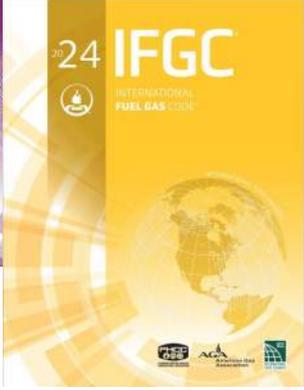




2024 IMC & IFGC

2024 IMC & IFGC Overview & Update

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InternationalCode Council, 2024 IMC & IFGC



Washington State 2021
IMC Amendments

Course Learning Objectives

1. Become familiar with the layout and content of the mechanical related portions of the **International Mechanical Code and International Fuel Gas Code**.
2. Develop a methodology and mindset for effectively and efficiently navigating the code to find desired content.
3. Learn critical aspects of mechanical systems and associated requirements for use in the field.
4. Understand the key updates to the 2024 IMC and IFGC



Course Format

1. Introduction
2. General Requirements
3. Required Ventilation
4. Exhaust Systems
5. Duct Systems
6. Combustion Air
7. Chimneys & Vents
(oil- and solid-fuels)
8. Specific Appliances
9. Heated Water &
Hydronics
10. Fuel Gas General
Requirements
11. Fuel Gas Appliance
Venting
12. Gas Line Sizing



1. Introduction



Arrangement and Format

- **IMC/IFGC**
 - **Chapter 1:** Scope and Administration
- **IMC/IFGC**
 - **Chapter 2:** Definitions
- **IMC/IFGC**
 - **Chapter 3:** General Regulations
- **IMC**
 - **Chapter 4:** Ventilations
 - **Chapter 5:** Exhaust Systems
 - **Chapter 6:** Duct Systems
 - **Chapter 7:** Combustion Air (**IFGC 304**)
- **IMC**
 - **Chapter 8:** Chimneys and Vents (**IFGC Chapter 5**)
 - **Chapter 9:** Specific Appliances (**IFGC Chapter 6**)
 - **Chapter 10:** Boilers, Water Heaters and Pressure Vessels
 - **Chapter 11:** Refrigeration
 - **Chapter 12:** Hydronic Piping
 - **Chapter 13:** Fuel Oil Piping & Storage (*Not Gas Piping*)
 - **Chapter 14:** Solar Thermal Systems
 - **Chapter 15:** Referenced Standards (**IFGC Chapter 8**)
- **IFGC**
 - **Chapter 4:** Gas Piping Installations



Foundational Concepts

1. Ventilation
2. Duct Design
3. Combustion Air
4. Appliance Installation
5. Venting of Appliances



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Ventilation

- Buildings need fresh air so people can breathe and stay healthy
- Ventilation systems bring in clean outdoor air and remove stuffy and contaminated indoor air
- Bathrooms and kitchens need fans to blow out moisture and smells
- Good ventilation helps prevent mold and keeps air from feeling stale or becoming unhealthy



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Duct Design

- Ducts are like tunnels that carry warm or cool air to each space within a building
- They have to be the right size – not too big or too small – so the air flows well
- If they leak or aren't sealed, air escapes and wastes energy and effort
- Ducts should be insulated so the air stays warm (in winter) or cool (in summer)



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Combustion Air

- Gas-fired appliances burn fuel to make heat – like a controlled fire
- Fires need air (oxygen) to burn safely – this is called combustion air
- Without enough air, the fire can make dangerous gases like carbon monoxide
- We bring air from inside or outside the building to keep the flame burning clean



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Appliance Installation

- Heating and cooling appliance need space around them
- They need to sit on solid surfaces so they don't tip over or move around
- Technicians need room to reach them for repairs
- Every piece of equipment comes with instructions and those must be followed exactly



Venting of Appliances

- When fuel burns, it makes smoke and gases which must go outside
- Vents are like chimneys that carry the gases safely out of the house
- Vents have to be sloped correctly so gases don't get stuck
- The discharge point of the vent must be far from windows and doors so gases don't come back in



2. General Requirements



IMC Chapter 1

- **Part 1: Scope and Application**
 - Purpose
 - Conflicts
 - Existing Structures
- **Part 2: Administration & Enforcement**
 - Duties & Powers
 - Permits
 - Construction Documents
 - Fees & Inspections



Scope of the IMC

- **IMC 101.2:**
 - Installation, alteration, movement, replacement and repair of mechanical equipment that are permanently installed



101.2 Scope. This code shall regulate the design, installation, maintenance, alteration and inspection of mechanical systems that are permanently installed and utilized to provide control of environmental conditions and related processes within buildings. This code shall also regulate those mechanical systems, system components, equipment and appliances specifically addressed herein. The installation of fuel gas distribution piping and equipment, fuel gas-fired appliances and fuel gas-fired appliance venting systems shall be regulated by the *International Fuel Gas Code*. References in this code to Group R shall include Group I-1, Condition 2 assisted living facilities licensed by Washington state under chapter 388-78A WAC and Group I-1, Condition 2 residential treatment facilities licensed by Washington state under chapter 246-337 WAC.

Exceptions:

1. Detached one- and two-family dwellings and multiple single-family dwellings (townhouses) not more than three stories high with separate means of egress and their accessory structures shall comply with the *International Residential Code*.
2. The standards for liquefied petroleum gas installations shall be the 2020 Edition of NFPA 58 (*Liquefied Petroleum Gas Code*) and the 2021 Edition of ANSI Z223.1/NFPA 54 (*National Fuel Gas Code*).



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Purpose of the Code

○ IMC 101.3:

- Establish minimum requirements to provide a reasonable level of safety, health and general welfare through:

- Affordability
- Structural Strength
- Sanitation
- Ventilation
- Energy Conservation
- Safety to Life and Property



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Duties & Powers

○ IMC/IFGC 104 - Completely Reformatted

- **IMC 104.2-** Has the authority to determine compliance, issue interpretations, set policies and procedures
 - Must match the intent and purpose of the code
 - Shall not “waive” the requirements of the code



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Technical Assistance

- **IMC 104.2.2.1-** The code official is authorized to require the owner or owner's agent to provide a technical opinion and report
 - Without charge to the jurisdiction
- **IMC 104.2.2.2-** Must be prepared by a qualified engineer, specialist, laboratory or specialty organization **acceptable** to the code official
- **IMC 104.2.2.3-** Opinion and report to analyze the design, operation or use and identify or propose necessary recommendations
- **IMC 104.2.2.4-** If insufficient evidence of compliance exists, tests can be required



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Equivalency Criteria

- **IMC 104.2.3.4-** Alternatives shall not be less than equivalent with respect to the following:
 1. **Quality**
 2. **Strength**
 3. **Effectiveness**
 4. **Durability**
 5. **Safety** (general)
 6. **Fire safety**
- **IMC 104.2.3.5-** Tests
 - Test shall be of a **scale** that is sufficient to predict performance
 - Must be performed by a party acceptable to the code official



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Supporting Data & Reports

- **IMC 104.2.3.6-** Data supporting alternatives:
 - Evaluation reports must be from an *approved* agency
 - Criteria used must be identified
 - Other reports be prepared by qualified engineers, specialists, laboratories and specialty organizations acceptable to the code official
- **IMC 104.2.3.7-** Peer reviews
 - The code official can require a peer review report
 - Peer reviewer must be approved by the code official



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Warrants & Record Keeping

- **IMC 104.4.1-** If a warrant is issued to allow entry for inspection, entry shall not be prevented
- **IMC 104.7-** Unless other local laws exist, department records shall be kept for **not less than 5 years**, or as long as the building remains in existence.
 - Records of approval must be made available to the public during business hours
 - Records of alternatives approved, tests conducted and fees collected must be kept



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Inspections

- **IMC 104.7.2-** Authority to inspect can be delegated to approved agencies or individuals.
 - Records of all reports must be made and kept



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Permits

- **IMC 105.1:** Required
 - Owner or Owner's Authorized Agent intends to
 - Construct, enlarge, alter, repair, move, demolish or change mechanical equipment
 - Must make application, and obtain a **permit**



Exempt from Permits (*key items*)

○ IMC 105.2:

- Portable heating, ventilation, cooling, cooking or clothes drying appliances
- Replacement of minor parts
- Portable heating, ventilation or cooling units
- Piping within equipment (factory installed)
- Self-contained refrigeration systems (10 lbs. or less)
- Portable-fuel-cell appliances



Documentation Requirements

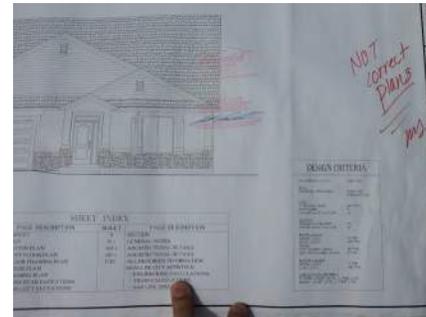
○ IMC 106.1.1:

- "*Construction documents* shall be of sufficient clarity to indicate the location, nature and extent of the work proposed and show in detail that it will conform to the provisions of this code...as determined by the *building official*."



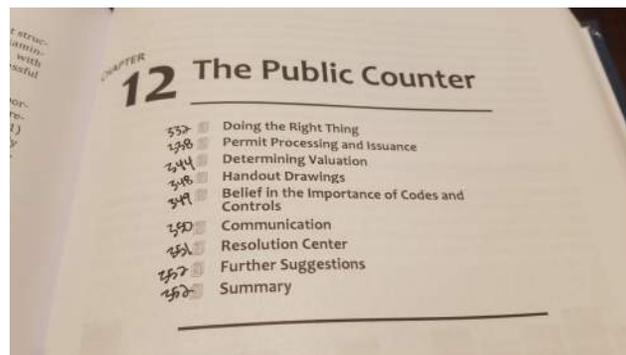
Approval of Construction Documents

- **IMC 105.4.1:**
 - "...approved in writing or by a stamp that states **"APPROVED."**
 - Approved plans shall not be changed
 - Work must be done per the plans
 - Code official may not require plans



Valuations

- **IMC 108.3-** The code official shall have the authority to adjust the final valuation for permit fees.



Inspection Process

- **IMC 111.1:**
 - The code official is authorized to conduct inspections “deemed necessary”
 - Work for which a permit is required is subject to inspection
 - Work must remain visible and accessible until **approved**
 - Inspection approval does not mean acceptance of code violations



Types of Inspections

- **IMC 111.2:**
 - Required inspections include:
 - **Underground inspection-** Prior to backfill placement
 - **Rough-in inspection-** Prior to concealment
 - **Final inspection-** When all work is complete
 - Other necessary inspections to ascertain compliance with the code



Stop Work Orders

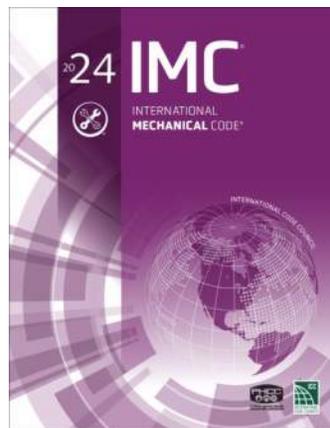
- **IMC 115.4:**
 - Method of suspending construction activities
 - Issued in writing by the Building Official when:
 - Work is dangerous, unsafe, contrary to the code
 - Violation results in fines or other penalties



115.4 Failure to comply. Any person who shall continue any work after having been served with a stop work order, except such work as that person is directed to perform to remove a violation or unsafe condition, shall be subject to fines established by the **authority having jurisdictioncode official**



IMC Ch. 2. Definitions



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New definitions:

GREASE DUCT. A duct serving a Type I hood, or cooking appliances equipped with integral down-draft exhaust systems that produce grease, to convey grease laden air from the hood or cooking appliance directly to the outdoors.



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New definitions:

PEER REVIEW. An independent and objective technical review conducted by an approved third party.

REFRIGERANT DESIGNATION. The unique identifying alphanumeric value or refrigerant number assigned to an individual refrigerant and published in ASHRAE 34.



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Modified definitions:

- **BALANCED VENTILATION SYSTEM.** A ventilation system that simultaneously supplies outdoor air to and exhausts air from a space, where the mechanical supply airflow rate and the mechanical exhaust airflow rate are each within **10 percent** of the average of the two airflow rates.

BALANCED WHOLE HOUSE VENTILATION. Any combination of concurrently operating residential dwelling or sleeping unit mechanical exhaust and mechanical supply whereby the total mechanical exhaust airflow rate is within 10 percent or 5 cfm, whichever is greater, of the total supply airflow rate.



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Modified definitions:

HEAT PUMP. A refrigeration system or factory-made appliance that utilizes refrigerant to transfer heat into a space or substance.

LISTED. Equipment, materials, products or services included in a list published by an organization acceptable to the code official and concerned with evaluation of products or services that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services and whose listing states either that the equipment, material, product or service meets identified standards or has been tested and found suitable for a specified purpose. **Terms that are used to identify listed equipment, products or materials include "listed," "certified," "classified" or other terms as determined appropriate by the listing organization.**





Modified definitions:

NONCOMBUSTIBLE MATERIAL. A material that passes ASTM E136.
(simplified)

REFRIGERANT. *The fluid used for heat transfer in a refrigeration system that undergoes a change of state to absorb heat.*

REFRIGERATION SYSTEM. *A combination of interconnected parts in which a refrigerant is enclosed and is circulated for the purpose of extracting then rejecting heat.*



IMC/IFGC Chapter 3- General Regulations

- General Mechanical and Fuel Gas System Requirements
- Broad requirements that don't fit elsewhere:
 - Testing and certification of materials
 - Installation requirements
 - Listing and labeling
 - Access to appliances
 - Clearances to combustible
 - Protection of mechanical systems and building structure



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Pipe, Fittings and Components

- **IMC 301.3 – 301.5**
 - Bear the identification of the manufacturer
 - Plastic (**Conform to NSF 14**)
 - Comply with applicable referenced standards
 - Tested or certified by an approved 3rd party



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Approval

- **IMC 301.7, IFGC 301.3:**
 - Appliances must be **listed and labeled** for the application in which they are used
 - Indoor vs. Outdoor
 - Wet vs. Dry Environments
 - Clearances to Combustibles
 - Etc.



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Labeling of Appliances

- **IMC 301.8 & 301.9, IFGC 301.5:**
 - **Permanent** factory-applied nameplates required:
 - Affixed to appliance
 - Manufacturer's Name or Trademark
 - Model Number
 - Serial Number
 - Seal or Mark of Testing Agency
 - Requirements vary based on type



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Type of Fuel

- **IFGC 301.7:**
 - Fuel-fired appliances must be designed for the type of fuel utilized and the altitude of the location installed
 - Conversion to alternate fuel, only when approved by manufacturer



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Seismic Resistance

- **IMC 301.18:**
 - Where earthquake loads are applicable (IBC)
 - Design and install all mechanical:
 - System supports
 - Anchorage
 - Bracing

In accordance with **IBC Chapter 16**



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Cutting & Notching Cold-formed steel

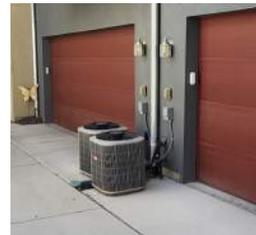
- **IMC 302.5-** The cutting and notching of holes in cold-formed steel framing members shall be in accordance with [AISI S240](#) for structural members and [AISI S220](#) for nonstructural members.
- Simplifies the requirements, aligns the IFGC, IMC and IPC



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Appliances Installation

- **IMC 304.3:**
 - Appliances in garages must be elevated 18" or more
 - Water heaters, furnaces, clothes dryers, etc.
 - **Note:** Applies to appliances in the garage or in storage rooms etc. that communicate directly with the garage
 - **Exception:** Appliances listed as "flammable-vapor-ignition resistant"
- **IMC 303.4:** Protect from damage



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Access and Working Space

- **IMC 306.1:**
 - Appliances must be located to allow for access:
 - Inspection
 - Service
 - Repair
 - Replacement
 - Cannot require removal of permanent construction
 - Walls, floors, ceilings, door frames, fire-resistance-rated assemblies



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Appliance Working Space

- **IMC 306.1:**
 - Minimum Size: 30" x 30" at control side of appliance
 - **Amendment:** Ladder rungs not to exceed **12 inches**
- **IMC 306.2:** In rooms
 - Minimum door or passageway 24" wide, large enough to remove the largest appliance



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Appliances in Attics

- **IMC 306.3:**
 - Passageway:
 - Minimum 30" x 22" and large enough to remove the largest appliance
 - Limited to 20' in length from opening to appliance
 - Flooring must be 24" wide
 - **Exception:** If passageway is **6' or more tall**, limited to **50'** Opening (access hatch)
 - Minimum 20" x 30" and large enough to remove the largest appliance



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Appliances Under Floors

o IMC 306.4:

- Opening (access hatch)
 - Minimum 22" x 30" and large enough to remove the largest appliance
 - Switched light required at the opening, with GFCI at appliance
- Passageway:
 - Minimum 30" x 22" and large enough to remove the largest appliance
 - Limited to 20' in length from opening to appliance
 - If walking surface is > 12" below adjoining grade- line with concrete/masonry and extend 4"+ above adjoining grade
 - **Exception:** If passageway is **6' or more tall**, limited to **50'**



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Appliances Under Floors

o IMC 306.4:

- Clearances: Ground mount
 - Concrete slab or other, 3" higher than adjoining grade
 - Follow manufacturer's instructions
- Clearances: Suspended
 - Maintain 6" clearance from grade
- Pit Locations:
 - Maintain 3" above pit floor
 - 12" clearance on sides
 - Line walls, extend 4"+ above adjoining grade
 - Excavate for 30" clearance on control side



Condensate Disposal

IMC 307, IFGC 307:

- Conveyed from drain pan to an approved place of disposal
 - Cannot discharge into a street, ally or cause a nuisance
- Maintain 1/8" per foot (1%) min. slope



Condensate Sizing

IMC Table 307.2.2:

- Sizing is based on the equipment capacity
- In no case smaller than 3/4" diameter

TABLE 307.2.2CONDENSATE DRAIN SIZING

EQUIPMENT CAPACITY	MINIMUM CONDENSATE PIPE DIAMETER
Up to 20 tons of refrigeration	3/4 inch
Over 20 tons to 40 tons of refrigeration	1 inch
Over 40 tons to 90 tons of refrigeration	1 1/4 inch
Over 90 tons to 125 tons of refrigeration	1 1/2 inch
Over 125 tons to 250 tons of refrigeration	2 inch

For SI: 1 inch = 25.4 mm, 1 ton = 3.517 kW.

