
- Lawn irrigation systems
- Solar heating piping

Backflow Protection Devices

Hose bibbs req. backflow protection devices, except for clothes washers, tank drains, & water heaters.

Air Gap

The air gap is the distance between the lowest edge of the faucet opening D & the top of the flood level. 2× D or 1 in. min.

Table 21: Minimum Air Gaps

<table>
<thead>
<tr>
<th>Opening diameter &amp; typical fixtures (in.)</th>
<th>Not Affected by Side Walls (in.)</th>
<th>Affected by Side Walls (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I ½ (lav)</td>
<td>IRC 1</td>
<td>UPC 1</td>
</tr>
<tr>
<td>I ¾ (LT)</td>
<td>IRC 1½</td>
<td>UPC 1½</td>
</tr>
<tr>
<td>I 1 (BT)</td>
<td>IRC 2</td>
<td>UPC 2</td>
</tr>
<tr>
<td>&gt;1 (pool)</td>
<td>2×diameter</td>
<td>2×diameter</td>
</tr>
</tbody>
</table>

A. Affected by side walls = any time the distance from the spout to the wall is <3× the diameter of the effective opening, or <4× the dia for 2 intersecting walls.
JOINTS & VALVES

Joints & Connections  15 IRC  15 UPC
☐ Joints between dissimilar materials AMI  2906.17  605.16
☐ Cu to Fe req’s brass (UPC: min 6 in.) or dielectric fitting  2906.17.1  605.16.1b
☐ Cu joints in or under concrete slab on grade within building req brazed wrought-Cu fittings  local 609.3#2
☐ Slip joints only at exposed fixture supply  local 609.5
☐ Unions req’d within 12 in. of WH  local 609.5
☐ Unions req’d ≤ 12 in. of softeners, filters, regulators, etc.  local 609.5

Prohibited Joints
☐ Connection between different types of plastic piping or different piping materials req approved adapter fitting  2906.17  605.16.2
☐ Except for necessary valves, intermixing of dissimilar metals only at exposed or accessible locations  local 310.6
☐ Female threaded CPVC fittings w/ male plastic only  local 605.2.3
☐ Female threaded PVC fittings w/ male plastic only  local 605.12.3

Required Valves
☐ Accessible main valves req’d near water entrance  2903.9.1  606.2
☐ Main & WH valve must be full-open type F48, F49  2903.9.1&2  606.2
☐ Throttling valves not OK for main & WH F50  2903.9.1&2  606.2
☐ Main valve must be on discharge side of water meter  local 606.2
☐ Main valve must have bleed orifice or separate drain  2903.9.1  n/a
☐ Valve req’d on each appliance supply  2903.8.3  606.5
☐ Valves req’d on each fixture supply EXC  2903.8.3  606.5
* Tubs & showers (UPC: fixtures w/o slip joints)  2903.8.3  606.5
☐ Valves OK at accessible manifold F53 if labeled EXC  2903.8.4  606.5
* If manifold in attic, crawlspace, or otherwise not readily accessible, separate shutoff req’d at each individual fixture  n/a 606.5b
☐ Hose bibs subject to freezing req valve w/drain (stop-and-waste-type) EXC  2903.10  603.5.7
* Frostproof hose bibs w/ stem through insulation  2903.10X  local
☐ Valves req’d on cold-water supply at each WH  2903.9.2  606.2
☐ Req’d shutoffs must be accessible  2903.9.3  606.6

Pressure Regulators – General  15 IRC  15 UPC
☐ Req’d when building water pressure exceeds 80 psi  2903.3.1  608.2
☐ Strainer req’d ahead of regulator F51  n/a 608.2
☐ Regulator & strainer accessible w/o removing piping MFR  608.2
☐ Pipe sizing based on 80% of regulated pressure n/a 608.2
☐ Expansion tank req’d on systems w/ regulators w/o integral bypass or devices that prevent pressure dissipation F52  2903.4.1  608.3
☐ Expansion tank req’d for systems w/ supply check valves  2903.4.2  608.3
☐ Booster req’d if min flow rates not achieved (UPC: ≥ 15 psi)  2903.3  608.0

Pressure Regulators

A “closed system” is created when a one-way valve is installed on the main water supply. As water in a storage tank water heater is replaced by cold water, pressure in the tank is reduced. As the temperature rises in the tank, pressure increases but is equalized with the municipal water system pressure. Backflow preventers or pressure-reducing regulators prevent this pressure equalization, and an expansion tank is necessary to prevent excess pressure in the piping. The expansion tank is installed on the cold water line at the water heater and is set to the static pressure of the system. Some pressure regulators have an “integral backflow” feature and do not create a closed system; check the specifications of the regulator to determine if such is the case.

Pressure Regulators – General

- Strainer
- Regulator
- Expansion tank

FIG. 48
Gate Valve

FIG. 49
Ball Valve

FIG. 50
Globe Valve

FIG. 51
Pressure Regulator

Pressure is increased by turning the bolt further into the regulator

Strainer must remain accessible

FIG. 52
Expansion Tank

Hot water

Cold water

TPRV not to be used for thermal expansion control

Expansion tank

UPC: Unions or flex connectors req’d within 12 in. of tank

Strapped to wall

WATER SUPPLY ◆ VALVES ◆ REGULATORS  19
GAS PIPE SIZE

Gas piping systems in series (F59) can be sized using either the longest length or the branch length method. Systems with MP regulators are sized using the hybrid pressure method.