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Condensate Disposal

IMC 307.1.1:

- Identification required when condensate piping is concealed
 - Primary drain
 - Secondary drain
- Condensate is often corrosive and requires a neutralizer per IPC 803.2



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Condensate Materials & Sizing

- **IMC 307.2.2: Materials**
 - ABS
 - Cast Iron
 - Copper
 - Cross-linked Polyethylene
 - CPVC
 - Galvanized Steel
 - PER-RT,
 - Polyethylene
 - Polypropylene
 - PVC



Auxiliary and Secondary Drains

- **IMC 307.2.3:** Required
 - Where damage to the building could occur from overflow of the pan, or blockage in the primary drain
- **Four Options Available:**
 1. Auxiliary drain pan w/separate drain (1.5" minimum depth)
 2. Separate overflow drain, at a higher level than the primary drain
 3. Auxiliary drain pan with water level detection device
 4. Water-level detection device in primary drain (above the primary drain & below the overflow rim)



Clearances to Combustibles

- **IMC 308.2:**
 - Comply with the appliance label and manufacturer's instructions
- **IMC 308.4.2:**
 - Reduction allowed per Table 308.4.2

TABLE 308.4.2 CLEARANCE REDUCTION METHODS^b

TYPE OF PROTECTIVE ASSEMBLY ^a	REDUCED CLEARANCE WITH PROTECTION (inches) ^c							
	Horizontal combustible assemblies located above the heat source				Horizontal combustible assemblies located beneath the heat source and all vertical combustible assemblies			
	Required clearance to combustibles without protection (inches) ^d				Required clearance to combustibles without protection (inches)			
	36	18	9	6	36	18	9	6
Galvanized sheet steel, having a minimum thickness of 0.0236 inch (No. 24 gage), mounted on 1-inch glass fiber or mineral wool batt reinforced with wire on the back, 1 inch off the combustible assembly	18	9	5	3	12	6	3	3
Galvanized sheet steel, having a minimum thickness of 0.0236 inch (No. 24 gage), spaced 1 inch off the combustible assembly	18	9	5	3	12	6	3	2
Two layers of galvanized sheet steel, having a minimum thickness of 0.0236 inch (No. 24 gage), having a 1-inch airspace between layers, spaced 1 inch off the combustible assembly	18	9	5	3	12	6	3	3
Two layers of galvanized sheet steel, having a minimum thickness of 0.0236 inch (No. 24 gage), having 1 inch of fiberglass insulation between layers, spaced 1 inch off the combustible assembly	18	9	5	3	12	6	3	3

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Ventilated Airspaces

○ IMC 308.3:

- Spacers must be noncombustible
- Spaces must allow for air circulation by convection
- At least 1" of airspace shall be provided between protection and combustible surface



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Solid Fuel-Burning Appliances

○ IMC 308.4.2.1:

- The use of Table 308.4.2 is limited
 - Do not **further reduce** if appliance is listed for clearances of 12" or less
 - Appliances listed for clearances of >12" should **not be reduced to < 12"**



3. Required Ventilation



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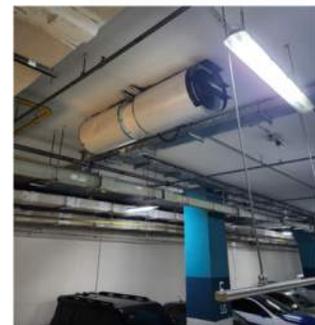
Ventilation Required

○ OMC 401.2:

- Occupied spaces shall be ventilated by:
 1. Natural means - **Section 402**
 2. Mechanical means - **Section 403**
 - **Group R- Section 403.4**

○ BREATHING ZONE:

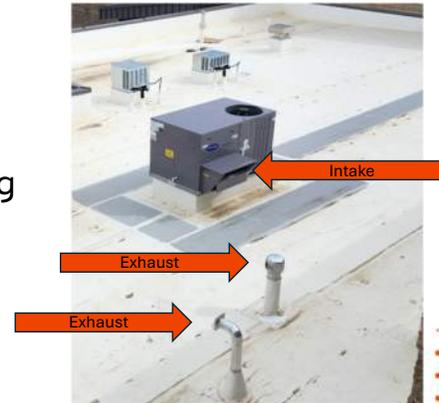
- The region within an occupied space **3" – 72"** above the floor and more than **2'** from the walls.



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Intake Openings

- **IMC 401.4:**
 - Must be separated from exhaust openings
(see IMC 501.3.1)
 - Purpose is to avoid reentry into the building
 - Ch. 4 and 5 have corresponding requirements



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Intake Openings

- **IMC 401.4:**
 1. 10' from lot lines or other buildings
 - Lot lines shall not be defined as separation from a street or public way
 2. 10' from hazardous sources (or 25' above)
 3. 3' below contaminant sources within 10'
 - Combination intake/exhaust permitted
 4. At or above the flood hazard elevation



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Intake Openings

○ IMC 401.4:

• Exceptions:

- Intake air **<500 CFM** for **Group R** occupancies
- 10 feet horizontally from parking lots
- 15 feet vertically above parking lots/garages



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Intake & Exhaust Locations

- **IMC 401.4:** Intake openings shall be located not less than 3 feet below contaminant sources where such sources are located within 10 feet of the opening. Separation is not required between intake air openings and living space exhaust air openings of an individual dwelling unit or sleeping unit where **an approved** a factory-built intake/exhaust combination termination fitting is used to separate the air streams in accordance with the fan manufacturer's instructions.
- Allows for **free-use** of factory-built combination intake/exhaust termination fittings



Openings

- **IMC 401.5:**
 - Openings in louvers, grilles and screens

TABLE 401.5 OPENING SIZES IN LOUVERS, GRILLES AND SCREENS PROTECTING AIR INTAKE OPENINGS

OUTDOOR OPENING TYPE	MINIMUM AND MAXIMUM OPENING SIZES IN LOUVERS, GRILLES AND SCREENS ^a
Intake openings in residential occupancies	Not < 1/4 inch and not > 1/2 inch
Intake openings in other than residential occupancies	> 1/4 inch and not > 1 inch

For SI: 1 inch = 25.4 mm.
 a. For rectangular openings, the table requirements apply to the shortest side. For round openings, the table requirements apply to any side.



Testing and Balancing



- **IMC 401.7:**

401.7 Testing and balancing.

At the discretion of the building official, flow testing may be required to verify that the mechanical system(s) satisfies the requirements of this chapter. Flow testing may be performed using flow hood measuring at the intake or exhaust points of the system, in-line pitot tube, or pitot-traverse-type measurement systems in the duct, short-term tracer gas measurements, or other means *approved* by the code official.



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Natural Ventilation

○ OMC 402:

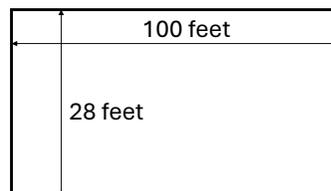
- Requires a minimum open-able area of at least **4 percent** of the floor area
- Intended to create cross-ventilation where possible
- Permitted openings include doors, windows and louvers



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Example:

- A new office building with a proposed floor area of **2,800** ft² will be naturally ventilated. What is the minimum openable area to the outdoors?



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Example #1- OMC 402.2

- Calculate building floor area to be ventilated: $28' \times 100' = 2,800 \text{ ft}^2$
- Calculate minimum openable area required (4%): $2,800 \text{ ft}^2 \times 0.04 = 112 \text{ ft}^2$ (Min. required area)



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Mechanical Ventilation

- **OMC 403.1**
 - Achieved by a method of supply air and return or exhaust air
 - Supply air shall be approximately equal to return and exhaust

Supply Air \approx Return & Exhaust Air



Mechanical Ventilation

- Required ventilation is based on room area and occupant loads as indicated in **Table 403.3.1.1**.



> Exception: Where occupancy density is known and documented in the plans, the outside air rate may be based on the design occupant density. Under no circumstance shall the occupancies used result in outside air less than one-half that resulting from the application of [Table 403.3.1.1](#) estimated maximum occupancy rates.

TABLE 403.3.1.1 MINIMUM VENTILATION RATES

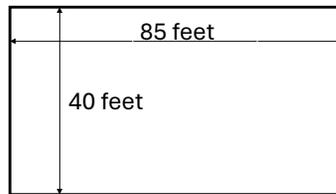
OCCUPANCY CLASSIFICATION	OCCUPANT DENSITY #/1000 FT ² ^a	PEOPLE OUTDOOR AIRFLOW RATE IN BREATHING ZONE, R _p CFM/PERSON	AREA OUTDOOR AIRFLOW RATE IN BREATHING ZONE, R _a CFM/FT ² ^a	EXHAUST AIRFLOW RATE CFM/FT ² ^a
Correctional facilities				
Booking/waiting	50	7.5	0.06	—
Cells				
without plumbing fixtures	25	5	0.12	—
with plumbing fixtures ⁹	25	5	0.12	1.0
Day room	30	5	0.06	—
Dining halls (see "Food and beverage service")	—	—	—	—
Guard stations	15	5	0.06	—
Dry cleaners, laundries				
Coin-operated dry cleaner	20	15	—	—
Coin-operated laundries	20	7.5	0.12	—
Commercial dry cleaner	30	30	—	—
Commercial laundry	10	5	0.12	—
Storage, pick up	30	7.5	0.12	—
Education				
Art classroom ⁹	20	10	0.18	0.7
Auditoriums	150	5	0.06	—
Classrooms (ages 5–8)	25	10	0.12	—



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Equation 4-1

- **Question:** An office building with a floor area of **3,400 ft²** will be mechanically ventilated. Calculate the required outdoor air volume required to be provided?



$$V_{bz} = R_p P_z + R_a A_z \quad \text{(Equation 4-1)}$$

where:

- A_z = Zone floor area: the net *occupiable floor area* of the space or spaces in the zone.
- P_z = Zone population: the number of people in the space or spaces in the zone.
- R_p = People outdoor air rate: the outdoor airflow rate required per person from Table 403.3.1.1.
- R_a = Area outdoor air rate: the outdoor airflow rate required per unit area from Table 403.3.1.1.

Equation 4-1

- Calculate building floor area to be ventilated: $85' \times 40' = 3,400 \text{ ft}^2$
- Calculate minimum breathing zone outdoor air (V_{bz}):

Minimum Outside Air Calculation						
IMC Chapter 4- Table 403.3.1.1						
Equation 4-1 - $V_{bz} = R_p P_z + R_a A_z$						
	Az	Occupancy Density	Pz	Rp	Ra	Vbz
Space Type/Name	Area (ft2)		People	People Outdoor Air Rate (CFM/person)	Area Outdoor Air Rate (CFM/person)	Breathing Zone Outdoor
Office	3,400	5	17	5	0.06	289
	$P_z = A_z / 1000 \times \text{Occupancy Density}$			$R_p P_z = 5 \times 17 = 85$	$R_a A_z = 0.06 \times 3400 = 289$	$85 + 289 = 374 \text{ CFM}$
	= shaded values from Table 403.3.3.1.1					



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Ventilation Required

- **OMC 403.3:**
 - All R-2, R-3 and R-4 occupancies must comply with local exhaust and ventilation requirements (previously limited to 3-stories and less)
- **Equation 4-9** was modified, resulting in 30-50% more required outdoor air and ventilation

$$Q_{OA} = 0.01 + 0.03A_{\text{floor}} + 7.5(N_{\text{br}} + 1)$$



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Ventilation Occupancy Classifications

- **Table 403.3.1.1:**
 - Animal related facilities, such as veterinary offices, operating rooms, procedure rooms etc. are now addressed in the table
 - Outpatient healthcare facilities, such as birthing rooms, dental operatories, speech therapy rooms etc. have also been added
 - Other minor modifications to various classifications have been added, such as break rooms, laundry rooms and various manufacturing workrooms



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Adult Changing Stations

○ Table 403.3.1.1:

- Added a specific row to the table to address adult changing station ventilation
- Exhaust Airflow of **50 CFM** (continuous) or **70 CFM** (intermittent) required



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All R-2, R-3 and R-4 Occupancies

- **IMC 403.4:** Whole-House Mechanical Ventilation
 - Every **Group R dwelling or sleeping unit** must have a **whole-house mechanical ventilation system**
 - **Local exhaust** also required for kitchens and bathrooms
 - Supporting occupied spaces must meet **natural or mechanical ventilation** requirements
- **Washington Amendment**
 - **ASHRAE 62.2-compliant systems** permitted when designed/commissioned under the **WA Energy Code**
 - Applies to **continuous or intermittent systems**, with adjustments



Minimum Ventilation Rate



○ **Determined by:**

- **Equation 4-10** or **Table 403.4.2**
- Based on **floor area + bedrooms**
- Minimum **30 cfm** per unit
- Adjust based on system

$$Q_v = 0.01 \cdot A_{\text{floor}} + 7.5 \cdot (N_b + 1) \tag{Equation 4-10}$$

where:
 Q_v = Ventilation airflow rate, cubic feet per minute (cfm) but not less than 30 cfm for each dwelling unit.
 A_{floor} = Conditioned floor area, square feet (ft²).
 N_b = Number of bedrooms, not less than one.

TABLE 403.4.2
 WHOLE-HOUSE MECHANICAL VENTILATION AIRFLOW RATE (CONTINUOUSLY OPERATING SYSTEMS)

FLOOR AREA (ft ²)	BEDROOMS ^a				
	1	2	3	4	≥ 5
< 500	30	30	35	45	50
500-1,000	30	35	40	50	55
1,001-1,500	30	40	45	55	60
1,501-2,000	35	45	50	60	65
2,001-2,500	40	50	55	65	70
2,501-3,000	45	55	60	70	75
3,001-3,500	50	60	65	75	80
3,501-4,000	55	65	70	80	85
4,001-4,500	60	70	75	85	90
4,501-5,000	65	75	80	90	95

a. Minimum airflow (Q_v) is set at not less than 30 cfm for each dwelling unit.



Testing & Documentation



○ **IMC 403.4.6.6- Testing & Documentation**

- Systems must be:
 - **Tested, balanced, and verified**
 - Flow ≥ adjusted minimum rate

○ **IMC 403.4.6.7- Certificate**

- Lists airflow rate and system type
- Install in utility room
- Do not cover electrical panel schedule, etc.



Local Exhaust



o IMC 403.4.7- Minimum Rates

- Comply with the Table 403.4.7 and Table 403.3.1.1
- Provide with manual override or occ. sensor, humidity, timer, pollutant sensors etc.
- **On/Off** switch shall meet the requirements

TABLE 403.4.7 MINIMUM EXHAUST RATES

AREA TO BE EXHAUSTED	EXHAUST RATE	
	Intermittent	Continuous
Open kitchens	In accordance with Section 403.4.7.3	Not permitted
Enclosed kitchens	In accordance with Section 403.4.7.3	5 ACH based on kitchen volume
Bathrooms – Toilet rooms	50 cfm	20 cfm

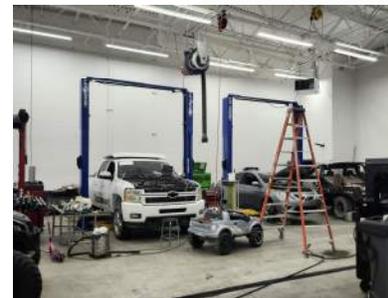


Automobile Repair Facilities



o IMC 404.3:

- Each stall must be equipped with an exhaust extension duct extending to outdoors
- Ducts **over 10 feet** in length must exhaust **300 CFM** minimum
- Connected offices and waiting rooms require positive pressure supply air



4. Exhaust Systems



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IMC Chapter 5

- Exhaust systems related to:
 - Clothes dryers
 - Domestic cooking
 - Toilet rooms
 - Bathrooms
 - Whole-house ventilation systems
- Exhaust discharge locations
- Protection of exhaust ducts from damage
- Exhaust duct construction
- Duct length limitations
- Exhaust termination clearances



Exhaust Terms

BALANCED VENTILATION SYSTEM: A ventilation system that simultaneously supplies outdoor air to and exhausts air from a space, where the mechanical supply airflow rate and the mechanical exhaust airflow rate are within 10 percent of the average of the two airflow rates.

EXHAUST AIR: Air being removed from any space or piece of equipment or *appliance* and conveyed directly to the atmosphere by means of openings or ducts.

LOCAL EXHAUST: An exhaust system that uses one or more fans to exhaust air from a specific room or rooms within a dwelling.

MAKEUP AIR: Any combination of outdoor and transfer air intended to replace exhaust air and exfiltration. For the definition applicable in Chapter 24, see Section G2403.

MECHANICAL EXHAUST SYSTEM: A system for removing air from a room or space by mechanical means.



General

○ IMC 501.3:

- Exhaust air must be discharge to the outdoors
- Cannot be discharged to:
 - Attic, crawl space, onto walkways
 - Where potential to be drawn back into the building

• Exceptions:

- Whole-house ventilation-type attic fans
(dwelling unit private attic)
- Commercial recirculating systems
- Domestic ductless range hoods



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Exhaust Discharge

- **IMC 501.3.1: Environmental Air**
 - 3' from property lines
 - 3' from gravity intakes, operable windows and doors
 - **Unless** located at least **1' above***
 - 10' from mechanical air intakes
 - **Unless** located at least **3' above** OR
 - Part of factory-built combination fitting



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Exhaust Outlet Locations

- **IMC 501.3.1:**
 3. For all environmental air exhaust: 3 feet from property lines; 3 feet from operable openings, **except where the exhaust opening is located not less than 1 foot above the gravity air intake opening** into buildings for all occupancies other than Group U; and 10 feet from mechanical air intakes. (cont...)
 - Effectively reduces required clearances to openings if located above the gravity air intake



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Common Ductwork

○ IMC 501.6:

- Combining exhaust ductwork serving separate dwelling units (or sleeping units) can only occur if the common duct (or shaft) is maintained at **negative (-)** pressure
- Essentially requires a common fan outside the units no longer permitting positive pressure fans inside each unit.
- Reduces potential to spread smoke between units



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Clothes Dryer Exhaust

○ IMC 504: (electric dryers)

- Must be independent of all other systems (bath fans, kitchen fans, etc.)
- Convey moisture to the outdoors

○ IMC 504.4: Termination

- Minimum 3' from openings into the building and vented soffits
- Equipped with a backdraft damper
- Screens are not permitted!



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Dryer Duct Protection

- **IMC 504.8:**
 - Shield plates required where dryer duct is within 1.25" of edge of framing
 - Must extend 2" above or below top and bottom plates
- **IMC 504.7: Makeup Air**
 - Required when exhausting > 200 CFM
 - Required in closet installations
 - Openings totaling **100 in²** required



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Clothes Dryer Exhaust

- **IMC 504.4.2:**
 - Passageway must be undiminished and **12.5 in²**
- **IMC 504.9.1:**
 - Smooth interior finish
 - Constructed of metal
 - Minimum 4" diameter
- **IMC 504.9.2:**
 - Supported every **4'** or less
 - Seal and fasten joints (**1/8"** maximum projection)
 - Cannot be **deformed**



Transition Duct

- **IMC 504.9.3:**
 - Limited to a single length
 - Listed and labeled **per UL 2158A**
 - Limited to **8' maximum length**
 - Cannot be concealed in construction
- **IMC 504.5:**
 - Exhaust duct power ventilators- **UL705**
 - Booster fans prohibited



Dryer Duct Length Limitations

- **IMC 504.9.4.1:**
 - Limited to 35' maximum **equivalent length**

TABLE 504.9.4.1 DRYER EXHAUST DUCT FITTING EQUIVALENT LENGTH

DRYER EXHAUST DUCT FITTING TYPE	EQUIVALENT LENGTH
4" radius mitered 45-degree elbow	2 feet 6 inches
4" radius mitered 90-degree elbow	5 feet
6" radius smooth 45-degree elbow	1 foot
6" radius smooth 90-degree elbow	1 foot 9 inches
8" radius smooth 45-degree elbow	1 foot
8" radius smooth 90-degree elbow	1 foot 7 inches
10" radius smooth 45-degree elbow	9 inches
10" radius smooth 90-degree elbow	1 foot 6 inches

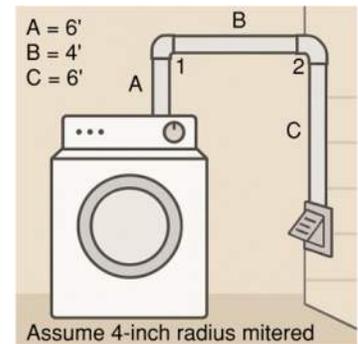
For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 degree = 0.0175 rad.

2024 IMC



Dryer Duct Length Example

- **Measure straight runs:**
 - $A + B + C = 16'$ Length
- **Elbows per Table M1502.4.6.1:**
 - (2) 90's @ 5' ea. = 10' Equivalent
- **Add straight runs to elbow equivalents:**
 - $16' + 10' = 26'$ Equivalent Length



Dryer Box

- With dryer box no additional elbows
- Without dryer box add (1) 90-Deg. Elbow



Dryer Duct Length Limitations

- **IMC 504.9.4.2:** Manufacturer's Instructions
 - Size and maximum length can be per the manufacturer
 - Provide installation instructions
 - Specific to the make and model of the dryer
- **IMC 504.9.4.3:**
 - Where exhaust duct power ventilators are used- maximum length determined per the manufacturer



Length Identification

- **IMC 504.9.5:** Permanent Tag or Label
 - Located within 6' of the connection
 - Indicate equivalent length
- **IMC 504.9.6:**
 - Provide 4" exhaust wherever a space for a dryer is provided
 - If not installed label "future use"
 - **Exception:** Condensing dryers installed prior to occupancy

RISK OF FIRE

THE NET EQUIVALENT' LENGTH
OF DRYER DUCT FROM THIS
LOCATION IS FEET

The maximum allowable exhaust duct length stated in the clothes dryer's installation instructions shall be equal to or greater than the posted equivalent length indicated on this placard.