### Pipe Size

- Size per max demand based on appliance input ratings
- Assume all appliances operating simultaneously
- Where diversity of load can be established
- Size AMI or per tables T30 & T32
- Adjust volumetric flow rate for altitudes > 2,000 ft.

#### TABLE 32  GAS PIPE SIZING PROCEDURES IRC 2413.3 & UPC 1216.1

1. Determine Btu/cu.ft. from local gas provider
2. Determine cu.ft./hr. demand for each appliance
3. Sketch layout w/ piping lengths to each appliance
4. Determine total cu.ft./hr. demand on each pipe section
5. Determine length to most remote appliance

6A. (longest length method) use row of T32 for that length for all appliances
6B. (branch length method) use same row for all sections in series w/ most remote appliance. For other branches, use actual length of each branch.

**The “longest length” method is more conservative, and compensates for pressure losses throughout the system. The “branch length method” has less leeway, and consideration should be given to the lengths of pipe fittings. The codes accept both methods. Systems w/ MP regulators use the “hybrid pressure” method, where the pipe sizes before the regulator are determined separately, each by the longest length method.**

### FIG. 59  Gas Pipe Size Example

- 100,000 Btu Furnace 91 cu. ft.
- 199,000 Btu Tankless water heater 181 cu. ft.
- 65,000 Btu Freestanding range 59 cu. ft.

### TABLE 33  GAS PIPE SIZE EXAMPLE

<table>
<thead>
<tr>
<th>Pipe Section</th>
<th>Total cu. ft./hr.</th>
<th>Longest Length</th>
<th>Longest-Length Method</th>
<th>Actual Lengths</th>
<th>Branch-Length Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>363</td>
<td>90 ft.</td>
<td>1½ in.</td>
<td>90 ft.</td>
<td>1½ in.</td>
</tr>
<tr>
<td>B</td>
<td>272</td>
<td>90 ft.</td>
<td>1½ in.</td>
<td>90 ft.</td>
<td>1½ in.</td>
</tr>
<tr>
<td>C</td>
<td>213</td>
<td>90 ft.</td>
<td>1¾ in.</td>
<td>90 ft.</td>
<td>1¾ in.</td>
</tr>
<tr>
<td>D</td>
<td>181</td>
<td>90 ft.</td>
<td>1 in.</td>
<td>90 ft.</td>
<td>1 in.</td>
</tr>
<tr>
<td>E</td>
<td>91</td>
<td>90 ft.</td>
<td>¾ in.</td>
<td>30 ft.</td>
<td>½ in.</td>
</tr>
<tr>
<td>F</td>
<td>59</td>
<td>90 ft.</td>
<td>¾ in.</td>
<td>40 ft.</td>
<td>½ in.</td>
</tr>
<tr>
<td>G</td>
<td>32</td>
<td>90 ft.</td>
<td>½ in.</td>
<td>80 ft.</td>
<td>½ in.</td>
</tr>
</tbody>
</table>

A. Ex based on 1100 Btu/cu. ft. – contact local provider for actual values.

### TABLE 34  CUBIC FEET CAPACITY OF SCHEDULE 40 METALLIC GAS PIPE* IRC 2413.4(1) & UPC T1216.2(1)

<table>
<thead>
<tr>
<th>Nominal Pipe Size (in.)</th>
<th>½</th>
<th>¾</th>
<th>1</th>
<th>1¼</th>
<th>1½</th>
<th>2</th>
<th>2½</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe Length (in ft.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>172</td>
<td>360</td>
<td>678</td>
<td>1,390</td>
<td>2,090</td>
<td>4,020</td>
<td>6,400</td>
<td>11,300</td>
<td>23,100</td>
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<td>771</td>
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</table>

A. Based on inlet pressure <2 psi, pressure drop 0.5 in. water column, specific gravity 0.60

### GAS PIPE SIZE EXAMPLE FILL-IN

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<tr>
<th>Pipe Section</th>
<th>Total cu. ft./hr.</th>
<th>Longest Length</th>
<th>Longest-Length Method</th>
<th>Actual Lengths</th>
<th>Branch-Length Method</th>
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<td></td>
<td></td>
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<tr>
<td>B</td>
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<td>C</td>
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<td>D</td>
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</tr>
<tr>
<td>G</td>
<td></td>
<td></td>
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</table>

A. Btu/cu.ft. (from gas supplier)
WATER HEATERS

Water heaters should be maintained at as low a temperature as comfortably practical to reduce the risk of scalding. An undersized water heater is more likely to be turned to a dangerously high setting. Other means of protection against scalding include tempering valves at the water heater or at individual fixtures. Tankless water heaters are becoming more popular, including hybrid systems that contain a small storage tank and circulating line. T36 sizing represents the minimum the code allows but may not provide adequate hot water supply under all conditions. Improperly sized tankless water heaters is a common issue. Local energy codes may influence sizing as well. Water heaters that are part of a boiler system are discussed on p.28.

Water Heaters ~ General  15 IRC  15 UPC
- Replacement water heaters req permits __________ 105.1  502.1
- Installation & maintenance instructions to be left w/ WH __________ 1307.1  507.1
- Size to meet demand T36 ______ 2448.1  507.1
- Installation AMI & all instructions in L&L ______ 2406.1  501.1
- Full-open type valve req’d on supply at WH F48,49 ______ 2903.8.2  606.2
- WH also used for space heating must be L&L for both ______ 2448.2  501.1
- Systems also used for space heating req master mixing valve to temper domestic water to 140°F or less F68 ______ 2803.2  n/a
- Unions req’d (UPC: Within 12 in.) to allow removal F61,67 ______ local  609.5
- Electric WH req’s in-sight or lockable disconnect F67 ______ T4101.5  505.1
- Fuel-fired WH combustion air (p.40) ______ ______ 2407.1  506.1
- Fuel-fired WH venting (pp. 33,41–43) ______ 1801.1 & 2427.1  509.0

TABLE 36

<table>
<thead>
<tr>
<th>Number of Bathrooms</th>
<th>Number of Bedrooms</th>
<th>1st hr. Rating</th>
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<tr>
<td>1 to 1½</td>
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<td>42</td>
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<td>2 to 3</td>
<td>2</td>
<td>54</td>
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<td>2 to 2½</td>
<td>3</td>
<td>67</td>
</tr>
<tr>
<td>3 to 3½</td>
<td>4</td>
<td>67</td>
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</table>

Access & Working Space  15 IRC  15 UPC
- Clearances to combustibles per L&L & AMI ______ 1307.1  504.3.1
- Remain accessible for service, inspection, & removal ______ 1305.1  504.3.1
- Attic hatch or door min 22 in. wide × 30 in. high ______ 1305.1.3&1.4  508.4
- Largest appliance fits through access (crawl, attic) ______ 1305.1.3&1.4  508.4
- Attic min 24 in. passageway, solid floor to WH ______ 1305.1.3&1.4  508.4
- Max 20 ft. from attic access if ceiling <6 ft. ______ 1305.1.3&1.4  508.4
- Min 30 × 30 in. level working platform req’d EXC ______ 1305.1.3&1.4  508.4
- Platform not req’d if can be serviced from opening ______ 1305.1.3X1  local
- Attic & crawl req’s light & receptacle near WH ______ 1305.1.3&1.4  508.4
- Light switch req’d at normal access ______ 1305.1.3&1.4  3903.4  508.4

Special Locations  15 IRC  15 UPC
- Fuel-fired WH prohibited in storage closets ______ 2005.2 & 2406.2  local
- Not in bedrooms or bathrooms EXC ______ 2005.2 & 2406.2  504.1
- In dedicated enclosure w/ solid, weatherstriped, self-close door & all combustion air from exterior ______ 2005.2 & 2406.2  504.1(1)
- Direct-vent WH OK w/o enclosure ______ 2005.2 & 2406.2  504.1(2)
- Ignition source ≥18 in. above garage floor EXC F61 ______ 2801.7  507.13
- Flame Vapor Ignition-Resistant (FVIR) WH F62 ______ 2801.7X  507.13
- WH in separate enclosure accessible only from outside the garage & no combustion air from garage ______ 1307.3  507.13.2
- Min 18 in. above floor in area where flammables stored (basements) unless FVIR F61 ______ local  507.12
- Seismic bracing req’d upper & lower ½ of tank in SDC D & townhomes SDC C (UPC: all occupancies SDC C,D,F) F61 ______ 1307.2 & 2801.8  507.2CA
- Barrier or elevation req’d in vehicle path (garages, etc) F61 ______ 1307.3.1  507.13.1
- Min 3 in concrete pad req’d if supported on ground ______ 1305.1.4.1  507.4

FIG. 61

FVIR Water Heater in Garage

- Elevate source of ignition 18 in. above floor if not FVIR type
- Fire-exposed pipe, fittings, & valves req’d
- Temperature & pressure-relief valve (TPRV)
- Fullway valve: Gate or Ball type
- Cold water
- Vent
- Push-button pilot ignitor
- Flame-arrestor plate
- TPRV drain
- Protective bollards
- Gate or Ball type
- Bonding jumpers on hot, cold & gas pipe

FIG. 62

FVIR Water Heater

- Air enters through the vents and passes through a flame-arrestor plate into the sealed combustion chamber. Vent openings should be periodically cleaned.
Boilers & Hydronics

Modern high-efficiency boilers can be used for hydronic heating systems and for indirect-fired water heating systems. Distribution can be through radiators, baseboard convectors, radiant in-floor tubing, or duct heaters. Valves, backflow preventers, drain piping, and other items are governed also by plumbing codes.