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Domestic Cooking Exhaust

IMC 505: (Group R)

- Discharge outdoors through a duct (galvanized, stainless, CU)
 - Duct must be smooth interior (no flex)
- Must have backdraft damper
- Independent of other systems

Exception: Ductless, recirculating hoods permitted



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Domestic Cooking Exhaust

IMC 505.4:

- Makeup air required when exhausting **>400 CFM**

IMC 505.6:

- Where domestic cooktops are installed in **other than Group R** occupancies, used for domestic purposes domestic cooking exhaust systems shall be provided



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Grease Duct Testing

○ IMC 506.3.2.5:

- Clarifies the test is a field test
- Requires a light test, but no longer references "**100 watts**" now that LED etc. are common
- Allows for multiple test options



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Grease Duct Testing Options

○ IMC 506.3.2.5.1: Light Test

- Requires a lamp with minimum **1600 lumens**
- Lamp must emit light in all directions
- No light visible from the exterior of the duct



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Kitchen Hood Exceptions

- **IMC 507.1:** Kitchen Appliances
 - Wood fuel ovens listed and labeled per **UL 2162** may not require Type I hoods
 - Electric cooking appliances listed and labeled per **UL 197** may not require Type I hoods
 - Electric dishwashers listed and labeled per **UL 921** may not require Type II hoods
 - Type II hoods may be omitted when exhaust is provided in the space of at least **0.70 CFM** per ft²



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Appliances in Kitchens

- **IMC 507.1.3:** Natural Draft Appliances
 - Appliances with draft hoods or atmospheric burners can't be in the same space as a Type I or II hood, unless:
 - Installed in a sealed enclosure
 - Self-closing doors
 - Outdoor source of combustion air
 - Hood exhaust can lead to negative pressure and pull products of combustion back into the building





Compensating Hoods

- **IMC 508.1.1:** Makeup air temperature
- New exception, on compensating hoods makeup air temperature does not have to be within **10 Deg. F**



5. Duct Systems



IMC Chapter 6

- Duct systems including:
 - Ductwork for HVAC & exhaust
 - Materials
 - Construction
 - Installation
 - Insulation
 - Sealing
 - Above-ground and underground
 - Return air intake
 - Air plenums



Duct Terms

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.

FACTORY-MADE AIR DUCT: A listed and labeled duct manufactured in a factory and assembled in the field in accordance with the manufacturer's instructions and conditions of the listing.

FLEXIBLE AIR CONNECTOR: A conduit for transferring air between an air duct or plenum and an air terminal unit, an air inlet or an air outlet. Such conduit is limited in its use, length and location.



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Duct Terms

FORCED AIR CIRCULATION: A means of providing space conditioning utilizing movement of air through ducts or plenums by mechanical means.

PLENUM: A chamber that forms part of an air-circulation system other than the *occupied space* being conditioned.

SUPPLY AIR: Air delivered to a conditioned space through ducts or plenums from the heat exchanger of a heating, cooling or ventilating system.

VOLUME DAMPER: A device that will restrict, retard or direct the flow of air in any duct, or the products of combustion of heat-producing equipment, vent connector, vent or chimney.



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Return Air Openings

- **IMC 601.5:** Prohibited From
 - Min. 10' from open combustion chamber or draft hood
 - Hazardous or insanitary locations
 - Refrigeration room
 - Volume of return air cannot exceed supply volume
 - One dwelling unit to another
 - Direct connection to return side of crawl space furnace
- Size per manufacturer, ACCA Manual D or engineered



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Return Air Openings

- **IMC 601.5:** Heating & Air-Conditioning Systems
 - Clarifying language added throughout focusing the return air requirements primarily to HVAC systems
 - Return air from closets allowed (*Items 8 & 9*) to permit circulation of air, prevent mold and ensure ventilation
 - If closet is **smaller than 30 ft²** source of makeup air required:
 - Door undercut of **1.5 inches** minimum
 - Louvered door
 - Transfer air with **30 in²** NFA



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Return Air Openings

- **IMC 601.5:** Prohibited From
 - Closet (see exceptions)
 - Bathroom
 - Toilet room
 - Kitchen
 - Garage
 - Boiler room
 - Furnace room
 - Unconditioned Attic
 - Indoor swimming pool enclosure



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Wall and Floor Cavities

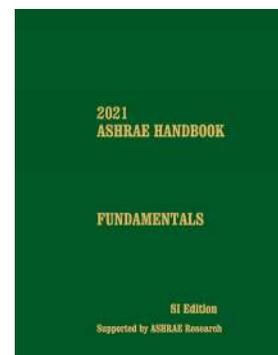
- **IMC 602.3:** Limitations
 1. Return air plenums only
 2. Cannot be fire rated assemblies
 3. Limited to conveying air from one level
 4. Spaces must have tight-fitting fireblocking
 5. Cannot be exterior walls part of the thermal envelope
 6. Cavities must be sealed



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Duct Construction

- **IMC 603.1:** Sizing
 - Design and installed **in dwelling units** must be sized per **ACCA Manual D**, manufacturer or other approved methods
 - For all other buildings size per **ASHRAE Handbook of Fundamentals**, or equivalent



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Duct Construction

- **IMC 603.4: Metallic Ducts**
 - Construct per SMACNA HVAC Duct Construction Standards- Metal and Flexible
 - Inside a dwelling unit- thickness can be per **Table 603.4**
- **IMC 603.4.1: Fasteners**
 - **Round Duct- (3)** screws or rivets spaced equally
- **IMC 603.4.2: Duct Lap**
 - Minium of **1-inch**, extend in the direction of airflow



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Duct Installation

- **IMC 603.9:**
 - Install per SMACNA HVAC Duct Construction Standards
 - Seal and fasten all joints and seams:
 - Welds
 - Gaskets
 - Mastics
 - Mastic+ embedded fabric
 - Liquid sealants
 - Tapes (**UL 181A**)



Insulation

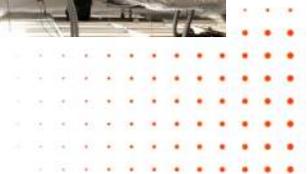
- **IMC 604.1:**
 - Must comply with the IECC
 - If operating at **>120 Deg. F-** thermal insulation at **exposed** surfaces
- **IMC 604.3:**
 - Flame spread of 25, smoke-developed of 50 (plenum)
- **IMC 604.7:**
 - External insulation- Identified at 36" o.c. with manufacturer, R-value, thickness, etc.



Duct Covers & Linings

- **IMC 604.3:** Non-Plenum Locations
 2. Coverings and linings in non-plenum locations must meet standard flam spread and smoke-developed requirements.
 - Linings in plenum spaces must comply with **IMC 602.2.1**

Plenum		Non-Plenum	
IMC 602.2.1		IMC 604.3	
Flame Spread	Smoke-Developed	Flame Spread	Smoke-Developed
25	50	25	450



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MEP Controls

- **IMC 607.2.4:** New sections
 - Mechanical, electrical and plumbing controls **shall not** be installed in air duct systems
 - **Exception:** If directly associated with the air distribution system- total length limited to 4' maximum
 - Controls **cannot** be installed through fire dampers, smoke dampers, combination dampers, radiation dampers etc.



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Particulate Matter Removal

- **IMC 605.4**
 - **MERV 13-** A, B, E, M, R and I Occupancies
 - **MERV 8-** F, H, S and U Occupancies
 - **MERV 4-** Unducted air handlers and fan coil units
- **Exceptions:**
 - Systems **500 CFM** or less- **MERV 8**
 - Recirculated air for VAV or electric resistance – **MERV 8**
 - Exhaust or relief air upstream of the heat exchanger – **MERV 6**



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Group R Corridors

○ IMC 606.2.4

• Non-High-Rise Buildings

- Supply air only- equipped with smoke detectors (NFPA 72)
 - Shut off supply fan upon activation
- **Exception:** Supply and return air- equipped with smoke detectors in return (NFPA 72)
 - Upstream of filters, exhaust air, outdoor air, etc.
 - Shut off supply fan upon activation



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Group R Corridors

○ IMC 606.2.5

• High-Rise Buildings

- Supply air only- equipped with smoke detectors (NFPA 72)
 - Air supply inlets equipped with smoke/fire dampers
 - Dampers to close upon activation
- **Exceptions:** Supply and return air- equipped with smoke detectors in return (NFPA 72)
 - Upstream of filters, exhaust air, outdoor air, etc.
 - Shut off supply fan upon activation
 - Dampers not required if part of a building stairwell or elevator pressurization smoke control system



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Through Penetrations

- **IMC 607.6.1:** I-2 and I-3 Occupancies
 - Ducts connecting **2 stories**, with a fire damper at the floor penetration are now allowed in all occupancies
 - The exception allowing for penetration of up to (3) floors **does not apply to I-2 or I-3 occupancies**



6. Combustion Air



IMC Ch. 7 & IFGC Section 304

- Combustion Air
 - IMC Ch. 7- Limited to oil-fired and solid-fuel fired appliances only
 - IFGC Section 304- Gas-fired appliances



Combustion Air Terms

COMBUSTION AIR: The air provided to fuel-burning equipment including air for fuel combustion, draft hood dilution and ventilation of the equipment enclosure.

COMBUSTION: In the context of this code, refers to the rapid oxidation of fuel accompanied by the production of heat or heat and light.

COMBUSTION PRODUCTS: Constituents resulting from the combustion of a fuel with the oxygen of the air, including the inert gases, but excluding excess air.

DILUTION AIR: Air that is introduced into a *draft hood* and is mixed with the *flue gases*.

DIRECT-VENT APPLIANCES: *Appliances* that are constructed and installed so that all air for combustion is derived directly from the outside atmosphere and all *flue gases* are discharged directly to the outside atmosphere.



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Combustion Air

- **IMC 701.1:**
 - For solid fuel-burning appliances follow manufacturer
 - Oil-fired appliances per **NFPA 31**
 - Gas-fired appliances follow **IMC Chapter 24**
 - Chapter (M1701.2) not applicable to:
 - Fireplaces
 - Fireplace stoves
 - Direct vent appliances
- **IMC 701.2:**
 - Dampers must be interlocked with the firing cycle of the appliance
 - No manual dampers allowed



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Indoor Combustion Air

- **IFGC 304.5: Two Methods**
 - 1. Standard Method**
 - Minimum volume of **50 cubic feet** per 1,000 BTU/h
 - 2. Known Air-Infiltration-Rate Method**
 - Required when infiltration rate is known to be **< 0.40 ACH**
 - Can be used with infiltration rates 0.60 ACH or less
 - Standard appliances- **Equation 3-1**
 - Fan-assisted appliances- **Equation 3-2**



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Standard Method Example

- **IFGC 304.5.1:** **50 CF** per 1,000 BTU/h
 - Assume a 199,000 BTU boiler, how large of a room is needed if the room has standard 8' ceiling heights?

Answer:

- 199,000 BTU / 1,000 BTU = 199
- 199 x 50 cubic feet = 9,950 cubic feet
- 9,950 cubic feet / 8' ceiling height = **1,232.75 ft²**



Caution! Modern construction will typically result in infiltration rates of < 0.35 ACH. Utilization of standard method is discouraged!

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Known Air-Infiltration-Rate Example

- **IFGC 304.5.2:** Equation 3-1
 - Assume standard appliance (natural draft), with known air-infiltration rate of **0.30 ACH**, and an input rating of **140,000 BTU** and a standard 8' ceiling

Answer:

- $21 \text{ ft}^3 / 0.30 \text{ ACH} = 70$
- $140,000 \text{ BTU} / 1,000 \text{ BTU} = 140$
- $70 \times 140 = 9,800 \text{ cubic feet}$
- $9,800 \text{ CF} / 8' \text{ ceiling height} = \mathbf{1,225 \text{ ft}^2}$

$$\text{Required Volume}_{\text{other}} \geq \frac{21 \text{ ft}^3}{\text{ACH}} \left(\frac{I_{\text{other}}}{1,000 \text{ Btu/h}} \right)$$



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Known Air-Infiltration-Rate Example

o IFGC 304.5.2: Equation 3-2

- Assume a fan-assisted appliance, with known air-infiltration rate of **0.30 ACH**, and an input rating of **140,000 BTU** and a standard 8' ceiling

Answer:

- $15 \text{ ft}^3 / 0.30 \text{ ACH} = 50$
- $140,000 \text{ BTU} / 1,000 \text{ BTU} = 140$
- $50 \times 140 = 7,000$ cubic feet
- $7,000 \text{ CF} / 8' \text{ ceiling height} = \mathbf{875 \text{ ft}^2}$

$$\text{Required Volume}_{\text{fan}} \geq \frac{15 \text{ ft}^3}{\text{ACH}} \left(\frac{I_{\text{fan}}}{1,000 \text{ Btu/h}} \right)$$



132

Combination Example

o IFGC 304.5.2: Equations 3-1 & 3-2

- Assume (1) standard appliance (natural draft) with an input rating of 80,000 BTU, and (1) fan assisted appliance with an input rating of 60,000 BTU, with known air-infiltration rate of **0.30 ACH**, and a standard 8' ceiling

Answer:

- $21 \text{ ft}^3 / 0.30 \text{ ACH} = 70$
- $80,000 \text{ BTU} / 1,000 \text{ BTU} = 80$
- $70 \times 80 = 5,600$ cubic feet
- $5,600 \text{ CF} / 8' \text{ ceiling height} = \mathbf{700 \text{ ft}^2}$
- Add $700 + 375 = \mathbf{1,075 \text{ ft}^2}$

Answer:

- $15 \text{ ft}^3 / 0.30 \text{ ACH} = 50$
- $60,000 \text{ BTU} / 1,000 \text{ BTU} = 60$
- $50 \times 60 = 3,000$ cubic feet
- $3,000 \text{ CF} / 8' \text{ ceiling height} = \mathbf{375 \text{ ft}^2}$



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Minimum Volumes:

○ IFGC 304.5:

- Rooms communicating with other spaces through openings not furnished with doors, **or** combustion air openings (grills, louvers, etc.) can be considered part of the (room) or required volume
- If the room, space or volume is too small, additional openings and/or ductwork is required!

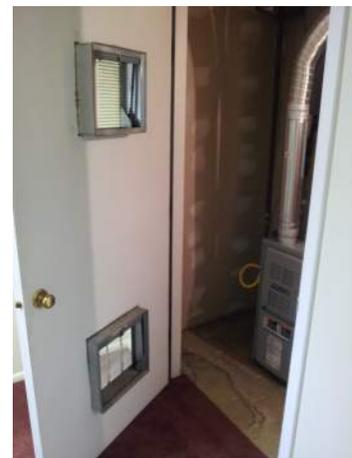


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Indoor Opening Size & Location:

○ IFGC 304.5.3.1: Same Story

- Minimum of (2) Openings:
 - One within 12" of the ceiling
 - One within 12" of the floor
- Each Opening:
 - Minimum of **1 in² per 1,000 BTU**
 - Minimum of **100 in²** regardless of calculation
 - Minimum of 3" wide/tall (indoor or outdoor)



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Indoor Openings Example

○ IFGC 304.5.3: Same Story

- Assume an appliance with 165,000 BTU, located in a small mechanical room. The volume of an adjacent family room is needed to meet indoor air volume requirements. What size openings comply?

Answer:

- $165,000 \text{ BTU} / 1,000 = 165 \text{ in}^2$
- **This applies to each opening**

Options:

- A: 12" x 16" openings ←
- B: 2" x 90" openings
- C: 6" x 10" openings
- D: 3" x 50" openings



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Indoor Opening Size & Location:

○ IFGC 304.5.3.2: Different Stories

- Minimum of (1) Opening
 - Ceiling, floor, wall or duct
- Opening:
 - Minimum of **2 in² per 1,000 BTU**



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Indoor Openings Example

o IFGC 304.5.3.2: Different Stories

- Assume an appliance with 165,000 BTU, located in a small mechanical room. The volume of dining room above is needed to meet minimum volume requirements. What size opening complies?

Answer:

- $165,000 \text{ BTU} / 2,000 = 82.5 \text{ in}^2$

Options:

- A: 10" x 8" opening
- B: 2" x 40" opening
- C: 6" x 12" opening
- D: 8" x 12" opening ←



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Outdoor Combustion Air

o IFGC 304.6: Two Methods

1. Two-Permanent-Opening Method

- One within 12" of the ceiling
- One within 12" of the floor
- Communicate directly outdoors (through a wall **or vertical duct**)
 - Minimum of **1 in² per 4,000 BTU**
- Communicate outdoors through a vertical or horizontal duct
 - Minimum of **1 in² per 2,000 BTU**



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Outdoor Openings Example

o IFGC 304.6: Directly Communicating Outdoors

- Assume appliances with combined 145,000 BTU, located in a small mechanical room. The volume of the outdoor atmosphere is needed to meet air volume requirements. What size openings comply?

Answer:

- $145,000 \text{ BTU} / 4,000 = 36.25 \text{ in}^2$
- **This applies to each opening**

Options:

- A: 3" x 8" openings
- B: 4" x 10" openings ←
- C: 4" x 8" openings
- D: 6" x 6" openings



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Outdoor Openings Example

o IFGC 304.6.1: Horizontal Ducts

- Assume appliances with combined 225,000 BTU, located in a closet. The volume of the outdoor atmosphere is needed to meet air volume requirements. What size openings comply?

Answer:

- $225,000 \text{ BTU} / 2,000 = 112.5 \text{ in}^2$
- **This applies to each opening**

Options:

- A: 3" x 30" openings
- B: 4" x 25" openings
- C: 6" x 20" openings ←
- D: 6" x 6" openings



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Outdoor Combustion Air

o IFGC 304.6: Two Methods

2. One-Permanent-Opening Method

- Within 12" of the ceiling
- Appliance Clearances:
 - 1" Sides and back
 - 6" Front
- Communicate outdoors through a vertical or horizontal duct
 - Minimum of **1 in² per 3,000 BTU**



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Outdoor Openings Example

o IFGC 304.6.1: Vertical Duct

- Assume appliances with combined 185,000 BTU, located in small crawlspace. The volume of the outdoor atmosphere is needed to meet air volume requirements. What size openings comply?

• Answer:

- $185,000 \text{ BTU} / 3,000 = 61.67 \text{ in}^2$

Options:

A: 3" x 20" openings

B: 4" x 15" openings

C: 6" x 10" openings

D: 8" x 12" openings ←



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Combination Example

o IFGC 304.7: Horizontal Ducts

- Assume appliances with combined 105,000 BTU, located in small crawl space. The additional volume of the outdoor atmosphere is needed to meet air volume requirements. What size openings comply? The volume of the crawl space is 2,400 ft³.