Steam & Hot-Water Boilers

- Install AMI & per ASME standards
  - 2001.1 1002.1
  - 2004.1 & 2448.2
- Installer to supply control diagram & operating manual
  - 2001.1 1012.1
  - 2004.1 & 2448.2
- Must be securely anchored to structure
  - 1307.2 1001.5
- Hot water boilers req pressure & temperature gauges
  - F69 2002.2
  - 1003.3
- Steam boilers req sight-glass & pressure gauge
  - 2002.3
  - 1003.3
- Pressure regulator req’d on water feed
  - F69 MFR
  - 2002.5
  - 1008.1
- Shutoff valves req’d in supply & return piping
  - F69 2001.3
  - 1212.3
- Low-water cutoff control req’d
  - EXC 2002.5
  - 1008.1
- Coil-type or forced-circulation boiler w/ flow sensor
  - 2002.5x
  - 1008.1
- Hydronic boilers req expansion tanks
  - F69 2003.1
  - 1004.1
- Tank test pressure
  - 2½ × allowable system pressure
  - 2003.1.1
  - 1004.3
- Tank support designed for twice waterlogged weight
  - 2003.1.3
  - 1004.1
- Tank capacity based on system volume
  - T37 2003.2
  - 1004.4
- PRV req’d
  - F69 2002.4
  - 1206.2
- PRV drain piped to within 18 in. of floor or receptor
  - 2002.4 Ø
- Discharge piping same rules as for WH
  - (p.26) n/a
  - 1005.2

Dual Purpose Water Heaters

- Water heaters used for space heating & domestic HW
  - L&L for the purpose & installed AMI
  - F68 2004.1 & 2448.2
  - 1203.2
- Tempering valve must limit potable water to 140°F
  - max F68
  - 1207.3.1
- Indicate flow directions on system
  - T3.4
  - 2101.9
  - 1210.3
- Allow for expansion & contraction
  - 2101.8
  - 1210.2
- Wrap/sleeve pipes through concrete walls or floors
  - 2101.4
  - 12176.1

Indirect Water Heater

- Thermocouple
- Shutoff valves
- Drain valve

Indirect water heaters can use a shared boiler, a solar heating system, or both, as the energy source for the storage tank.

Embedded Piping (Radiant Heating)

- Plastic pipe rated min 100psi at 180°F
  - T203.1
  - 1221.2
- Copper tubing joints brazed not soldered
  - T201.1
  - 1221.2
- Tubing embedded in concrete
  - min 2 in. below surface
  - n/a
  - 12176
- Min R-5 insulation under poured concrete radiant system in soil contact
  - R-5 on vertical slab edges on grade
  - T203.2
  - 12176.2

Expansion Tank Capacity

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<td>100</td>
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</table>

*Based on average water temperature of 195°F, fill pressure of 12 PSIG, max operating pressure 30 PSIG*

The concept shown here has primary and secondary circulation lines. Systems can be designed w/ pumps for each zone or w/ individual zone valves from a single pump. We have depicted this system w/ the pump on the supply side, though it could also be on the return to the boiler.

FIG. 68

Indirect Water Heater

FIG. 69

Hydronic Heating Boiler
Oil-fired Appliances can be vented to listed L vents, into masonry or listed chimneys. IRC chapter 18 deals with this subject. The UMC defers to NFPA 211 for oil-fired appliances, though NFPA 31 also contains similar rules. NFPA 211 does not address as many topics on oil-fired vents as NFPA 31, and for consistency with the rest of the codes in this section we are providing the NFPA 31 rules below.

**Oil Appliance Chimneys & Vents – General**

- Appliances must be listed
- Fuel-burning appliances req venting to outdoors
- Vent system AMI of connected appliance
- Draft regulator req’d if connected to chimney
- Arrangements that prevent excessive chimney draft
- Appliances L&L for use w/o draft regulator
- No manually operated dampers
- Automatic dampers req burner interlock
- Unused openings not OK in vent system

**Chimneys & Type L Vents**

- Chimney flues serving oil systems sized per NFPA 31
- Verify existing chimney OK if installing new appliance
- Installer verify chimney size OK or resize per NFPA 31
- If deterioration visible, inspect per NFPA 211 (Chapter 14)
- Type L vents must be L&L & installed AMI
- Type L vent termination min 2 ft. above roof
- Chimney termination min 3 ft. above roof
- Vent or chimney termination min 2 ft. above any portion of building within 10 ft.
- Masonry chimneys req CO
- Masonry chimneys req liner

**Oil-fired Appliance Combustion Air – General**

- Source from outside if building is unusually tight
- Consider effect from exhaust fans (kitchen, bath, laundry)
- Screen req’d on outside openings, mesh openings
- Consider restrictive effect of louvers on openings
- Net free area 60–75% for metal louvers
- Net free area 20–25% for wood louvers

**Indoor Air Source**

- Only OK for buildings of ordinary tightness
- Infiltration sufficient for unconfined space
- Unconfined space = ≥50 cu. ft./kBtu/hr. of all appliances in space
- Confined area req’s openings to unconfined space of adequate volume
- Openings to unconfined space min 1sq. in./kBtu/hr.
- Openings located near top & bottom of confined space

**Outside Air Source**

- Openings located near top & bottom of confined space
- Openings to vented attic or crawlspace equivalent to outdoors
- Direct exterior openings each sized at 1sq. in./4kBtu/hr.
- Vertical ducts each sized at 1sq. in./4kBtu/hr.
- Horizontal ducts each sized at 1sq. in./2kBtu/hr.
**VENTILATION & EXHAUST SYSTEMS**

In general, building codes tell us when we must provide ventilation for interior spaces, and mechanical codes tell us how to provide it. The energy codes and green building standards also impact required ventilation. ASHRAE 62.2, Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings is the standard referenced by many energy codes. Check with your local jurisdiction to determine the standards in your area. Greater energy efficiency results in the need to provide systematic whole-house ventilation to dilute contaminants from materials such as volatile organic compounds (VOCs) found in furnishings, and building products. Localized exhaust removes contaminants from specific sources, such as kitchens and baths.

### Whole Building Ventilation

**ASHRAE 62.2**

- Mechanical exhaust, supply, or combination system req’d [ ]
- Min ventilation rate must comply w/ T39 [ ]
- Local exhaust fans can count to req’d whole-house continuous ventilation [ ]
- Min ventilation rates from T39 averaged over min 3 hr. period [ ]
- Measured infiltration rate can be used as credit to req’d ventilation [ ]
- Whole building or continuous ventilation fans max 1.0 sone EXC [ ]
  - Mechanical air handlers [ ]
  - Remote-mounted fans w/min 4 ft. ductwork between grill & fan [ ]

### Additional Air Quality Requirements

- Clothes dryers req exterior exhaust except condensing dryers [ ]
- Air inlets min 10 ft. from contaminants such as plumbing vents [ ]
- Exhaust ventilation may not deplete combustion air to appliances within pressure boundary (sum of 2 largest exhaust max 15 cfm/100 sq. ft.) [ ]
- Door from attached garage to house weather-stripped [ ]
- Duct leakage outside pressure boundary max 6% [ ]
- Central furnace or AC system filter min efficiency MERV 6 [ ]
- Habitable spaces req ventilation ≥4% (min 5 sq. ft.) of floor area [ ]
- Utility/WC rooms req ventilation ≥4% (min 1½ sq. ft.) of floor area EXC [ ]
  - Utility rooms w/dryer exhaust duct [ ]
  - All controls labeled as to purpose, manuals present for occupants [ ]

### Heat Recovery Ventilators (HRV)

**15 IRC 15 15 UMC**

- Install per L&L to UL 815 & AMI [ ]
- Exhaust outside, not to attics or crawlspaces [ ]
- Combine all sources for red’l ventilation rate per T39 [ ]
- Do not recirculate Class II air (baths, kitchens) to Class I [ ]

### MIN. VENTILATION RATES IN CFM

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### Exhaust Duct Size

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<td>NL</td>
<td>NL</td>
<td>158</td>
<td>91</td>
<td>55</td>
<td>18</td>
<td>1</td>
<td>Ø</td>
</tr>
<tr>
<td>7</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
<td>161</td>
<td>78</td>
<td>40</td>
<td>19</td>
</tr>
<tr>
<td>≥8</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
</tr>
</tbody>
</table>

*Multiple continuously operating exhaust fans adding up to a min of the required amount is acceptable. Assumes 2 occupants up to 1 BR, plus 1 additional occupant per BR. Add 7.5 cfm per additional occupant.*

**FIG. 86**

**Paddle Fan Support**

### Ceiling-Suspended Paddle Fans

**F86**

- Ceiling fans >70 lb. must be supported independently from box.
- Box systems rated >35 lb. must be marked w/ rating.

### Bathroom Exhaust & Ventilation

**15 IRC ASHRAE**

- Mechanical ventilation 50 cfm intermittent or 20 cfm continuous direct to exterior OK EXC [ ]
- Natural ventilation openings min 1.5 sq. ft. OK [ ]
- Air may not be exhausted into attic [ ]
- WC room vent openings min 1.5 sq. ft. ≥4% of floor area EXC [ ]
- Toilet compartments within bathrooms [ ]
- Air exhaust & intake openings req screens (62.2: intake only) [ ]

**FIG. 87**

**Bathroom Exhaust Venting**

Exhaust air is vented to the outside to prevent the build-up of mold or mildew from condensation.

**TABLE 40**

<table>
<thead>
<tr>
<th>Fan CFM</th>
<th>50</th>
<th>80</th>
<th>100</th>
<th>125</th>
<th>150</th>
<th>200</th>
<th>250</th>
<th>300</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>56</td>
<td>4</td>
<td>Ø</td>
<td>Ø</td>
<td>Ø</td>
<td>Ø</td>
<td>Ø</td>
<td>Ø</td>
</tr>
<tr>
<td>5</td>
<td>NL</td>
<td>81</td>
<td>42</td>
<td>16</td>
<td>2</td>
<td>Ø</td>
<td>Ø</td>
<td>Ø</td>
</tr>
<tr>
<td>6</td>
<td>NL</td>
<td>NL</td>
<td>158</td>
<td>91</td>
<td>55</td>
<td>18</td>
<td>1</td>
<td>Ø</td>
</tr>
<tr>
<td>7</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
<td>161</td>
<td>78</td>
<td>40</td>
<td>19</td>
</tr>
<tr>
<td>≥8</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
<td>NL</td>
</tr>
</tbody>
</table>

*A. Flex duct smaller than 4 in. not allowed.  
C. NL = No Limit, Ø = not allowed*
FORCED AIR FURNACES

Furnace design must be in accordance with approved methods, such as ACCA Manuals S & J. High-efficiency furnaces may have options for combustion air and venting; follow the manufacturer’s instructions and have the installation instructions and user’s manuals on site.