Answer: (Indoor portion)

- $105,000 \text{ BTU} / 1,000 = 105$
- $105 \times 50 \text{ cubic feet} = 5,250 \text{ ft}^3$ required
- $2,400 \text{ ft}^3 \text{ available} / 5,250 \text{ ft}^3 \text{ required} = 0.457 \text{ ratio}$



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Combination Example

Answer: (Outdoor portion)

Assume two-permanent-openings in the wall

- Reduction factor = $1 - 0.457 = 0.543$
- $105,000 \text{ BTU} / 4,000 = 26.25 \text{ in}^2$
- $26.25 \text{ in}^2 \times 0.543 = 14.25 \text{ in}^2$

Options:

- A: 2" x 8" openings
- B: 4" x 5" openings ←
- C: 3" x 4" openings
- D: 2" x 7" openings



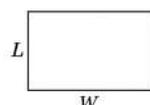
145

Duct Sizing Review:

- Combustion air requires knowing the cross-sectional area of ductwork and openings:

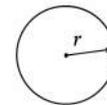
- For Square Duct: Length x Width
- For Round Duct: $\pi \times r^2$
 - Radius half the diameter
 - Pi (π) = 3.14

Cross-Sectional
Area



$$\text{Area} = L \times W$$

Cross-Sectional
Area



$$\text{Area} = \pi r^2$$

Examples:

- 4" x 10" ductwork = 40 in²
- 6" diameter ductwork (3" radius) = $3.14 \times 3 \times 3 = 28.26$ in in²



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Mechanical Combustion Air

IFGC 304.9:

- Supply air from the outdoors at a rate of **0.35 ft³** per 1,000 BTU
- If exhaust fans are provided- makeup air required
- Appliances must be interlocked with the mechanical air supply



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Mechanical Combustion Air Example

○ IFGC 304.9:

- Assume appliances with 205,000 BTU total input rating

Answer:

- $205,000 / 1,000 = 205$
- $205 \times 0.35 = \mathbf{71.75\ CFM}$



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Louvers and Grilles

○ IFGC 304.10:

- Opening sizes are based on net free areas (NFA)
- **Reduce** opening sizes as follows:
 - Manufacturer's specifications **or**
 - Wood Louvers- Use **25%** of the actual opening size
 - Metal Louvers- Use 75% of the actual opening size
- Screens or mesh- limited to ¼" or larger
- Must be fixed in the open position
- Motorized- Must be interlocked with the appliance



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Louver and Grill Examples

○ IFGC 304.10

- Determine NFA of a 10" x 4" duct with a metal louver

Answer

- $4" \times 10" = 40 \text{ in}^2$
- $40 \text{ in}^2 \times 0.75 = 30 \text{ in}^2$

○ IFGC 304.10

- Determine NFA of a 12" x 6" duct with a wood louver

Answer

- $12" \times 6" = 72 \text{ in}^2$
- $72 \text{ in}^2 \times 0.25 = 18 \text{ in}^2$



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Combustion Air Ducts

○ IFGC 304.11

- Galvanized steel or equivalent
- Stud and joist cavities allowed (one fireblock)
- Unobstructed
- Serve a single enclosure (room)
- Separate ducts for upper/lower
- No screens in attic space (insulation)
- Horizontal upper- slope inside
- Can't use voids in chimneys, etc.
- Outdoor intakes must be 12"+ above grade



7. Chimneys and Vents



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IMC Chapter 8

- Chimneys and Vents that serve **oil- and solid fuel-fired appliances**, includes wood pellet appliances
- **Notes:**
 - **IFGC Chapter 5:** Covers venting gas-fired appliances
 - **NFPA 31:** Also applicable for oil-fired appliances



Venting Terms

CHIMNEY OR VENT CONNECTOR: The *pipe* that connects an *appliance* to a *chimney* or *vent*.

CLEARANCE: The minimum distance through air measured between the heat-producing surface of the mechanical *appliance*, device or equipment and the surface of the *combustible material* or assembly.

DIRECT-VENT APPLIANCES: *Appliances* that are constructed and installed so that all air for combustion is derived directly from the outside atmosphere and all *flue gases* are discharged directly to the outside atmosphere.

DRAFT: The pressure difference existing between the *appliance* or any component part and the atmosphere, that causes a continuous flow of air and products of combustion through the gas passages of the *appliance* to the atmosphere.

DRAFT HOOD: A nonadjustable device built into an *appliance*, or made as part of the *vent connector* from an *appliance*, that is designed to: provide for ready escape of the *flue gases* from the *appliance* in the event of no *draft*, backdraft, or stoppage beyond the *draft hood*, prevent a backdraft from entering the *appliance*, and neutralize the effect of stack action of the *chimney* or gas *vent* upon operation of the *appliance*.

NATURAL DRAFT: The pressure difference created by a *vent* or *chimney* because of its height, and the temperature difference between the *flue gases* and the atmosphere.



Venting Terms

MECHANICAL OR INDUCED DRAFT: The pressure difference created by the action of a fan, blower or ejector that is located between the *appliance* and the *chimney* or *vent* termination.

OFFSET (VENT): A combination of *approved* bends that make two changes in direction bringing one section of the *vent* out of line, but into a line parallel with the other section.

VENT: A *pipe* or other conduit composed of factory-made components, containing a passageway for conveying *combustion products* and air to the atmosphere, *listed* and *labeled* for use with a specific type or class of *appliance*.

- **Special gas vent.** A *vent* *listed* and *labeled* for use with *listed* Category II, III and IV gas *appliances*.
- **Type B vent.** A *vent* *listed* and *labeled* for use with *appliances* with *draft hoods* and other Category I *appliances* that are *listed* for use with Type B vents.
- **Type BW vent.** A *vent* *listed* and *labeled* for use with wall *furnaces*.
- **Type L vent.** A *vent* *listed* and *labeled* for use with *appliances* that are *listed* for use with Type L or Type B vents.

VENTING SYSTEM: A continuous open passageway from the *flue collar* or *draft hood* of an *appliance* to the outdoor atmosphere for the purpose of removing flue or vent gases. A venting system is usually composed of a *vent* or a *chimney* and *vent connector*, if used, assembled to form the open passageway.



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Venting Required

○ IMC 801.2:

- Every fuel-burning appliance must discharge products of combustion to a vent, factory-built chimney, masonry chimney
- **Exceptions:**
 - Appliances and equipment listed for **unvented use**
 - Commercial cooking appliances- Type I hoods



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Single-Appliance Venting

○ IMC 801.4:

- Must convey product of combustion outside

○ IMC 801.6:

- Cross-sectional area \geq the connector



Vent Types

- **Table 802.2:**
 - Oil- Type L
 - Pellet
 - Gas- Type B (IFGC)



TABLE 802.2 VENT APPLICATION

VENT TYPES	APPLIANCE TYPES
Type L oil vents	Oil-burning appliances listed and labeled for venting with Type L vents; gas appliances listed and labeled for venting with Type B vents.
Pellet vents	Pellet fuel-burning appliances listed and labeled for venting with pellet vents.

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Type L Vent Terminations

- **IMC 802.4 & IFGC 502.1:**
 - Must be **UL 641** listed
 - Terminate 2' above the roof
 - Terminate 2' above any portion of the building **within 10'**



Vent Connectors

- **IMC 803:**

- Connect appliances to vertical chimney or vent (generally horizontal elements)

- **IMC 803.9: Low- Medium- and High-Heat**

TABLE 803.9(1) MINIMUM CHIMNEY CONNECTOR THICKNESS FOR LOW-HEAT APPLIANCES

DIAMETER OF CONNECTOR (inches)	MINIMUM NOMINAL THICKNESS (galvanized) (inches)
5 and smaller	0.022 (No. 26 gage)
Larger than 5 and up to 10	0.028 (No. 24 gage)
Larger than 10 and up to 18	0.034 (No. 22 gage)
Larger than 18	0.064 (No. 16 gage)

For SI: 1 inch = 25.4 mm.

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TABLE 803.9(2) MINIMUM CHIMNEY CONNECTOR THICKNESS FOR MEDIUM- AND HIGH-HEAT APPLIANCES

AREA (square inches)	EQUIVALENT ROUND DIAMETER (inches)	MINIMUM THICKNESS (inches)
0-154	0-14	0.0575 (No. 16 gage)
155-201	15-16	0.075 (No. 14 gage)
202-254	17-18	0.0994 (No. 12 gage)
Greater than 254	Greater than 18	0.1292 (No. 10 gage)

For SI: 1 inch = 25.4 mm, 1 square inch = 645.16 mm².

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Horizontal Length & Size

- **IMC 803.3: Size**

- Connector must match flue collar size

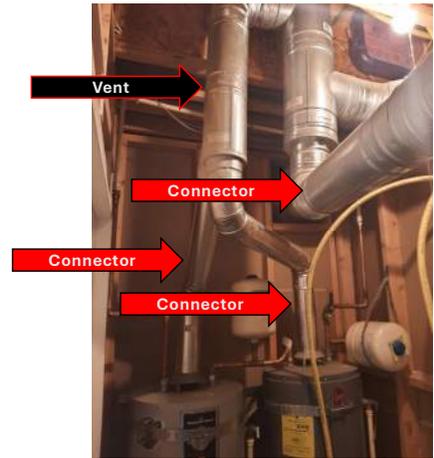
- **IMC 803.10.2: Length**

- **Single-wall:** Limited to **75%** of the vertical chimney above



Connectors

- **IMC 803.2:**
 - Appliances must be located entirely within the room where the appliance is located
- **IMC 803.5:**
 - No dampers or other obstructions
- **IMC 803.10:**
 - Supported, fastened with metal screws or rivets
 - Minimum slope **¼" per foot**



Clearances to Combustibles

- **IMC 803.10.6:**
 - Clearances per [Table 803.10.6](#) or appliance listing and labeling
 - Reductions per IMC 308 allowed

TABLE 803.10.6 CONNECTOR CLEARANCES TO COMBUSTIBLES

TYPE OF APPLIANCE	MINIMUM CLEARANCE (inches)
Domestic-type appliances	
Chimney and vent connectors	
Electric and oil incinerators	18
Oil and solid-fuel appliances	18
Oil appliances labeled for venting with Type L vents	9
Commercial, industrial-type appliances	
Low-heat appliances	
Chimney connectors	
Oil and solid-fuel boilers, furnace and water heaters	18
Oil unit heaters	18
Other low-heat industrial appliances	18
Medium-heat appliances	
Chimney connectors	
All oil and solid-fuel appliances	36
High-heat appliances	
Masonry or metal connectors	(As determined by the code official)
All oil and solid-fuel appliances	

For SI: 1 inch = 25.4 mm.



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Decorative Shroud

- **IMC 805.7 & IFGC 503.6.5.1:**
 - Prohibited at the termination of vents unless listed and labeled for use with the **specific venting system**
- **IMC 802.6 & IFGC 503.6.6:**
 - Vents must terminate not less than **5'** above the highest connected appliance
 - Wall furnaces, **12'** above the bottom of the furnace



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Mechanical Draft Systems

- **IMC 804.3: Requirements**
 - Must be **UL 378** compliant
 - **Vertical Terminations**
 1. Minimum 7' above walkways
 2. Minimum 3' above forced air inlets within 10'
 3. Minimum 3' below any adjacent roof structure
 4. Minimum 4' below, 4' horizontally from or 1' above doors, windows, gravity air inlets
 5. Must have vent cap to prevent rain from entering
 6. Minimum 3' horizontally from roof structure



Factory-Built Chimneys

- **IMC 805.1:**
 - Install per manufacturer's installation instructions
- **IMC 805.8:**
 - Insulation shield required where passing through insulated spaces
 - Extend **2" minimum** above insulation level



8. Special Appliances



IMC Chapter 9

- o Special Appliances, Equipment and Systems
 - Establishes installation requirements unique to individual appliance types
 - Addresses appliance-specific safety provisions beyond general mechanical system rules
 - Incorporates common manufacturer instructions in conjunction with prescriptive code requirements
 - Covers residential, commercial, and industrial appliance applications
 - Regulates special-use and specialty appliances not addressed elsewhere in the code
 - Serves as the appliance-specific counterpart to general mechanical system chapters



General & Common Fuel-Burning Appliances

IMC Section	Appliance Type	Notes / Typical Use
901	General	Baseline requirements for fuel-burning appliances
902	Masonry Fireplaces	Site-built masonry fireplaces
903	Factory-Built Fireplaces	Listed prefabricated fireplaces
904	Pellet Fuel-Burning Appliances	Biomass pellet stoves
905	Fireplace Stoves and Room Heaters	Freestanding solid-fuel heaters
906	Factory-Built Barbecue Appliances	Listed barbecue units
907	Incinerators and Crematories	Specialized combustion equipment
908	Cooling Towers / Evaporative Equipment	Heat rejection equipment
909	Vented Wall Furnaces	Wall-mounted vented heaters
910	Floor Furnaces	Recessed floor-mounted heaters



Commercial, Industrial & Process Appliances

IMC Section	Appliance Type	Notes / Typical Use
911	Duct Furnaces	Installed within HVAC duct systems
912	Infrared Radiant Heaters	Radiant heating for large spaces
913	Clothes Dryers	Residential and commercial dryers
914	Sauna Heaters	Electric or fuel-fired sauna heaters
915	Engine and Gas Turbine Equipment	Generators and cogeneration
916	Pool and Spa Heaters	Fuel-fired water heaters
917	Cooking Appliances	Residential and commercial cooking
918	Forced-Air Warm-Air Furnaces	Central ducted furnaces
919	Conversion Burners	Fuel-conversion devices
920	Unit Heaters	Garage and industrial heaters



General & Common Fuel-Burning Appliances

IMC Section	Appliance Type	Notes / Typical Use
921	Vented Room Heaters	Single-room vented heaters
922	Kerosene and Oil-Fired Stoves	Liquid-fuel space heaters
923	Small Ceramic Kilns	Educational or studio kilns
924	Stationary Fuel Cell Power Systems	On-site power generation
925	Masonry Heaters	High-mass solid-fuel heaters
926	Gaseous Hydrogen Systems	Hydrogen fuel systems
927	Radiant Heating Systems	Hydronic or electric radiant heating
928	Evaporative Cooling Equipment	Direct or indirect evaporative coolers
929	Unvented Alcohol Decorative Appliances	Decorative alcohol fireplaces
930	Large-Diameter Ceiling Fans	HVLS air circulation fans
931	Steam Bath Equipment	Steam room generators



New Section →

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Specific Appliances

○ IMC Chapter 9:

- **Recurring Theme:** Heating and cooling equipment shall be installed per the manufacturer's instructions and the requirements of the code (IMC)

○ IMC 303.6:

- Equipment installed outdoors, must be listed and labeled for outdoor installation



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Fireplace Stove (wood burning)

○ IMC 905.3:

- Hearth extensions per listing
- Readily distinguishable from surrounding floor
- When listed and labeled- **UL 1618**



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Sauna Heaters (non-gas)

○ IMC 914:

- Controls required limiting temperature to **194 Deg. F**
- Heat sensor within **6"** of the ceiling
- Timer with a **1-hr.** maximum operating time
- Ventilation opening **4" x 8"** near the top of the door
- **Warning: Do not exceed 30 minutes in sauna. Excessive exposure can be harmful to health. Any person with poor health should consult a physician before using sauna.**



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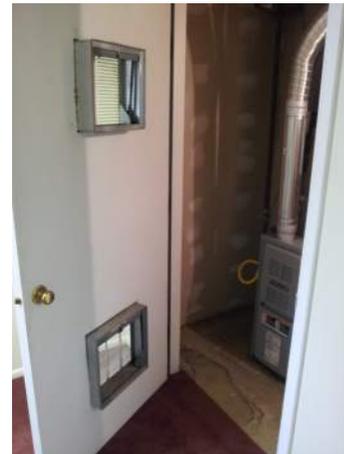
Central Furnaces

○ IMC 918.1:

- Oil-fired- UL 727
- Electric- **UL 1995** or UL/CSA 60335-2-40
- Solid Fuel- **UL 391**

○ M1402.3:

- Combustion air per IMC Ch. 7 & IFGC 304
 - **No combustion air needed for electric furnaces!**



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Small Ceramic Kilns

○ IMC 923:

- Must be listed and labeled- Electric [UL 499](#)
- **Exceptions:**
 - Unlisted appliances per IMC 105.2 and based on **approved engineering evaluation**



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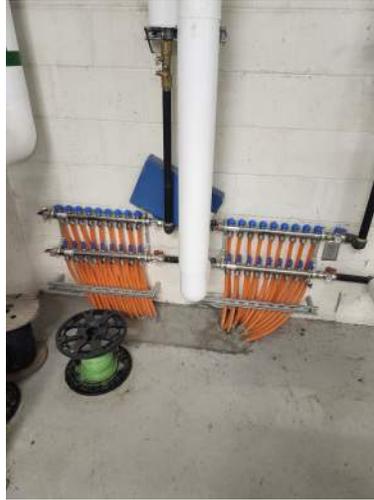
Evaporative Cooling

○ IMC 928.1:

- Installed on a level platform
- Flash openings in walls
- Protect the potable water supply
- Locate intake openings per R325.4.1



9. Heated Water & Hydronics



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IMC Chapters 10 & 12

○ Boilers & Water Heaters

- Ch. 10- Applicable to water heating appliances regardless of energy source
 - Gas-fired
 - Electric
 - Gas-fired also addressed in IFGC (both chapters apply)
- **Also regulated by:**
 - **Chapter 70.79 RCW and Chapter 296-104 WAC**



Hydronic Terms Terms

BOILER: A self-contained *appliance* from which *hot water* is circulated for heating purposes and then returned to the boiler, and that operates at water pressures not exceeding 160 pounds per square inch gage (psig) (1102 kPa gauge) and at water temperatures not exceeding 250°F (121°C).

GROUND-SOURCE HEAT PUMP LOOP SYSTEM: Piping buried in horizontal or vertical excavations or placed in a body of water for the purpose of transporting heat transfer liquid to and from a *heat pump*. Included in this definition are closed loop systems in which the liquid is recirculate and open loop systems in which the liquid is drawn from a well or other source.

HOT WATER: Water at a temperature greater than 120°F (49°C).

POTABLE WATER: Water free from impurities present in amounts sufficient to cause disease or harmful physiological effects and conforming in bacteriological and chemical quality to the requirements of the public health authority having *jurisdiction*.



Boilers

- **IMC 1004.1: Standards**
 - Design per ASME Boiler and Pressure Vessel Code
 - Oil-fired- UL 726
 - Electric- UL 834
 - Solid Fuel- UL 2523
 - Gas- **IFGC**
- **IMC 1004.2: Installation**
 - Comply with the IMC requirements
 - Comply with the manufacturer's instructions



Operating and Safety Controls

o IMC 1010: Gauges

- Temperature & Pressure or Combination
- Steam Boilers- Also, water-gauge glass
 - Midpoint = normal water level
- Pressure relief- set at maximum rating of the boiler
 - Discharge Piping: A total of **13** requirements
- Low-water cutoff, stop the combustion operation



Expansion Tanks

Table 1009.2:

TABLE 1009.2.CLOSED-TYPE EXPANSION TANK SIZING

SYSTEM VOLUME IN GALLONS	TANK CAPACITIES IN GALLONS	
	Pressurized Diaphragm Type	Nonpressurized Type
100	9	15
200	17	30
300	25	45
400	33	60
500	42	75
1,000	83	150
2,000	165	300

For St: 1 gallon = 3.795 L.

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Water Heaters

- **IMC 1002.1:** Installation
 - Per **IPC** & manufacturer's instructions
 - Gas- **IFGC**
 - Electric- **NEC**
 - Domestic Electric- **UL 174 or UL 1453**
 - Commercial Electric- **UL 1453**
 - Oil-Fired- **UL 732**
 - Solid Fuel- **UL 2523**
 - Solar Thermal- **IMC Ch. 14 & ICC 900/SRCC 300**



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Water Heater Pans

- **IMC 1002.4:** Required (new text)
 - Where a storage-type water heater or tank is installed where leakage will cause damage
 - Galvanized or aluminum 0.0236 inches (0.6mm)
 - Plastic 0.036 (0.9mm) with flame spread of 25 smoke-developed of 450 max
 - Other *approved* materials
 - Requirements now match IPC, IRC, IFGC



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Safety and Relief Valve Discharge

- **IMC 1006.6:** Updated
 7. If discharge point isn't readily visible, a leak detection device with alarm is required.
 10. Terminate not more than 6" above the floor or flood level rim of the waste receptor
 13. Utilize piping material compliant with IMC 1202
(previously directed users to the IPC)



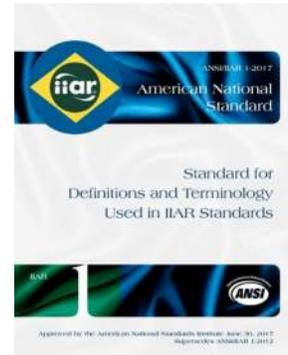
IMC Ch.11. Refrigeration





Maintenance of Ammonia Systems

- **IMC 1101.1.2:** IIAR 6
 - New referenced standard listed, *IIAR 6- Inspection, Testing, and Maintenance of Closed-Circuit Ammonia Refrigeration Systems*



IIAR ©



A2L and B2L Refrigerants

- **IMC 1106.4:** Machinery Rooms
 - No permanent open flames
 - No continuously operating surfaces over 1290 Deg. F
 - Refrigerant detectors activate (**Table 1106.4.2**)

Table 1106.4.2 GROUP A2L AND B2L DETECTOR ACTIVATION

ACTIVATION LEVEL	MAXIMUM RESPONSE TIME (seconds)	ASHRAE 15 VENTILATION (seconds)	ALARM RESET	ALARM TYPE
Less than or equal to the OEL in Table 1103.1	300	1	Automatic	Trouble
Less than or equal to the refrigerant concentration level in Table 1103.1	15	2	Manual	Emergency

- Mechanical ventilation per ASHRAE 15 (deleted prior IMC req's)



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Refrigerant Piping Locations

- **IMC 1109.2.3:** Interior Exit Stairways
 - Allowed in interior exit stairways if **enclosed/concealed**



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Piping Surface Temperatures

- **IMC 1109.2.6:** Nonauthorized personnel
 - Piping with temperatures >120 Deg. F or <5 Deg. F shall be protected from contact
 - **Prior codes** did not distinguish between access by authorized personnel vs. nonauthorized personnel



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Identification

- **IMC 1109.2.7:** Pipe Identification
 - Additional identification for Group **A2L** and **B2L** refrigerants



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Installation of Refrigerants

- **IMC 1109.3.1:** Protection of piping
 - Piping within **1 ¼"** (~~was 1 ½"~~) of edge of framing member require protection
- **IMC 1109.3.2:** Shaft ventilation
 - A2L and B2L: Shaft can be naturally (gravity) or mechanically ventilated
 - A2, A3, B2 or B3: Shafts must be **continuously mechanically ventilated AND** include a refrigerant



IMC Chapter 12

- Hydronic piping, including:
 - Steam
 - Hot water
 - Ground-source heat-pump loops
- Addresses:
 - Materials
 - Joints
- Support
- Protection of structure
- Testing
- Protection of potable water
- General installation



Hydronic Piping

- IMC 1202:
 - Pipe and fittings must be rated for:
 - Operating temperature
 - Operating pressure
 - Used materials must be free of foreign materials
 - Materials must comply with **Table 1202.4**



Hydronic Piping

Table 1202.4:

TABLE 1202.4 HYDRONIC PIPE

MATERIAL	STANDARD (see Chapter 15)
Acrylonitrile butadiene styrene (ABS) plastic pipe	ASTM F2806
Chlorinated polyvinyl chloride (CPVC) plastic pipe	ASTM D2846; ASTM F441; ASTM F442
Chlorinated polyvinyl chloride/aluminum/chlorinated polyvinyl chloride (CPVC/AL/CPVC)	ASTM F2855
Copper or copper-alloy pipe	ASTM B42; ASTM B43; ASTM B302
Copper or copper-alloy tube (Type K, L or M)	ASTM B75; ASTM B88; ASTM B135; ASTM B251
Cross-linked polyethylene/aluminum/cross-linked polyethylene (PEX-AL-PEX) pressure pipe	ASTM F1281; CSA CAN/CSA-B-137.10
Cross-linked polyethylene (PEX) tubing	ASTM F876; ASTM F3253; CSA B137.5
Ductile iron pipe	AWWA C115/A21.15; AWWA C151/A21.51
→ Polyethylene/aluminum/polyethylene (PE-AL-PE) pressure pipe	ASTM F1282; CSA B137.9
Polypropylene (PP) plastic pipe	ASTM F2389
Polyvinyl chloride (PVC) plastic pipe	ASTM D1785; ASTM D2241
Raised temperature polyethylene (PE-RT)	ASTM F2623; ASTM F2769; CSA B137.18
Stainless steel pipe	ASTM A269; ASTM A312; ASTM A778
Stainless steel tubing	ASTM A269; ASTM A312; ASTM A778
Steel pipe	ASTM A53; ASTM A106
Steel tubing	ASTM A254



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Stainless Steel Piping

- **Tables 1202.4 & 1202.5:** Hydronic Pipe and Fittings
 - Tables expanded to include **stainless steel** materials
 - Listings per **ASTM A269, ASTM A312, ASTM A778 and ASTM F3226**
- **IMC 1203.13 & M1203.14:** Stainless Steel Pipe & Tubing
 - Mechanical joints with elastomeric seal (pipe)
 - Threaded or welded joints (pipe)
 - Mechanical or welded (tubing)



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Joins & Connections

○ IMC 1203:

- Brazed
- Mechanical
- Soldered
- Solvent-cemented
- Threaded
- Welded
- Grooved and Shouldered



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Shutoff Valves

○ IMC 1205:

- Supply and return of heat exchangers
- Supply of central utility system
- Pressure vessel
- Both sides of PRV
- Equipment & appliances
- Expansion tanks



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Other Requirements

- **IMC 1206.3:** Potable Water
 - Provide backflow protection per the **IPC**
- **IMC 1206.5:** Clearances
 - Minimum **1"** clearance to combustibles (**250 Deg. F** surface temp.)



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Transfer Fluids

- **IMC 1207.1:** Flash point
 - Must be less than **50 Deg. F above** the maximum system operating temperature
- **IMC 1207.2:** Makeup water
 - Transfer fluid must be **compatible** with makeup water utilized



Hydronic Testing

- **IMC 1208.1:** Hydrostatic Test
 - Test at **1.5x** maximum design pressure
 - Minimum 100 psi
 - Duration: **15 min.**
- Exception:** PEX piping- air test per manufacturer



Radiant & Ice Melt Tubing

- **IMC 1209.6 & 1209.7:** Hydronic tubing
 - Install per manufacturer
 - Layout and spacing as per design
 - Circuit lengths within **10%** (snow/ice only)



Table 1209.6.1 MAXIMUM CIRCUIT LENGTH OF RADIANT TUBING FROM A SUPPLY-AND-RETURN MANIFOLD ARRANGEMENT

NOMINAL TUBE SIZE	MAXIMUM CIRCUIT LENGTH (feet)
1/4	125
5/16	200
3/8	250
1/2	300
5/8	400
3/4	500
1	750

For SI: 1 foot = 304.8 mm.

Table 1209.7.1 MAXIMUM CIRCUIT LENGTH OF SNOW- AND ICE-MELT TUBING FROM A SUPPLY-AND-RETURN MANIFOLD ARRANGEMENT

NOMINAL TUBE SIZE	MAXIMUM CIRCUIT LENGTH (feet)
1/2	140
5/8	250
3/4	325
1	475

For SI: 1 foot = 304.8 mm.



Snow Melt Insulation

- **IMC 1209.5:** Insulation & Thermal Break
 - **R-10** insulation under slab or
 - **R-5** insulation under, with **R-5** at slab edges
 - Install per manufacturer’s instructions
 - (Consult WSEC)



Ground-Source Heat Pump Loop

- **IMC 1210:**
 - Piping must be rated for the **temperature and pressure** of the system
 - Pipe materials must comply with **Table 1210.4**

TABLE 1210.4 GROUND-SOURCE LOOP PIPE

MATERIAL	STANDARD (see Chapter 15)
Chlorinated polyvinyl chloride (CPVC)	ASTM D2846; ASTM F441; ASTM F442
Cross-linked polyethylene (PEX)	ASTM F876; CSA B137.5; CSA C448 ; NSF 358-3
Polyethylene/aluminum/polyethylene (PE-AL-PE) pressure pipe	ASTM F1282; CSA B137.9
High-density polyethylene (HDPE)	ASTM D2737; ASTM D3035; ASTM F714; AWWA C901; CSA B137.1; CSA C448; NSF 358-1
Polypropylene (PP-R)	ASTM F2389; CSA B137.11; NSF 358-2
Polyvinyl chloride (PVC)	ASTM D1785; ASTM D2241
Raised temperature polyethylene (PE-RT)	ASTM F2623; ASTM F2769; CSA B137.18; CSA C448 ; NSF 358-4

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Labeling & Marking

○ IMC 1210.8.9:

- Where piping enters the building, marking required:
 - Tape
 - Metal Tags
 - Other Methods
- Indicate "GROUND-SOURCE HEAT-PUMP LOOP SYSTEM"
- Also indicate:
 - If antifreeze is used
 - Chemicals by name
 - Concentration



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Required Tests

○ IMC 1210.10:

- Pressure test at **100 psi** for **15 min.**
- Flow and pressure loss testing- Actual results within **10%** of design



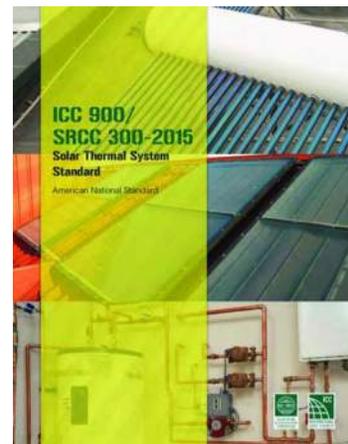
IMC Chapter 14

- Solar Thermal Systems
- **Addresses:**
 - Solar Collectors
 - System Design
 - Safety Devices
 - Relief Valves
 - Freeze Protection
 - Freeze Protection
 - Expansion Tanks
 - Signage
 - Labeling
 - Heat Transfer Fluids
 - Protection of Potable Water



Key Requirements

- **IMC 1401.2:**
 - Protect against backflow and contamination per the IPC
- **IMC 1401.3:**
 - Heat exchangers for domestic water-heating must be approved for the intended use- protect potability of water supply
- **IMC 1401.4:**
 - Solar thermal equipment must conform with **ICC 900/SRCC 300**



Access

- **IMC 1402.2:**
 - Access for maintenance
 - Not obstruct or interfere with:
 - Doors
 - Windows
 - Operable components
 - Equipment
 - Appliances
 - Chimneys
 - Plumbing Vents



- Roof Hatches
- Smoke Vents
- Skylights
- Roof Penetrations
- Openings



Pipe Materials

- **IMC 1402.8.3: Materials**

TABLE 1202.4HYDRONIC PIPE

MATERIAL	STANDARD (see Chapter 15)
Acrylonitrile butadiene styrene (ABS) plastic pipe	ASTM D1527; ASTM F2806
Chlorinated polyvinyl chloride (CPVC) plastic pipe	ASTM D2846; ASTM F441; ASTM F442
Chlorinated polyvinyl chloride/aluminum/chlorinated polyvinyl chloride (CPVC/AL/CPVC)	ASTM F2855
Copper or copper-alloy pipe	ASTM B42; ASTM B43; ASTM B302
Copper or copper-alloy tube (Type K, L or M)	ASTM B75; ASTM B88; ASTM B135; ASTM B251
Cross-linked polyethylene/aluminum/cross-linked polyethylene (PEX-AL-PEX) pressure pipe	ASTM F1281; CSA CAN/CSA-B-137.10
Cross-linked polyethylene (PEX) tubing	ASTM F876; ASTM F3253; CSA B137.5
Ductile iron pipe	AWWA C115/A21.15; AWWA C151/A21.51
Lead pipe	FS WW-P-325B
Polyethylene/aluminum/polyethylene (PE-AL-PE) pressure pipe	ASTM F1282; CSA B137.9
Polypropylene (PP) plastic pipe	ASTM F2389
Polyvinyl chloride (PVC) plastic pipe	ASTM D1785; ASTM D2241
Raised temperature polyethylene (PE-RT)	ASTM F2623; ASTM F2769; CSA B137.18
Steel pipe	ASTM A53; ASTM A106
Steel tubing	ASTM A254

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Labels, Caps and Limitations

- **IMC 1404:** Warnings
 - Description and warning identifying:
 - Fluid in the solar loop
 - Warning of high-temperature and pressure
 - Identify loops, i.e. potable water, toxic etc.
- **IMC 1404.4:** Heat Exchangers
 - Single-wall without leak protection
 - Double-wall without leak protection
 - Double-wall **with** leak protection



10. General Fuel Gas Requirements



IFGC Chapters 3, 4 & 5

- Fuel gas systems including:
 - Gas piping
 - Appliances
 - Combustion air
 - Appliance venting
 - Specific appliances



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Gas Terms- IFGC 202

APPLIANCE: Any apparatus or device that utilizes a fuel or a raw material as a fuel to produce light, heat, power, refrigeration or *air conditioning*. Also, an apparatus that compresses fuel gases.

BTU: Abbreviation for British thermal unit, which is the quantity of heat required to raise the temperature of 1 pound of water 1°F.

CUBIC FOOT: The amount of gas that occupies 1 cubic foot when at a temperature of 60°F, saturated with water vapor and under a pressure equivalent to that of 30 inches of mercury.

LIQUEFIED PETROLEUM GAS or LPG (LP-GAS): *Liquefied petroleum gas* composed predominately of propane, propylene, butanes or butylenes, or mixtures thereof that is gaseous under normal atmospheric conditions, but is capable of being liquefied under moderate pressure at normal temperatures.

PURGE: To free a gas conduit of air or gas, or a mixture of gas and air.

REGULATOR: A device for controlling and maintaining a uniform gas supply pressure, either pounds-to-inches water column (MP regulator) or inches-to-inches water column (*appliance regulator*).



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General

- **IFGC 101.2:** Not applicable to
 - Liquefied natural gas (LNG)
 - Temporary LP-gas (construction)
 - Utility provided equipment, meters, piping, regulators
 - Portable equipment- not connect to fixed piping
 - Portable fuel cells- not connect to fixed piping or power grid
 - Hydrogen gas, LP-gas and CNG on vehicles



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Structural Safety

IFGC 302.1:

- Buildings and structures cannot be weakened by installation of gas piping
- Trusses shall not be cut, drilled, notched or altered without approval of the design professional
- Engineered products, glue-lams, I-joists etc. cannot be cut, drilled or altered without manufacturer approval



217

Appliance Location

IFGC 303.3: Prohibited

- Sleeping Rooms
- Bathrooms
- Toilet Rooms
- Storage Closets
- Or rooms that only opening into such rooms

Exceptions: Direct-vent appliances, weather-stripped solid doors with closers, and others



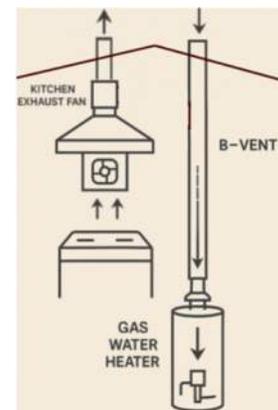
BCS
ELITE

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Combustion, Ventilation and Dilution Air

○ IFGC 304.4:

- Makeup air required when exhaust fans, clothes dryers or kitchen ventilation interfere with combustion air (negative pressure)



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ELITE

218

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Appliances Installation

○ IFGC 305.3:

- Appliances in garages must be elevated 18" or more
 - Water heaters, furnaces, clothes dryers, etc.
- **Note:** Applies to appliances in the garage or in storage rooms etc. that communicate directly with the garage
- **Exception:** Appliances listed as "flammable-vapor-ignition resistant"

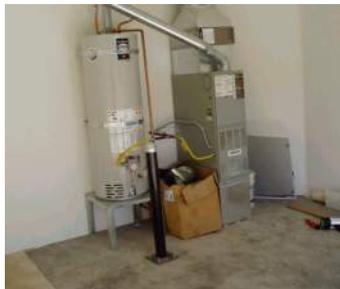


220

Private Garages

IFGC 305.5:

- Appliances must be elevated **6' above the floor**, or otherwise protected from motor vehicle impact



221

Clearances From Grade

IFGC 305.7:

- Installed on a level concrete slab
- Installed on approved material **3"** above grade
- Suspended with **6"** clearance above grade



222

Clearance to Combustibles

IFGC 305.8:

- Chimneys, vents, appliances, devices associated with gas-fired equipment
- Minimum clearances as per **Table 308.2** (next slide), **or** listed and labeled assemblies per **UL 1618**



Table 308.2

TABLE 308.2 REDUCTION OF CLEARANCES WITH SPECIFIED FORMS OF PROTECTION^a through k

TYPE OF PROTECTION APPLIED TO AND COVERING ALL SURFACES OF COMBUSTIBLE MATERIAL WITHIN THE DISTANCE SPECIFIED AS THE REQUIRED CLEARANCE WITH NO PROTECTION [see Figures 308.2(1), 308.2(2) and 308.2(3)]	WHERE THE REQUIRED CLEARANCE WITH NO PROTECTION FROM APPLIANCE, VENT CONNECTOR OR SINGLE-WALL METAL PIPE IS: (inches)									
	36		18		12		9		6	
	Allowable clearances with specified protection (inches)									
	Use Column 1 for clearances above appliance or horizontal connector. Use Column 2 for clearances from appliance, vertical connector and single-wall metal pipe.									
	Above Col. 1	Sides and rear Col. 2	Above Col. 1	Sides and rear Col. 2	Above Col. 1	Sides and rear Col. 2	Above Col. 1	Sides and rear Col. 2	Above Col. 1	Sides and rear Col. 2
1. 3 1/2-inch-thick masonry wall without ventilated airspace	—	24	—	12	—	9	—	6	—	5
2. 1/2-inch insulation board over 1-inch glass fiber or mineral wool batts	24	18	12	9	9	6	6	5	4	3
3. 0.024-inch (nominal 24 gage) sheet metal over 1-inch glass fiber or mineral wool batts reinforced with wire on rear face with ventilated airspace	18	12	9	6	6	4	5	3	3	3



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Electrical Grounding and Bonding

IFGC 309.1: Grounding

- Gas piping shall not be used as a grounding electrode

IFGC 310.1: Bonding (non CSST pipe)

- Above-ground gas piping likely to become energized must be bonded
- Considered bonded if connected to one or more appliances with equipment grounding conductor



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Electrical Grounding and Bonding

IFGC 310.2: Bonding (CSST pipe)

- If not listed as are-resistant jacket or coating- bonding required
- Bonding jumper **6 AWG** or larger
- Length limit of **75'**



226

Identification

IFGC 401.5:

- Other than steel pipe or CSST
- Identified every **5 feet**
- Yellow label with "**GAS**" in black letters



227

Metallic Pipe Materials

- **IFGC 403.3: Allowed**
 - Steel and Stainless Steel
 - Wrought-Iron
 - Copper and Copper-Alloy*
 - Polyethylene and Polyamide Plastic
- **IFGC 403.3: Not Allowed**
 - Cast Iron
 - PVC and CPVC
 - Materials less than **Schedule 10**



*Limited to gas with 0.3 grains of hydrogen sulfide per 100 ft³ (Enbridge +/- 0.25)

228

Metallic Pipe Joints

- **IFGC 403.9: Schedule 40+**
 - **IFGC 403.9: < Schedule 40**
- | | |
|---|--|
| <ul style="list-style-type: none"> • Threaded • Flanged • Brazed • Welded • Press-connect (listed) | <ul style="list-style-type: none"> • Press-connect • Flanged • Brazing • Welding |
|---|--|



229

Prohibited Piping Locations

IFGC 404.3:

- Through ducted supply, return or exhaust
- Through a clothes chute
- Through a chimney
- Through a gas vent
- Through a dumbwaiter
- Through an elevator shaft
- Extend through another townhouse unit



230

Solid Partitions & Concealed Locations

○ IFGC 404.4

- Concealed piping shall not be located in solid partitions

○ IFGC 404.5

- Fittings in concealed locations:
 - Threaded elbows, tees, couplings, plugs and caps
 - Brazed fittings
 - Welded fittings
 - Listed fittings



231

Underground Penetrations

- **IFGC 404.6:** Prohibited
 - Piping cannot penetrate a building foundation wall **below grade**
 - Annular spaces shall be sealed



232

Pipe Protection

- **IFGC 404.7:**
 - Piping in framing members **<1.5"** from face shall be protected with shield plates
 - Must extend not less than **4"** to each side, or above or below the plate or track



233

Piping Above Ground Outdoors

- **IFGC 404.9:**
 - Piping must be elevated **3.5"** above ground or roof
 - Securely supported and protected from damage



234

Underground Piping

- **IFGC 404.11.2:** Required protection
 - Corrosion-resistant material
 - Pipe with factory-applied, electrically insulating coating
 - Cathodic protection, monitored and maintained
- **IFGC 404.12:** Minimum burial depth
 - Depth of **12"** below grade
 - Depth of **8"** for individual lights, grills, etc.