Location & Clearances
- Prohibited in bedroom, bathroom or their closets EXC AMC 20.1.2 304.1
- Direct-vent type installed AMI 2046.2 #1 304.1(2)
- Separated by weather-stripped self-closing door & all combustion air from exterior 2046.2#5 304.1(1)
- Equipment room door & passageway min 24 in. wide & large enough to service or replace appliance 1305.1.2 304.142
- Work space min 30 in. deep & wide in front of appliance 1305.1 304.1
- Clearances to combustibles per nameplate _1306.1 & 2409.3.1 904.2(1)
- Install above design flood elevation 1401.5 305.2

Electrical Requirements
- Receptacle within 25 ft. of appliance _1305.1.3.1 & 1305.1.4.3 210.63
- Crawlspace furnace req’s light w/switch at access 1305.1.3 210.70A
- Attic furnace req’s light w/switch at access 1305.1.3.1 210.70A3
- Individual circuit req’d for central heating 3703.1 422.12
- No other equipment on central heating circuit EXC 3703.1 422.12X
- Associated pumps, humidifiers, air cleaners, & AC 3703.1 422.12X

Appliances Under Floors (also see p. 44)
- Access opening & passageway min size 22 × 30 in._ 1305.1.4 304.4
- Appliance must fit through opening 1305.1.4 304.4
- Passageway max 20 ft. long EXC 1305.1.4 304.4.1
- Passageway ≥ 6 ft. high OK for unlimited length 1305.1.4X2 304.4.1
- Min 30 × 30 in. level space on service side F90 1305.1.4 304.4.3
- Support on concrete slab min 3 in. above adjoining ground or suspend from floor AMI & min 6 in. above ground F90 1305.1.4.1 904.3.1
- Excavations min 6 in. below appliance, 12 in. on sides, 30 in. on control side F90 1305.1.4.2 904.3.1.3
- If excavation >12 in. below adjacent grade, line w/ concrete extending 4 in. above adjacent grade F90 1305.1.4.3 904.3.1.3
- Luminaire & receptacle outlet near appliance F90 1305.1.4.3 304.4.4
- Switch for luminaire at passageway entrance F90 1305.1.4.3 304.4.4
- Exposed lamp protected by location or lamp guards F90,F91 1305.1.4.3 n/a

Equipment on Roofs
- Appliances on roofs shall be accessible 1305.1 304.3
- Level work space min 30 × 30 in. req’d on service side of appliance (UMC: when roof slope ≥ 4:12) 1305.1 304.24
- Buildings > 15 ft. high must have inside means of access to roof or other means acceptable to AHJ

Appliances in Attics F91
- Appliance must fit through opening 1305.1.3.1 304.4
- Opening & passageway min 22 in. wide × 30 in. high 1305.1.3 304.4
- Max 20 ft. from access opening to appliance EXC 1305.1.3 304.4.1
- 50ft OK (UMC: unlimited) if passageway ≥ 6 ft. high 1305.1.3X2 304.4.1
- Solid floor min. 24 in. wide to equipment 1305.1.3 304.4.2
- Min 30 × 30 in. platform at service area EXC 1305.1.3 304.4.3
- Not req’d if equipment can be serviced from opening 1305.1.3X1 304.4.3X
- (UMC only) max 1 ft. setback if serviced from opening n/a 304.4.3X
- Floor under furnace noncombustible construction EXC 2449.4 304.5
- Not req’d if appliance L&L for combustible floor 2449.4 304.3X1
- Not req’d if floor protected in approved manner 2449.4 304.3X2
- Luminaire & receptacle req’d near appliance 1305.1.3.1 304.4.4
- Switch for luminaire req’d at entrance 1305.1.3.1 304.4.4
- Exposed lamp protected by location or lamp guards 1305.1.3.1 n/a

Garage
- Protect appliance from impact 1307.3.1 & 2408.3X 305.1.1
- Ignition source min 18 in. above floor EXC 1307.3 & 2408.2 305.1
- FVIR appliances 1307.3X & 2408.2X 305.1
- Gas-fired appliance OK on garage floor if in separate space w/ access only from outside & exterior combustion air 2408.2.1 305.1.2
- Ducts & penetrations min 26 gage steel 302.5.2 local
- Ducts through common wall to house min 26 gage steel 302.5.2 local
- No duct openings into garage 302.5.2 local
- Openings around duct penetrations through common wall sealed w/ approved materials 302.5.3 local

FIG. 89

“SSU” Switch

![SSU Switch Diagram]

Type S Fuse
Adapter
Fuseholders must be supplied w/ Type S adapters, which prevent replacement w/ the wrong size fuse.

FIG. 90

Furnace in Crawlspace

![Furnace in Crawlspace Diagram]

4 in. min. above adjacent grade if excavation >12 in. deep
30 in. min. working space on control side
12 in. min.
Sin. min.

FIG. 91

Attic Furnace

![Attic Furnace Diagram]

No added loads on trusses except per design.

Access hatch min. 22 × 30 in.

Light switch near opening

Lamp guard

Electrical outlet

Platform noncombustible or clearance per labeling

Min. 30 in. platform on control side

The codes allow the 30 in. working platform to be omitted if the furnace can be serviced from the opening. In the UMC, the max setback from the opening is 12 in.