235

Underground Beneath Buildings

- **IFGC 404.14:** Prohibited
 - Unless encased, designed for loads, protected
- **IFGC 404.14.1:** One end terminating outdoors
 - Sealed at termination point indoors
 - Conduit/Sleeve extends 2"+ above the floor
 - Conduit/Sleeve extends **4"+** outside building **and** must be vented, prevent entrance of water and insects



236

Underground Beneath Buildings

- **IFGC 404.14.2:** Two ends terminating indoors
 - Termination must have access
 - Do not seal conduit/sleeve
 - Conduit/sleeve extends 2"+ above the floor
- **IFGC 404.17.1:** Plastic pipe
 - Installed outdoors and underground only
 - See exceptions



237

Plastic Pipe Underground

- **IFGC 404.17.3:** Tracer Wire
 - A **yellow** insulated copper tracer wire is required
 - Shall not be less than **18 AWG**, insulated and suitable for direct burial



238

Bends and Changes in Direction

- **IFGC 404.16.2:** Metallic pipe
 - Use bending tools and procedures
 - Must be smooth, free from buckling, cracking, damage
 - Longitudinal weld on neutral axis
 - No bend **more than 90** degrees
 - Inside radius **6x** the outside diameter



239

Bends and Changes in Direction

- **IFGC 404.16.3:** Plastic pipe
 - Not damage the pipe
 - Not reduce the inside diameter
 - No joints in the pipe bend
 - Inside radius **25x** the *inside* diameter
 - Manufacturer tools and procedures used



240

Inspections and Testing

- **IFGC 406.1**
 - Prior to acceptance and initial operation, pipe shall be **visually inspected** and pressure tested
- **IFGC 406.2**
 - **Test mediums:** Air, Nitrogen, CO² or other inert gas
- **IFGC 406.4**
 - Gauge with a range not greater than **5x** the test pressure



241

Test Pressure & Duration

- **IFGC 406.4.1**
 - Test pressure of not less than **1.5x** the maximum working pressure
 - Not less than **3 PSI**
- **IFGC 406.4.2**
 - Test Duration: **10 minutes** or longer



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Abandoned in Place

- **IFGC 406.7.3.1:** Purging
 - Gas pipe to be abandoned in place or removed from service, must first be **purged** of all flammable gases
 - Minimizes risk of inadvertent ignition



Piping Supports

- **IFGC 407.5**

- Piping shall be supported per **Table 415.1**

TABLE 415.1 SUPPORT OF PIPING

STEEL PIPE, NOMINAL SIZE OF PIPE (inches)	SPACING OF SUPPORTS (feet)	NOMINAL SIZE OF TUBING (SMOOTH-WALL) (inch O.D.)	SPACING OF SUPPORTS (feet)
1/2	6	1/2	4
3/4 or 1	8	5/8 or 3/4	6
1 1/4 or larger (horizontal)	10	7/8 or 1 (horizontal)	8
1 1/4 or larger (vertical)	Every floor level	1 or larger (vertical)	Every floor level

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

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Pipe Supports

- **IFGC 407.2: Non-metallic**

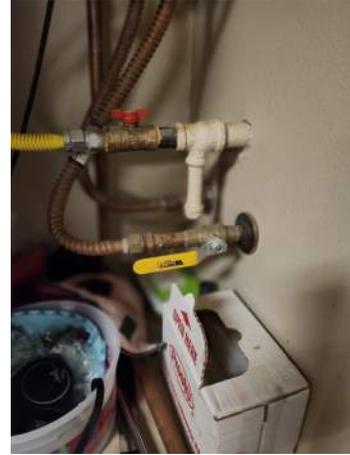
- Language modified which previously required **metal** hooks, straps, bands, brackets or hangers



245

Drips and Sloped Piping

- **IFGC 408.4.1 – 408.4.3:**
 - Piping sloped at **¼" per 15'** or greater
 - Drips required where wet gas exists
 - Must be readily accessible, not subject to freezing



245

246

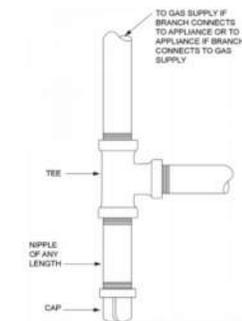
Sediment Trap

IFGC 408.4

- Required **downstream** of the appliance shutoff valve
- As close to the inlet of the appliance as practical
- Install per Fig. 408.4 (bottom of vertical pipe)

Not Required:

- Gas lamps, ranges, clothes dryers, gas fireplaces, outdoor grills, etc.



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Shutoff Valves

- **IFGC 409.1 – IFGC 409.5: Locations**
 - At the meter valve (supply side)
 - Outdoors at each building
 - Ahead of MP regulators
 - At each appliance (within **6'** and in the same room)
- Prohibited** in concealed locations and furnace plenums



248

Medium Pressure (MP) Regulators

- **IFGC 410:**
 - Suitable for the inlet and outlet pressures
 - Provided with access
 - Vented to the outdoors or have leak-limiting device
 - Tee fitting- between regulator and shutoff (upstream)
 - Tee fitting within 10 pipe diameters (downstream)
 - Union required within **1'** (rigid piping)



249

Appliance Connections

- **IFGC 411:** Allowed connections
 - Rigid metallic pipe
 - CSST
 - Listed and labeled appliance connectors (indoor and outdoor)
 - Limited to **6' maximum** length
 - Quick-disconnect devices
 - Convenience outlets
 - Gas hose connectors (portable)

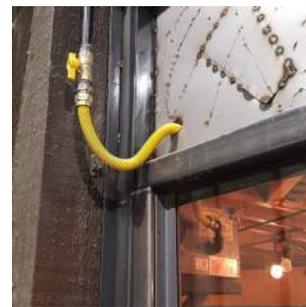


249

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Prohibited Locations

- **IFGC 411.1.3.3:** Connectors
 - Shall not be concealed or extended through:
 - Walls
 - Floors
 - Partitions
 - Ceilings
 - Appliance housings
 - **Exceptions:**
 - Rigid piping, Fireplace inserts with grommets, Listed semirigid tubing



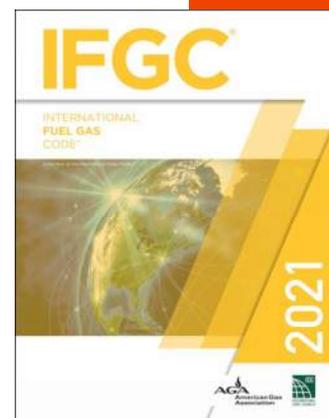
11. Gas Appliance Venting



252

IFGC Chapter 5

- Fuel gas systems including:
 - Gas piping
 - Appliances
 - Combustion air
 - **Appliance venting**
 - Specific appliances



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Appliance Categories

- **Category I:** Natural Draft- standard gas furnaces and water heaters with metal B-vents (Above 140 Deg. F)
- **Category II:** Rarely seen in residential- high condensation, requires corrosion-resistant flues (Below 140 Deg. F)
- **Category III:** Positive pressure, with sealed stainless steel venting- some tankless water heaters or boilers (Above 140 Deg. F)
- **Category IV:** Common high-efficiency furnaces and tankless water heaters with PVC flues, low temperature exhaust (Below 140 Deg. F)



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Abandoned Inlet Openings

- **IFGC 501.5:**
 - Must be closed by an approved method
- **IFGC 501.6:**
 - Mechanical systems creating positive pressure, must be vented with systems designed for positive pressure



255

Not Required to be Vented

○ IFGC 501.8:

- Ranges
- Listed built-in domestic cooking units
- Hot plates and laundry stoves
- Type 1 clothes dryers (residential)
- Refrigerators
- Counter appliances
- Listed room heaters

Limitation: Max 20 BTU per ft³



256

Chimney Connectors

○ IFGC 501.9: Masonry

- Connectors to enter **12" minimum** above the lowest portion of the flue

○ IFGC 501.10: Exhauster

- Connectors must enter on the inlet side, positive pressure side to be sealed for leakage



257

Vents & Connectors

- **IFGC 502.1:**
 - **Vent:** A pipe or other conduit, composed of factory-made components to convey combustion products and air to the atmosphere (vertical)
 - **Connector:** A pipe that connects an appliance to a chimney or vent (horizontal)



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Insulation Shields

- **IFGC 502.4:** Gas vents **and**
- **IFGC 503.5.11:** Factory-built Chimneys
 - Installed to provide clearance between the vent and the insulation materials in a roof or attic
 - No. 26 gage steel
 - Extend **2" above** insulation depth



Types of Vents

- **Special Gas Vent:** Vents listed and labeled for use with listed Cat. II, III and IV gas appliances
- **Type B:** Vents listed and labeled for use only with gas-fired appliances (round)
- **Type B-W:** Vents listed and labeled for use only with gas-fired wall furnaces (oval)
- **Type L:** Vents listed and labeled for use with oil-burning appliances or gas-fired appliances
- **Pellet Vent:** Vents listed and labeled for use with pellet-fuel-burning appliances.
- **Plastic Piping:** Venting typically used for Cat. IV appliances (low heat) in compliance with the manufacturer’s instructions and [UL 1738](#)



Correct Types of Vents

○ Table 503.4

TABLE 503.4 TYPE OF VENTING SYSTEM TO BE USED

APPLIANCES	TYPE OF VENTING SYSTEM
Listed Category I appliances	Type B gas vent (Section 503.6) Chimney (Section 503.5)
Listed appliances equipped with draft hood	Single-wall metal pipe (Section 503.7)
Appliances listed for use with Type B gas vent	Listed chimney lining system for gas venting (Section 503.5.3) Special gas vent listed for these appliances (Section 503.4.2)
Listed vented wall furnaces	Type B-W gas vent (Sections 503.6, 608)
Category II, Category III and Category IV appliances	As specified or furnished by manufacturers of listed appliances (Sections 503.4.1, 503.4.2)
Incinerators	In accordance with NFPA 82
Appliances that can be converted for use with solid fuel	Chimney (Section 503.5)
Unlisted combination gas and oil-burning appliances	Chimney (Section 503.5)
Listed combination gas and oil-burning appliances	Type L vent (Section 503.6) or chimney (Section 503.5)
Combination gas and solid fuel-burning appliances	Chimney (Section 503.5)
Appliances listed for use with chimneys only	Chimney (Section 503.5)
Unlisted appliances	Chimney (Section 503.5)
Decorative appliances in vented fireplaces	Chimney
Gas-fired toilets	Single-wall metal pipe (Section 626)
Direct-vent appliances	See Section 503.2.3
Appliances with integral vent	See Section 503.2.4

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Masonry Chimneys

○ IFGC 503.5.3

- Shall be lined with:
 - Clay flue lining
 - Chimney lining system **UL 1777**
 - Approved material (**1,800 Deg. F**)



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Chimney Termination

○ IFGC 503.5.4: Residential and Low-Heat

- Extend not less than **3'** above the highest point they pass through a roof and not less than **2'** higher than any portion within 10' horizontally



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Size of Chimneys

o IFGC 503.5.5: Type B Vents

- Appliances with draft hoods, Category I appliances etc.
 - Per IFGC 504 (vents)

Single Appliance:

- Not less than the area of the flue collar or draft hood outlet
- Not more than **7x** the draft hood outlet area

Two Appliances:

- The effective area of a chimney flue or venting system

Mechanical Draft Appliances:

- Approved engineering methods



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Chimney Sizing Example

Assume:

- o 40,000 BTU gas water heater with 3" diameter draft hood, connected to an 8" diameter chimney
 - **Area = πr^2 and $\pi = 3.14$**
 - $(3.14) \times (1.5) \times (1.5) = 7.07 \text{ in}^2$
- o Chimney Size Limitation = 7x draft hood area
 - $7.07 \text{ in}^2 \times 7 = 49.49 \text{ in}^2$
 - 8" diameter chimney flue = $(3.14) \times (4) \times (4) = 50.27 \text{ in}^2$ (too big)



Gas Vent Terminations

○ **Figure 503.6.5:**

- Where 12" or less diameter **and** less than **8 feet** from a vertical wall or obstruction

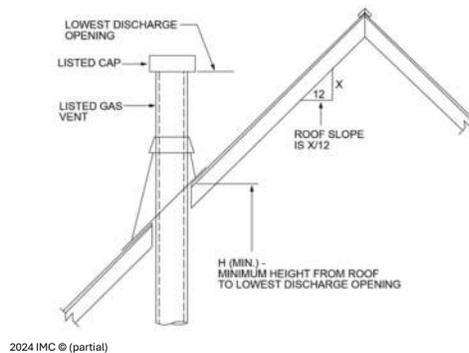
ROOF SLOPE	H (minimum) ft
Flat to 6/12	1.0
Over 6/12 to 7/12	1.25
Over 7/12 to 8/12	1.5
Over 8/12 to 9/12	2.0
Over 9/12 to 10/12	2.5
Over 10/12 to 11/12	3.25
Over 11/12 to 12/12	4.0
Over 12/12 to 14/12	5.0
Over 14/12 to 16/12	6.0
Over 16/12 to 18/12	7.0
Over 18/12 to 20/12	7.5
Over 20/12 to 21/12	8.0



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Gas Vent Terminations

○ **Figure 503.6.5:**

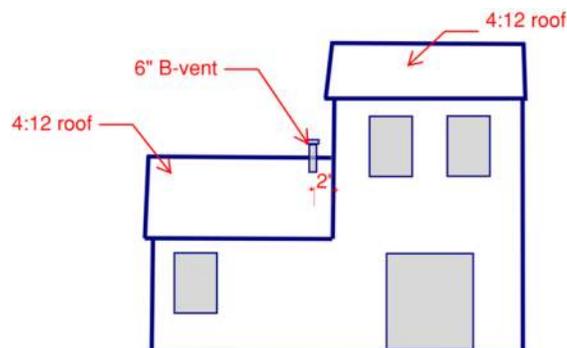


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Gas Vent Terminations

o IFGC 503.6.5:

- Where larger than 12" diameter or closer than 8' from a vertical wall or obstruction:
 - Terminate 2' or more above the roof and 2' above any portion of a building within 10'



503.6.5 Gas vent terminations. REPEATS

A gas vent shall terminate in accordance with one of the following:

1. Gas vents that are 12 inches (305 mm) or less in size and located not less than 8 feet (2438 mm) from a vertical wall or similar obstruction shall terminate above the roof in accordance with [Figure 503.6.5](#).
2. Gas vents that are over 12 inches (305 mm) in size or are located less than 8 feet (2438 mm) from a vertical wall or similar obstruction shall terminate not less than 2 feet (610 mm) above the highest point where they pass through the roof and not less than 2 feet (610 mm) above any portion of a building within 10 feet (3048 mm) horizontally.
3. As provided for industrial appliances in [Section 503.2.2](#).
4. As provided for direct-vent systems in [Section 503.2.3](#).
5. As provided for appliances with integral vents in [Section 503.2.4](#).
6. As provided for mechanical draft systems in [Section 503.3.3](#).
7. As provided for ventilating hoods and exhaust systems in [Section 503.3.4](#).

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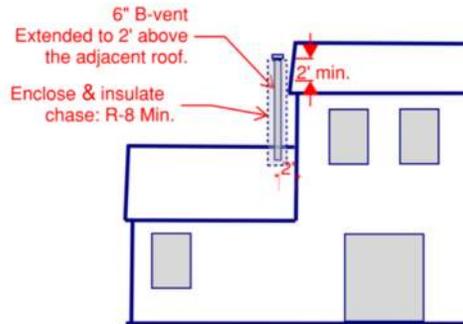


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504.2.9 Chimney and vent locations. ADDITION



Tables 504.2(1), 504.2(2), 504.2(3), 504.2(4) and 504.2(5) shall be used only for chimneys and vents not exposed to the outdoors below the roof line. A Type B vent or listed chimney lining system passing through an unused masonry chimney flue shall not be considered to be exposed to the outdoors. Where vents extend outdoors above the roof more than 5 feet (1524 mm) higher than required by Figure 503.6.5, and where vents terminate in accordance with Section 503.6.5, Item 2, the outdoor portion of the vent shall be enclosed as required by this section for vents not considered to be exposed to the outdoors or such venting system shall be engineered. A Type B vent shall not be considered to be exposed to the outdoors where it passes through an unventilated enclosure or chase insulated to a value of not less than R8.

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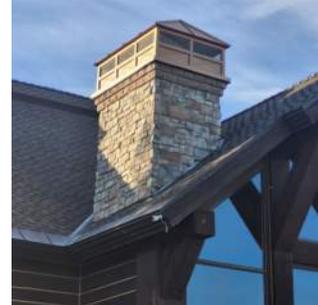


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Decorative Shrouds

○ IFGC 503.6.5.1:

- Prohibited at the termination of gas vents except:
 - Listed for use with specific gas venting system
 - Installed per the manufacturer's instructions



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Minimum Height

○ IFGC 503.6.6

- Type B or L gas vents:
 - Terminate **5' or more** above the highest draft hood or flue collar
- Type B-W gas vents:
 - Terminate **12' or more** above the bottom of the wall furnace

○ IFGC 503.6.7:

- Gas vents must terminate **3' above** forced air inlets within **10'**



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Wall Penetrations

○ IFGC 503.6.9

- Vents shall not terminate adjacent to a wall or below eaves
- Exceptions:
 - Listed direct-vent appliances
 - Listed and labeled, installed per manufacturer



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Vent Offsets

IFGC 503.6.10.2:

○ Type B & L

- Extend in a generally vertical direction (< 45 degrees)
- One 60 degree offset allowed
- Venting > **45** degrees from vertical considered horizontal
- Total of horizontal vents and connector cannot exceed **75%** of the vertical height



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Fasteners

○ IFGC 503.6.14: Allowed

- Screws
- Rivets
- Other Fasteners

Limitations: Cannot penetrate inner double wall except:

- Draft Hood Outlet
- Flue Collar
- Single Wall to Double Wall



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Cold Climates

○ IFGC 503.7.2: Single Wall

- Shall not be used outdoors where the 99-percent winter design temperature is below **32 Deg. F**



Figure & Table 503.8

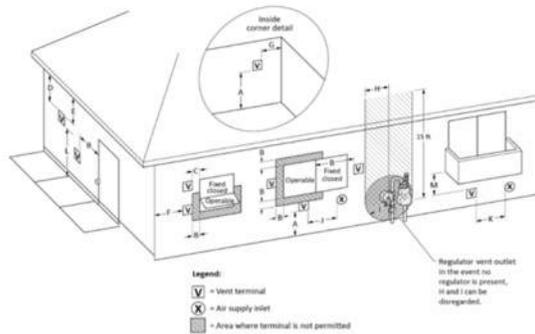


FIGURE 503.8 THROUGH-THE-WALL VENT TERMINAL CLEARANCES
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TABLE 503.8 THROUGH-THE-WALL VENT TERMINAL CLEARANCE

FIGURE CLEARANCE	CLEARANCE LOCATION	MINIMUM CLEARANCE FOR DIRECT-VENT TERMINALS	MINIMUM CLEARANCE FOR NONDIRECT-VENT TERMINALS
A	Clearance above finished grade level, veranda, porch, deck, or balcony	12 inches	
B	Clearance to window or door that is openable	6 inches: Appliances ≤ 10,000 Btu/hr	4 feet below or to side of opening or 1 foot above opening
		9 inches: Appliances > 10,000 Btu/hr ≤ 50,000 Btu/hr	
B	Clearance to window or door that is openable	12 inches: Appliances > 50,000 Btu/hr ≤ 150,000 Btu/hr	4 feet below or to side of opening or 1 foot above opening
		Appliances > 150,000 Btu/hr, in accordance with the appliance manufacturer's instructions and not less than the clearances specified for nondirect-vent terminals in Row B	
C	Clearance to nonopenable window	None unless otherwise specified by the appliance manufacturer	
D	Vertical clearance to ventilated soffit located above the terminal within a horizontal distance of 2 feet from the center line of the terminal	None unless otherwise specified by the appliance manufacturer	

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Venting Terminations

- **Row B: Nondirect-vent**
 - Minimum of **4' below** doors, windows, gravity inlets
 - Minimum of **4' feet horizontal from** doors, windows, gravity inlets
 - Minimum of **1' foot above** doors, windows, gravity inlets
- **Row B: Direct-vent**
 - Appliances up to ≤ 10,000 BTU = 6" minimum
 - Appliances up to ≤ 50,000 BTU = 9" minimum
 - Appliances up to ≤ 150,000 BTU = 12" minimum
 - Appliances up to > 150,000 BTU = Manufacturer (or Nondirect)



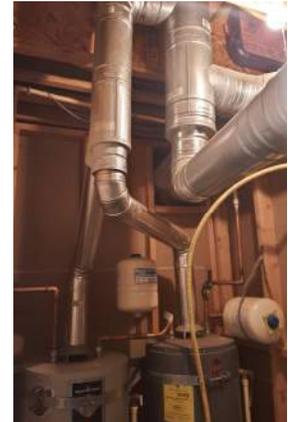
Multiple Appliances to a Single Vent

○ IFGC 503.10.4

- When **two or more** connectors enter a common vent or chimney
 - The **smaller connector** shall enter at the highest level possible
 - Larger connectors enter below

○ IFGC 503.10.4.1: Chimney Flue or Vent

- When two or more openings exist
 - Must be at different levels
 - Must be at angle of 45 degrees or less to vertical



Clearances for Connectors

Table 503.10.5:

TABLE 503.10.5 CLEARANCES FOR CONNECTORS^a

APPLIANCE	MINIMUM DISTANCE FROM COMBUSTIBLE MATERIAL			
	Listed Type B gas vent material	Listed Type L vent material	Single-wall metal pipe	Factory-built chimney sections
Listed appliances with draft hoods and appliances listed for use with Type B gas vents	As listed	As listed	6 inches	As listed
Residential boilers and furnaces with listed gas conversion burner and with draft hood	6 inches	6 inches	9 inches	As listed
Residential appliances listed for use with Type L vents	Not permitted	As listed	9 inches	As listed
Listed gas-fired toilets	Not permitted	As listed	As listed	As listed
Unlisted residential appliances with draft hood	Not permitted	6 inches	9 inches	As listed
Residential and low-heat appliances other than above	Not permitted	9 inches	18 inches	As listed
Medium-heat appliances	Not permitted	Not permitted	36 inches	As listed

For SI: 1 inch = 25.4 mm.
 a. These clearances shall apply unless the manufacturer's installation instructions for a listed appliance or connector specify different clearances, in which case the listed clearances shall apply.

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Connector Slopes

IFGC 503.10.8

- Installed without dips or sags
- Slope upward toward the vent or chimney
- Minimum **¼" per foot**

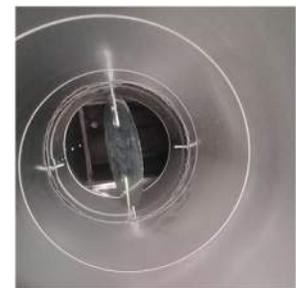


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Dampers and Baffles

○ IFGC 503.13

- Manually operated dampers prohibited
- Fixed baffles & balancing baffles allowed
- Balancing baffles **UL 378** listed, and locked in position
- Automatic vent dampers must be listed



Connector Lengths

- **IFGC 504.3.2:** Category I Appliance
 - Use the shortest possible route
 - Maximum horizontal length shall be **1.5' for each inch** of connector **diameter** (see table)
- **IFGC 504.3.3:** Longer Lengths
 - Reduce capacity by 10% each time to add additional lengths



Maximum Connector Lengths

Table 504.3.2

TABLE G2428.3.2 (504.3.2) MAXIMUM VENT CONNECTOR LENGTH

CONNECTOR DIAMETER (inches)	CONNECTOR MAXIMUM HORIZONTAL LENGTH (feet)
3	4½
4	6
5	7½
6	9
7	10½
8	12
9	13½

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

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Example: 4" Diameter connector at 90% can run 12' (6' +6')



Cat. I Systems

IFGC 504.2:

- Single Appliance Vent Tables
 - **Table 504.2(1)** – Directly connected
 - **Table 504.2(2)** – Single-wall metal connector



Venting Tables

Keys:

- Select Height (vertical)
- Select Lateral (horizontal)
- Select Vent Diameter
- Fan-assisted or Natural
- Min. & Max- Fan

TABLE 504.2(1) TYPE B DOUBLE-WALL GAS VENT

		Number of Appliances		Appliance Type		Appliance Vent Connection		VENT DIAMETER—(D) inches											
		Single		Category I		Connected directly to vent													
HEIGHT (H) (feet)	LATERAL (L)(feet)	APPLIANCE INPUT RATING IN THOUSANDS OF BTU/H																	
		3		4		5		6		7									
		FAN	NAT	FAN	NAT	FAN	NAT	FAN	NAT	FAN	NAT								
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max						
6	0	0	78	46	0	152	86	0	251	141	0	375	205	0	524	285			
	2	13	51	36	18	97	67	27	157	105	32	232	157	44	321	217			
	4	21	49	34	30	94	64	39	153	103	50	227	153	66	316	211			
	6	25	46	32	36	91	61	47	149	100	59	223	149	78	310	205			
8	0	0	84	50	0	165	94	0	276	155	0	415	235	0	583	320			
	2	12	57	40	16	109	75	25	178	120	28	263	180	42	365	247			
	5	23	53	38	32	103	71	42	171	115	53	255	173	70	356	237			
10	8	28	49	35	39	98	66	51	164	109	64	247	165	84	347	227			
	0	0	88	53	0	175	100	0	295	166	0	447	255	0	631	345			
	2	12	61	42	17	118	81	23	194	129	26	289	195	40	402	273			
	5	23	57	40	32	113	77	41	187	124	52	280	188	68	392	263			
	10	30	51	36	41	104	70	54	176	115	67	267	175	88	376	245			

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Single Example

A natural draft 120,000 BTU gas furnace, has a vent height of 10', an offset of 5' and a 4" diameter draft hood. What is the smallest allowable vent diameter?

- The 4" vent has a capacity of only 77,000 BTUs
- Increasing to 5" meets the 124,000 BTU requirement

TABLE 504.2(1) TYPE B DOUBLE-WALL GAS VENT

		Number of Appliances		Single												
		Appliance Type		Category I												
		Appliance Vent Connection		Connected directly to vent												
		VENT DIAMETER—(D) inches														
HEIGHT (H) (feet)	LATERAL (L)(feet)	APPLIANCE INPUT RATING IN THOUSANDS OF BTU/H														
		3			4			5			6			7		
		FAN		NAT	FAN		NAT	FAN		NAT	FAN		NAT	FAN		NAT
		Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max
6	0	0	78	46	0	152	86	0	251	141	0	375	205	0	524	285
	2	13	51	36	18	97	67	27	157	105	32	232	157	44	321	217
	4	21	49	34	30	94	64	39	153	103	50	227	153	66	316	211
	6	25	46	32	36	91	61	47	149	100	59	223	149	78	310	205
8	0	0	84	50	0	165	94	0	276	155	0	415	235	0	583	320
	2	12	57	40	16	109	75	25	178	120	28	263	180	42	365	247
	5	23	53	38	32	103	71	42	171	115	53	255	173	70	356	237
	8	28	49	35	39	98	66	51	164	109	64	247	165	84	347	227
10	0	0	88	53	0	175	100	0	295	166	0	447	255	0	631	345
	2	12	61	42	17	118	81	23	194	129	26	289	195	40	402	273
	5	23	57	40	32	113	77	41	187	124	52	280	188	68	392	263
	10	30	51	36	41	104	70	54	176	117	67	267	175	88	376	245

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Minimum Sizes

- **IFGC 504.2.2: Exceptions to Table**
 - If determined size is smaller than the draft hood- reduced vent size is allowed, provided:
 - Vent height is **at least** 10'
 - 12" or smaller- not reduced more than **1 size**
 - Over 12"- not reduced more than **2 sizes**
 - Fan assisted- reduce capacity 10%
 - Draft hood outlets 4" cannot connect to 3" vents



Reduction Example

A natural draft 40,000 BTU gas water heater, has a vent height of 10', no offset and a 4" diameter draft hood. What is the smallest allowable vent diameter?

- The 3" vent has a capacity of only 53,000 BTUs
- A 4" draft hood cannot connect to a 3" vent

TABLE 504.2(1) TYPE B DOUBLE-WALL GAS VENT

		Number of Appliances		Appliance Type		Appliance Vent Connection		Single		Category I		Connected directly to vent						
HEIGHT (H) (feet)	LATERAL (L)(feet)	VENT DIAMETER—(D) inches																
		3			4			5			6			7				
		APPLIANCE INPUT RATING IN THOUSANDS OF BTU/H																
		FAN		NAT		FAN		NAT		FAN		NAT		FAN		NAT		
		Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max
6	0	0	78	46	0	152	86	0	251	141	0	375	205	0	524	285		
	2	13	51	36	18	97	67	27	157	105	32	232	157	44	321	217		
	4	21	49	34	30	94	64	39	153	103	50	227	153	66	316	211		
	6	25	46	32	36	91	61	47	149	100	59	223	149	78	310	205		
8	0	0	84	50	0	165	94	0	276	155	0	415	235	0	583	320		
	2	12	57	40	18	109	75	25	178	120	28	263	180	42	365	247		
	5	23	53	38	32	103	71	42	171	115	53	255	173	70	356	237		
	8	28	49	35	39	98	66	51	164	109	64	247	165	84	347	227		
10	0	0	88	53	0	175	100	0	295	166	0	447	255	0	631	345		
	2	12	61	42	17	118	81	23	194	129	26	289	195	40	402	273		
	5	23	57	40	32	113	77	41	187	124	52	280	188	68	392	263		
	10	30	51	36	41	104	70	54	176	115	67	267	175	88	376	245		

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Two or More Example

Two natural draft 60,000 BTU gas water heaters, have a vent height of 8', a connector rise of 2' and 4" diameter draft hoods. What is the smallest allowable vent diameter?

- The 4" vent only has a capacity of only 57,000 BTUs
- Increasing to 6" meets the 120,000 BTU requirement

TABLE 504.3(2) TYPE B DOUBLE-WALL VENT

		Number of Appliances		Appliance Type		Appliance Vent Connection		Two or more		Category I		Single-wall metal connector							
VENT HEIGHT (H) (feet)	CONNECTOR RISE (R) (feet)	SINGLE-WALL METAL VENT CONNECTOR DIAMETER—(D) inches																	
		3			4			5			6			7			8		
		APPLIANCE INPUT RATING LIMITS IN THOUSANDS OF BTU/H																	
		FAN		NAT		FAN		NAT		FAN		NAT		FAN		NAT			
		Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	Max	Min	Max	
6	1	NA	NA	26	NA	NA	40	NA	NA	71	NA	NA	102	207	223	140	262	293	183
	2	NA	NA	31	NA	NA	55	NA	NA	85	188	182	123	215	251	167	271	331	219
	3	NA	NA	34	NA	NA	62	121	131	95	175	198	138	222	273	188	279	361	247
8	1	NA	NA	27	NA	NA	48	NA	NA	75	NA	NA	106	226	240	145	285	316	191
	2	NA	NA	32	NA	NA	67	125	129	89	184	193	127	234	265	173	293	353	228
	3	NA	NA	35	NA	NA	84	130	138	100	191	208	144	241	287	197	302	381	258
10	1	NA	NA	28	NA	NA	50	119	121	77	182	186	110	240	253	150	302	335	196
	2	NA	NA	33	84	85	99	124	134	91	189	203	132	248	278	183	311	369	235
	3	NA	NA	36	89	91	67	129	144	102	197	217	148	257	299	203	320	398	265

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Vent Offsets

IFGC 504.2.3:

- Lateral Length 0: No elbows allowed
- Lateral Lengths >0: (2) 90 Deg. elbows accounted for
 - Each additional elbow **45 Deg. – 0 Deg.** reduce by **5%**
 - Each additional elbow **>45 Deg. – 90 Deg.** reduce by **10%**



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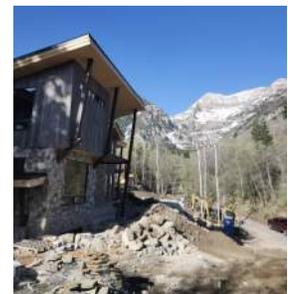
High Altitude

○ IFGC 504.2.5:

- Use sea level ratings used for **maximum** capacity
- Derated actual inputs used for **minimum** capacity

○ IFGC 504.2.6: Multiple Inputs

- Minimum capacity (FAN Min) < lowest appliance rating
- Maximum capacity (FAN Max/NAT Max) > highest appliance rating



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Vent Area & Diameter

- **IFGC 504.2.8:** Vertical Vent > Vent Connector
 - Vertical vent to be used for **minimum** capacity
 - Connector size used for the **maximum** capacity
 - Vertical vent area limited to **7x** the flow area of the appliance



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Table Utilization

IFGC 504.2.14:

- Interpolation permitted for sizes not shown

IFGC 504.2.15:

- Extrapolation is prohibited

IFGC 504.2.16:

- Engineering calculation required for vent heights **< 6'** or beyond the limits of the tables



Factory-Built Chimneys

IFGC 506.1:

- Appliances with flue gases **1,000 Deg. F** or less must be listed and labeled per UL 103



12. Gas Line Sizing



IFGC 402- Pipe Sizing

- Fuel gas systems including:
 - Gas piping
 - Appliances
 - Combustion air
 - Appliance venting
 - Specific appliances



Compliance Options

- **IMC 402.3:**
 1. Tables in the IMC (examples)
 2. Manufacturer's Tables (likely similar)
 3. Approved Engineering Methods (modeling, etc.)



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Three Primary Methods

- **IMC 402.1:** Objectives
 - Accommodate maximum demand, based on minimum supply pressures required by the appliance



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Considerations

- **IMC 402.2:**
 - Methods assume all connected appliances operating at **full capacity** *simultaneously*
 - Adjust for altitude when **above 2,000 ft.** elevation
- **IMC 402.4:** 37 Tables
 - Unique for pipe material, gas supplied, inlet pressures, pressure drops and specific gravities
 - Ensure you are in the correct table



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Determining Lengths

○ IMC 402.4:

1. Longest Length IMC 402.4.1

- Longest length from delivery to most remote outlet for all associated gas pipe

2. Branch Length IMC 402.4.2

- Length of each section or branch is utilized

3. Hybrid Pressure IMC 402.4.3

- Longest length from delivery to most remote pressure regulator
- Then from regulator (not delivery) to most remote outlet



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Maximum Pressure

○ IMC 402.7:

- System located in buildings limited to **5 PSI**

Exceptions:

- Welded or brazed
- Listed fittings
- Located in ventilated chase
- Temporary installations



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Key Knowledge

- **Pressure:**
 - 1 lb. of pressure = 16 oz/in²
 - 4 oz. of pressure = ¼ lb.
 - 7 in. w.c. = 0.25 psi (standard pressure)
 - 14 in. w.c. = 0.5 psi (higher pressure)
- **Specific Gravity:**
 - Natural Gas- 0.60
 - Propane- 1.50



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Key Knowledge

- **Pressure Drop:**
 - 0.5 in. w.c.- standard natural gas pressure (check with local utility)
 - 1.0 in. w.c.- standard propane gas pressure
 - 3.0+ psi. – elevated pressure systems



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Things to Watch For:

- Corrugated Stainless Steel Tubing (CSST)
 - Use manufacturer's tables for sizing
- Polyethylene Plastic (PE)
 - Separate tables for both pipe and tubing
- Semirigid Copper Tubing
- Stainless Steel Tubing



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Example #1

- Longest Length Method
- Natural Gas
- Schedule 40 Steel Pipe
- 4 oz. pressure
- 0.5 in w.c. pressure drop

Step #1: Find the appropriate table:

- **Table G2413.4(1)**

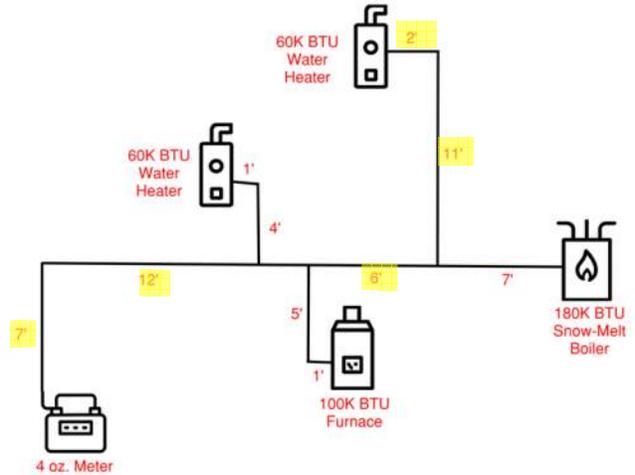


Step #2:

Determine the **longest length**

$$7 + 12 + 6 + 11 + 2 = \mathbf{38'}$$

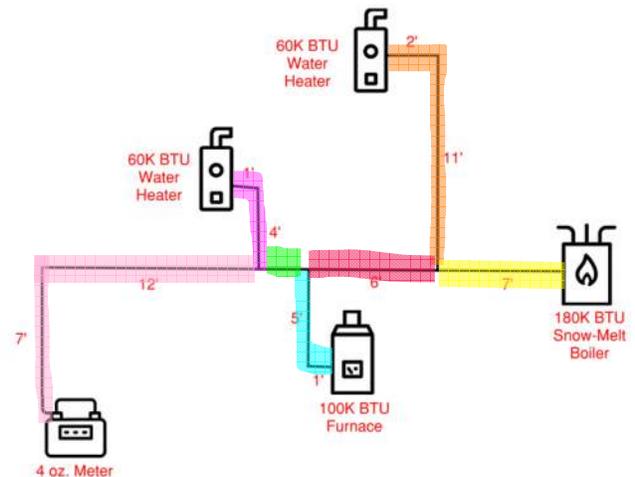
Use this length to size all the gas piping in the system



Step #3:

Determine loads for each segment

- **Yellow-** 180K / 1,000 = 180 CFH
- **Orange-** 60K / 1,000 = 60 CFH
- **Red-** 240K / 1,000 = 240 CFH
- **Blue-** 100K / 1,000 = 100 CFH
- **Green-** 340K / 1,000 = 340 CFH
- **Purple-** 60K / 1,000 = 60 CFH
- **Pink-** 400K / 1,000 = 400 CFH



Step #4:
Find Correct Row in Table
 38' is > 30' - **Use 40' row**

TABLE 402.4(2) SCHEDULE 40 METALLIC PIPE

		Gas									
		Natural									
		Inlet Pressure									
		Less than 2 psi									
		Pressure Drop									
		0.5 in. w.c.									
		Specific Gravity									
		0.60									
		PIPE SIZE (inch)									
Nominal	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	5	
Actual ID	0.622	0.824	1.049	1.380	1.610	2.067	2.469	3.068	4.026	5.047	
Length (ft)	Capacity in Cubic Feet of Gas Per Hour										
10	172	360	678	1,390	2,090	4,020	6,400	11,300	23,100	41,800	
20	118	247	466	957	1,430	2,760	4,400	7,780	15,900	28,700	
30	95	199	374	768	1,150	2,220	3,530	6,250	12,700	23,000	
40	81	170	320	657	985	1,900	3,020	5,350	10,900	19,700	
50	72	151	284	583	873	1,680	2,680	4,740	9,660	17,500	
60	65	137	257	528	791	1,520	2,430	4,290	8,760	15,800	

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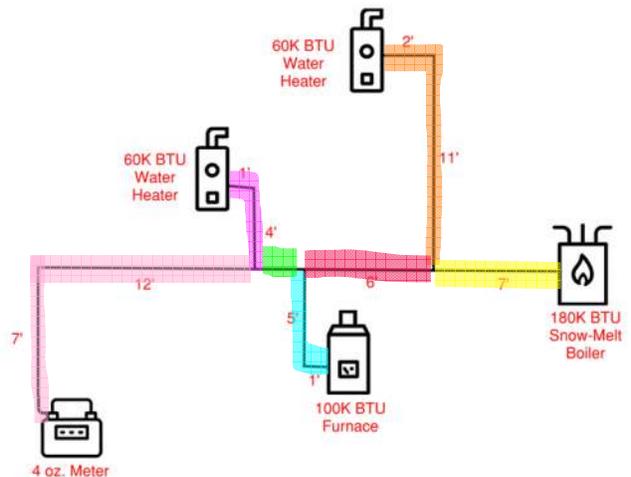
Table G2413.4(1)