The min height of a gas vent above the draft hood or flue collar is 5 ft. Appliances that are fan-assisted must use the vent sizing tables supplied w/ the appliance (see p. 42). These tables start at 6 ft., and therefore the furnace shown in this figure must have a vent at least 6 ft. above the flue collar.
**DUCTS**

Manual D by ACCE is the design standard for sizing residential duct systems. SMACNA provides fabrication and support standards for sheet metal ducting and installation standards for factory-made duct systems. Factory-made ducts must also comply with UL standards. Local or state energy codes may require duct leakage testing and other performance tests.

**Ducts – General**

- Factory-made ducts L&L, per UL 181 & installed AMI 1601.1.1 603.4
- Max. 2 stories for vertical riser on factory-made duct n/a 603.4
- Fireblock openings around ducts between floors 302.11(4) n/a
- Stud cavities prohibited as supply air plenum 1601.1.1 n/a
- 56
- 5.1.1
- 603.8
- 1103.3.1
- 1103.3.1
- 5.1.1
- 3.5: S3.33
- n/a 603.4
- 1103.3.1
- 1601.1.2 603.12
- 0-2
- 1601.1.2 603.12
- Closet Furnace 1601.1.1 603.4
- 1601.1.2 603.12
- 0-2
- 1602.2 & 2442.5 311.3(4)
- 0-5
- 1103.3.1
- 1103.3.1
- 1602.2(4) & 2442.4(6) 311.3(3&5)
- 0-5

**State energy codes** may require duct leakage testing and other performance tests.

**Ducts Installation**

1. **Duct Splices**
   - Step 1. Peel jacket & insulation from core & butt cores together, w/ min. 1 in. lap over collar on each side.
   - Step 2. Apply approved tape & secure w/ band clamps. If collar > 12 in. draw band must be behind a bead on the metal collar.
   - Step 3. Pull jacket & insulation back together & apply 2 wraps of UL-181 pressure-sensitive tape.

2. **Ducts** should not be compressed. Use the min length of duct to avoid extra turns and kinks.

3. The radius of the turn at the center line must be no less than the diameter of the duct.

4. Ducts should extend a few in. beyond a sheet metal connection before bending.

5. **Ducts** should be supported according to SMACNA Standards. ANSI/SMACNA 006-2006

6. **Return Air**
   - Air filters req’d
   - Not to be taken from bathroom, kitchen, Mechanical room, closet, garage, or separate dwelling unit
   - Amount of return air from any space ≤ supply air
   - System must be balanced by an approved method
   - No return air from one dwelling to another dwelling
   - Must be open to min 25% area served
   - Return openings min. 10 ft. from appliance vent outlets
   - Duct min size 2 sq. in./kBtu output rating
   - Return OK from room w/ fuel-burning equipment if supply air provided to replace return air, return min. 10 ft. from draft hood, & room volume min 100 cu. ft. per 1,000Btu of equipment

7. **Bends**
   - Violation!
   - No kinks in ducts

8. **Flexible Ducts**
   - Flex typical 1 1/2 in. straps @ 5 ft., round metal horizontal duct support typical 1/2 in. metal straps or 12 gauge wire every 10 ft. support bands

9. **Closet Furnace Above Return Air**
   - Separation of combustion and circulating air is essential for safe and complete combustion of flue gases. In this common setup, if the closet door is open the return air competes w/ the combustion air ducts, resulting in incomplete combustion and production of carbon monoxide. The basic rule is that return air must be at least 10 ft. from the appliance draft hood and burners.

10. **Insulation in Unconditioned Space**
    - Factory-made duct insulation value marked on duct 1601.3(3) 604.1
    - In Attics: R-8 ducts > 3 in. diameter, R-6 if ≤ 3 in. 1103.3.1
    - Other areas: R-6 > 3 in. diameter, R-4.2 if ≤ 3 in. EXC 1103.3.1
    - Ducts completely inside building thermal envelope 1103.3.1

Note: Energy codes may take precedence over mechanical code insulation reqs.
VENT SIZES

Category I appliances ship with tables for sizing the vent system. These supplied tables were developed by GAMA (the Gas Appliance Manufacturers Association). They are repeated in the model codes and downloadable from many web sites. IRC Appendix B and UMC Appendix F contain instructions and examples on how to use the tables. The tables distinguish between fan-assisted and “natural” draft appliances. Fan-assisted appliances must be sized using the tables.

Vvent Size (Appliances w/ Draft Hoods) 15 IRC 15 UMC

<table>
<thead>
<tr>
<th>Diameter (in.)</th>
<th>Max. Horizontal Length (ft.)</th>
<th>Diameter (in.)</th>
<th>Max. Horizontal Length (ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>4½</td>
<td>7</td>
<td>10½</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>5</td>
<td>7½</td>
<td>9</td>
<td>13½</td>
</tr>
<tr>
<td>6</td>
<td>9</td>
<td>10</td>
<td>15</td>
</tr>
</tbody>
</table>

Examples of GAMA Vent Tables

The first step is to select the correct table based on the type of vent, the connector type, and the number of appliances. In F114, the situation is a double-wall B vent connected directly to the appliance. Two 90° elbows are allowed w/o requiring a further reduction in table values. The table has different columns for natural and fan-assisted appliances.

Question: Is 4 in. vent adequate for an 80,000 Btu fan-assisted furnace if H = 10 ft. and L = 5 ft?
Solution: Use IRC table G2428.2(1) or UMC table 803.2(1). The 4 in. “fan” column, on the row for 10 ft. height and 5 ft. lateral, the minimum kBtu for this size vent is 32, and the maximum is 113, and the furnace is within that range. If this had been a natural draft appliance, the maximum kBtu rating would have been 77. It would require either a larger vent, a lesser “L” or taller “H”.

Appliances can share a common vent by separate connectors to the vent, or by a common manifold that then connects to the vent. When the common-vented appliances all have draft hoods, the vent and connector sizes are determined by the size of the draft hood outlets. If one or more appliances are fan-assisted, the tables are used to determine the proper sizes.

Multiple Appliances Vented in Common 15 IRC 15 UMC

- If both appliances have draft hoods, size vent for 100% of larger draft hood outlet + 50% of smaller & ≤ 7% area of smaller draft hood outlet 2427.8.1(3) 802.6.3.1(3)
- Tables mandatory for fan-assisted Category I 2427.8.1(4) 802.6.3.1(4)
- Max horizontal length of vent connector 18 in. per in. of connector diameter T43 EXC 2428.3.2 803.2.1
  - Longeur lengths allowed by subtracting 10% of max table capacity for each added multiplier of allowed length in T43 2427.8.11 803.2.2
  Ex: If a 4-in. connector, normally allowed to be 6 ft, is between 6 ft. & 12 ft. in length (one multiplier of 6), reduce the allowed BTU capacity in the tables by 10%.

- Size connectors using supplied tables 2427.10.3.3 802.10.2.2
- Join common vent connectors as high as possible per available headroom & clearance 2427.10.3.4 802.10.2.3
- Two or more connectors to common vent must enter at different levels EXC F116 2427.10.4.1 802.10.3
  - OK at same level if max 45° from vertical F116 2427.10.4.1 802.10.3
  - Smaller connector to enter above larger 2427.10.4.1 802.10.3.1
- Reduce connector table capacity 5% each elbow up to 45° & 10% each elbow up to 45° to 90° 2428.3.4 803.2.5

Examples of GAMA Vent Tables for Common Venting

Given that the appliances in F116 are a 35,000 Btu water heater and a 100,000 BTU fan-assisted furnace, each w/ 4-inch flue collars, connecting to a type B common vent. The overall height of the common vent (measured from the taller appliance outlet to the top of the common vent) is 20 ft. The horizontal length of each vent connector is 4 ft., the rise of the water heater connector is 2 ft., and the rise of the furnace connector is 4 ft. Though that is in the 3-in. diameter column, a 4-in. connector must be used to be at least the same size as the flue collar. Do the same procedure for the furace, using the 10 ft. connector rise row, and going across to the first number in the “FAN” column that exceeds 35k.
**GAS VENT TERMINATIONS**

**GAS VENT TERMINATIONS – General**

- Gas vents must extend above roof **EXC**
  - Direct vent appliances **F120, T127**
  - Appliances w/ integral vents
  - Mechanical draft appliances **AMI**
- Roof penetration req’s flashing
- Must have listed cap or listed roof assembly
- Decorative shrouds only if L&L & **AMI**
- Vent termination min 5 ft. vertical above flue collar
- Vent termination min 6 ft. vertical using tables
- B vents ≤ 12 in. per **F117 & T44** if > 8 ft. from wall
- B vents >12 in. diameter min 2 ft. above roof
- Wall furnace min 12 ft. from bottom of furnace **F124**
- Direct vent per **T45**  

**TABLE 44**

<table>
<thead>
<tr>
<th>Roof Slope</th>
<th>Min. Height above roof</th>
<th>Min. Height above roof</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat to 6/12</td>
<td>1</td>
<td>&gt;11/12 to 12/12</td>
</tr>
<tr>
<td>&gt;6/12 to 7/12</td>
<td>1¼</td>
<td>&gt;12/12 to 14/12</td>
</tr>
<tr>
<td>&gt;7/12 to 8/12</td>
<td>1½</td>
<td>&gt;14/12 to 16/12</td>
</tr>
<tr>
<td>&gt;8/12 to 9/12</td>
<td>2</td>
<td>&gt;16/12 to 18/12</td>
</tr>
<tr>
<td>&gt;9/12 to 10/12</td>
<td>2½</td>
<td>&gt;18/12 to 20/12</td>
</tr>
<tr>
<td>&gt;10/12 to 11/12</td>
<td>3¼</td>
<td>&gt;20/12 to 21/12</td>
</tr>
</tbody>
</table>

**FIG. 117**

**FIG. 118**

**FIG. 119**

**FIG. 120**

**FIG. 43**

**Gas Vents**

**RecommendedVentTerminations**

- **B Vent Termination**
  - If < 8 ft. vent must terminate 2 ft. higher than any portion of building within 10 ft.
  - Roof slope: X/12
  - Min. height above roof
  - B vent ≤ 12 in. diameter

**Location of Vent Termination**

- Min. 2 ft. above roof
- Chase w/ min. R-8 insulation

**For clearances to buildings, see T45 on p.45**