Nominal	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	5
40	81	170	320	657	985	1,900	3,020	5,350	10,900	19,700

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Step #5:
Apply Table to Loads

- **Yellow**- 180 CFH = 1" Pipe
- **Orange**- 60 CFH = 1/2" Pipe
- **Red**- 240 CFH = 1" Pipe
- **Blue**- 100 CFH = 3/4" Pipe
- **Green**- 340 CFH = 1 1/4" Pipe
- **Purple**- 60 CFH = 1/2" Pipe
- **Pink**- 400 CFH = 1 1/4" Pipe



Considerations:

- **Heating Value of NG:**
 - 1 CFH of gas = 1,000 BTU
- **Heating Value of Propane:**
 - 1 CFH = 2,500 BTU
- **Adjust based on elevation and manufacturer**
 - Example: 1 CFH = 894 BTU

TABLE 402.4(2) SCHEDULE 40 METALLIC PIPE

		Gas									
		Natural									
		Inlet Pressure									
		Less than 2 psi									
		Pressure Drop									
		0.5 in. w.c.									
		Specific Gravity									
		0.60									
		PIPE SIZE (inch)									
Nominal	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	5	
Actual ID	0.622	0.824	1.049	1.380	1.610	2.067	2.469	3.068	4.026	5.047	
Length (ft)	Capacity in Cubic Feet of Gas Per Hour										
10	172	360	678	1,390	2,090	4,020	6,400	11,300	23,100	41,800	
20	118	247	466	957	1,430	2,760	4,400	7,780	15,900	28,700	
30	95	199	374	768	1,150	2,220	3,530	6,250	12,700	23,000	
40	81	170	320	657	985	1,900	3,020	5,350	10,900	19,700	
50	72	151	284	583	873	1,680	2,680	4,740	9,660	17,500	
60	65	137	257	528	791	1,520	2,430	4,290	8,760	15,800	

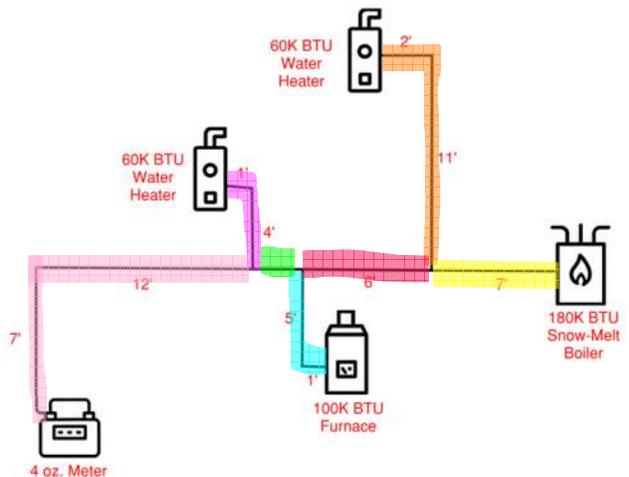
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Step #3: (Adjusted)

Determine loads for each segment

- **Yellow-** 180K / 894 = 201.4 CFH
- **Orange-** 60K / 894 = 67.15 CFH
- **Red-** 240K / 894 = 268.46 CFH
- **Blue-** 100K = 111.86 CFH
- **Green-** 340K = 380.32 CFH
- **Purple-** 60K / 894 = 67.15 CFH
- **Pink-** 400K = 447.43 CFH



315

Example #2

- Longest Length Method
- Natural Gas
- Schedule 40 Steel Pipe
- 2 lb. pressure
- 1.0 in w.c. pressure drop

Step #1: Find the appropriate table:

- **Table G2413.4(2)**



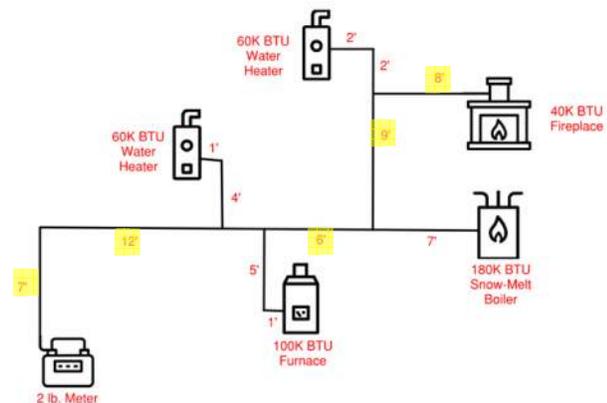
316

Step #2:

Determine the longest length

$$7 + 12 + 6 + 9 + 8 = 42'$$

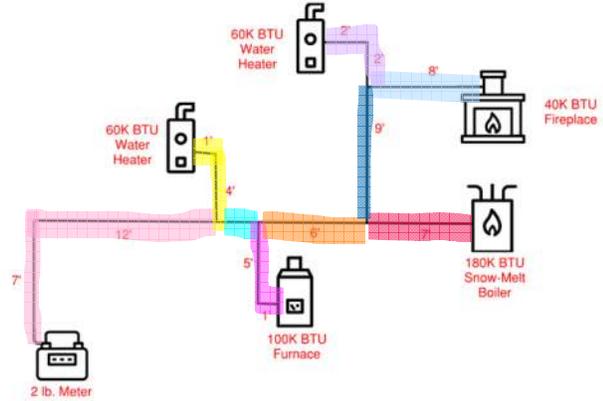
Use this length to size all the gas piping in the system



Step #3:

Determine loads for each segment

- Lavender- $60K / 1,000 = 60$ CFH
- Pale Blue- $40K / 1,000 = 40$ CFH
- Dark Blue- $100K / 1,000 = 100$ CFH
- Red- $180K / 1,000 = 180$ CFH
- Orange- $280K / 1,000 = 280$ CFH
- Purple- $100K / 1,000 = 100$ CFH
- Cyan- $380K / 1,000 = 380$ CFH
- Yellow- $60K / 1,000 = 60$ CFH
- Pink- $440K / 1,000 = 440$ CFH



Step #4:

Find Correct Row in Table

42' is > 40'- **Use 50' row**

TABLE 402.4(5) SCHEDULE 40 METALLIC PIPE

		Gas	Natural				
		Inlet Pressure	2.0 psi				
		Pressure Drop	1.0 psi				
		Specific Gravity	0.60				
PIPE SIZE (inch)							
Nominal	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2
Actual ID	0.622	0.824	1.049	1.380	1.610	2.067	2.469
Length (ft)	Capacity in Cubic Feet of Gas Per Hour						
10	1,510	3,040	5,560	11,400	17,100	32,900	52,500
20	1,070	2,150	3,930	8,070	12,100	23,300	37,100
30	869	1,760	3,210	6,590	9,880	19,000	30,300
40	753	1,520	2,780	5,710	8,550	16,500	26,300
50	673	1,360	2,490	5,110	7,650	14,700	23,500

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Table G2413.4(2)

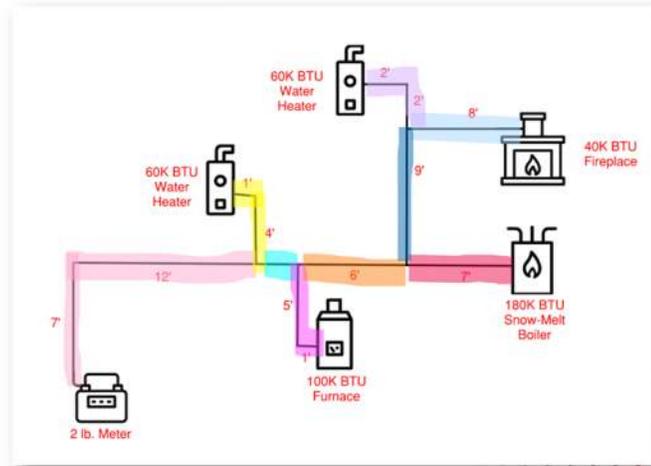
Nominal	1/2	3/4	1	1 1/4	1 1/2	2
50	673	1,360	2,490	5,110	7,650	14,700

Step #5:

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Apply Table to Loads

- **Lavender**- 60 CFH = 1/2" Pipe
- **Pale Blue**- 40 CFH = 1/2" Pipe
- **Dark Blue**- 100 CFH = 1/2" Pipe
- **Red**- 180 CFH = 1/2" Pipe
- **Orange**- 280 CFH = 1/2" Pipe
- **Purple**- 100 CFH = 1/2" Pipe
- **Cyan**- 380 CFH = 1/2" Pipe
- **Yellow**- 60 CFH = 1/2" Pipe
- **Pink**- 440 CFH = 1/2" Pipe



Example #3

- Longest Length Method
- Propane
- Schedule 40 Steel Pipe
- 10.5 in .w.c. pressure
- 0.5 in. w.c. pressure drop

Step #1: Find the appropriate table:

- **Table G2413.4(12)**



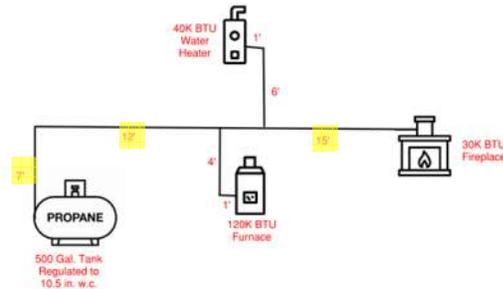
321

Step #2:

Determine the longest length

$$7 + 12 + 15 = \mathbf{34'}$$

Use this length to size all the gas piping in the system



322

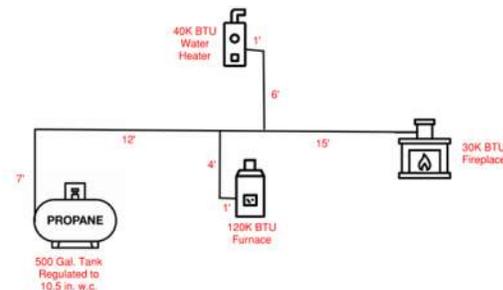
Step #3:

Determine loads for each segment

- **Orange**- 30K / 2,500 = **12 CFH**
- **Yellow**- 40K / 2,500 = **16 CFH**
- **Magenta**- 70K / 2,500 = **28 CFH**
- **Light Blue**- 120K / 2,500 = **48 CFH**
- **Pink**- 190K / 2,500 = **76 CFH**

Reminder: 1 CFH of Propane = +/- **2,500 BTU**

- Divide by input rating by 2,500 to get CFH demands



Step #4:
Find Correct Row in Table
 34' is > 30' - **Use 40' row**

TABLE 402.4(28) SCHEDULE 40 METALLIC PIPE

		Gas		Undiluted Propane		
		Inlet Pressure		11.0 in. w.c.		
		Pressure Drop		0.5 in. w.c.		
		Specific Gravity		1.50		
INTENDED USE	Pipe sizing between single- or second-stage (low pres					
PIPE SIZE (inch)						
Nominal	1/2	3/4	1	1 1/4	1 1/2	2
Actual ID	0.622	0.824	1.049	1.380	1.610	2.067
Length (ft)	Capacity in Thousands of Btu p					
10	291	608	1,150	2,350	3,520	6,790
20	200	418	787	1,620	2,420	4,660
30	160	336	632	1,300	1,940	3,750
40	137	287	541	1,110	1,660	3,210
50	122	255	480	985	1,480	2,840

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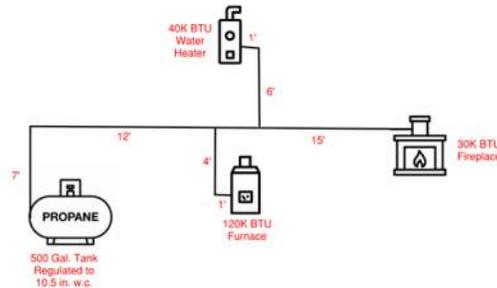
Table G2413.4(12)

Nominal	1/2	3/4	1	1 1/4	1 1/2	2
40	137	287	541	1,110	1,660	3,210

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Step #5:
Apply Table to Loads

- **Orange-** 12 CFH = 1/2" Pipe
- **Yellow-** 16 CFH = 1/2" Pipe
- **Magenta-** 28 CFH = 1/2" Pipe
- **Light Blue-** 48 CFH = 1/2" Pipe
- **Pink-** 76 CFH = 1/2" Pipe



325



Example #4

- Branch Length Method
- Natural Gas
- Schedule 40 Steel Pipe
- 4 oz. meter pressure
- 0.5 in. w.c. pressure drop

Step #1: Find the appropriate table:

- **Table G2413.4(1)**

326

Step #2:

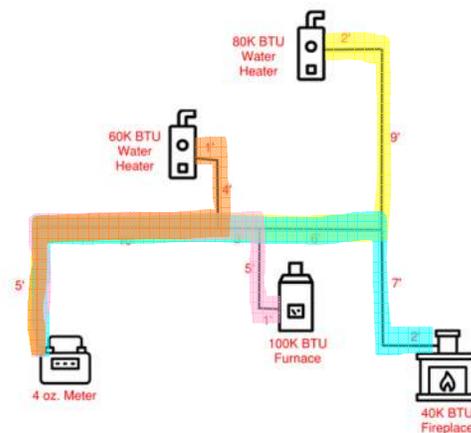
Determine the length of each branch

Yellow: $5 + 10 + 3 + 6 + 9 + 2 = 35'$

Blue: $5 + 10 + 3 + 6 + 7 + 2 = 33'$

Pink: $5 + 10 + 3 + 5 + 1 = 24'$

Orange: $5 + 10 + 4 + 1 = 20'$

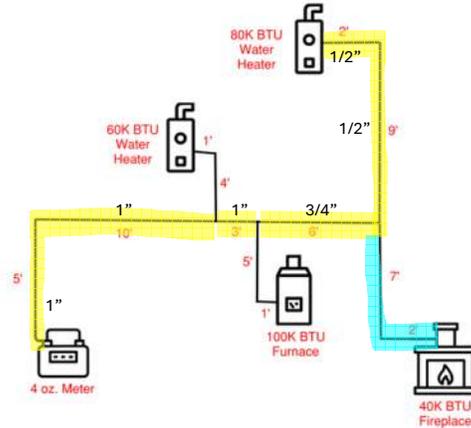


Step #5:

Move on to next branch

Blue: $5 + 10 + 3 + 6 + 7 + 2 = 33'$

Segment #1 = 40K



Step #6:

Find Correct Row in Table

33' is > 30'- Use 40' row

Blue: 33'

Segment #1 = 40K = 1/2" pipe

TABLE 402.4(2) SCHEDULE 40 METALLIC PIPE

		Gas		Natural							
		Inlet Pressure		Less than 2 psi							
		Pressure Drop		0.5 in. w.c.							
		Specific Gravity		0.60							
		PIPE SIZE (inch)									
Nominal	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	5	
Actual ID	0.622	0.824	1.049	1.380	1.610	2.067	2.469	3.068	4.026	5.047	
Length (ft)	Capacity in Cubic Feet of Gas Per Hour										
10	172	360	678	1,390	2,090	4,020	6,400	11,300	23,100	41,800	
20	118	247	466	957	1,430	2,760	4,400	7,780	15,900	28,700	
30	95	199	374	768	1,150	2,220	3,530	6,250	12,700	23,000	
40	81	170	320	657	985	1,900	3,020	5,350	10,900	19,700	
50	72	151	284	583	873	1,680	2,680	4,740	9,660	17,500	
60	65	137	257	528	791	1,520	2,430	4,290	8,760	15,800	

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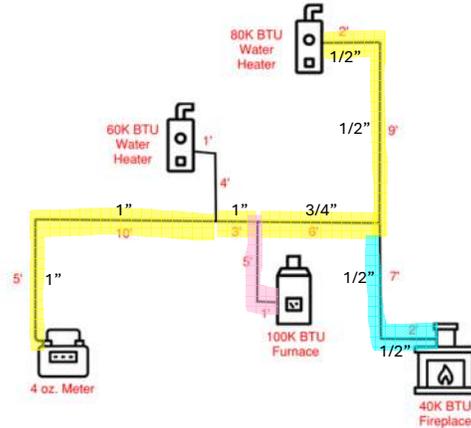


Step #7:

Move on to next branch

Pink: $5 + 10 + 3 + 5 + 1 = 24'$

Segment #1 = 100K



Step #8:

Find Correct Row in Table

24' is > 20'- Use 30' row

Pink: 24'

Segment #1 = 100K = 3/4" pipe

TABLE 402.4(2) SCHEDULE 40 METALLIC PIPE

		Gas									
		Natural									
		Inlet Pressure									
		Less than 2 psi									
		Pressure Drop									
		0.5 in. w.c.									
		Specific Gravity									
		0.60									
		PIPE SIZE (inch)									
Nominal	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	5	
Actual ID	0.622	0.824	1.049	1.380	1.610	2.067	2.469	3.068	4.026	5.047	
Length (ft)	Capacity in Cubic Feet of Gas Per Hour										
10	172	360	678	1,390	2,090	4,020	6,400	11,300	23,100	41,800	
20	118	247	466	957	1,430	2,760	4,400	7,780	15,900	28,700	
30	95	199	374	768	1,150	2,220	3,530	6,250	12,700	23,000	
40	81	170	320	657	985	1,900	3,020	5,350	10,900	19,700	
50	72	151	284	583	873	1,680	2,680	4,740	9,660	17,500	
60	65	137	257	528	791	1,520	2,430	4,290	8,760	15,800	

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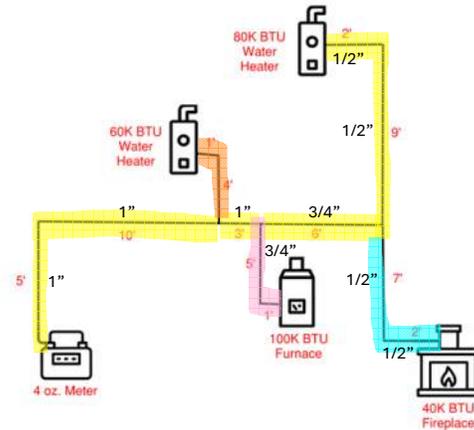


Step #9:

Move on to next branch

Orange: $5 + 10 + 4 + 1 = 20'$

Segment #1 = 60K



Step #8:

Find Correct Row in Table

Use 20' row

Orange: = 20'

Segment #1 = 60K = 1/2" pipe

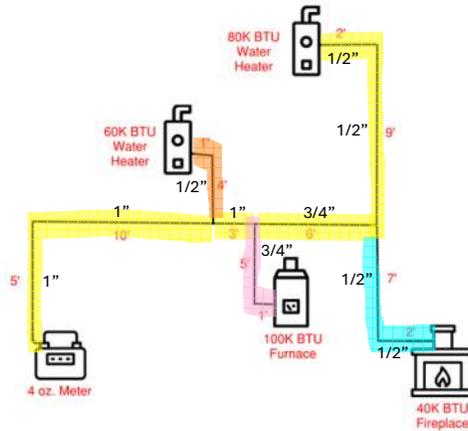
TABLE 402.4(2) SCHEDULE 40 METALLIC PIPE

		Gas									
		Natural									
		Inlet Pressure									
		Less than 2 psi									
		Pressure Drop									
		0.5 in. w.c.									
		Specific Gravity									
		0.60									
		PIPE SIZE (inch)									
Nominal	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	5	
Actual ID	0.622	0.824	1.049	1.380	1.610	2.067	2.469	3.068	4.026	5.047	
Length (ft)	Capacity in Cubic Feet of Gas Per Hour										
10	172	360	678	1,390	2,090	4,020	6,400	11,300	23,100	41,800	
20	118	247	466	957	1,430	2,760	4,400	7,780	15,900	28,700	
30	95	199	374	768	1,150	2,220	3,530	6,250	12,700	23,000	
40	81	170	320	657	985	1,900	3,020	5,350	10,900	19,700	
50	72	151	284	583	873	1,680	2,680	4,740	9,660	17,500	
60	65	137	257	528	791	1,520	2,430	4,290	8,760	15,800	

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Final Sizes:



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