Chimney Design Solutions

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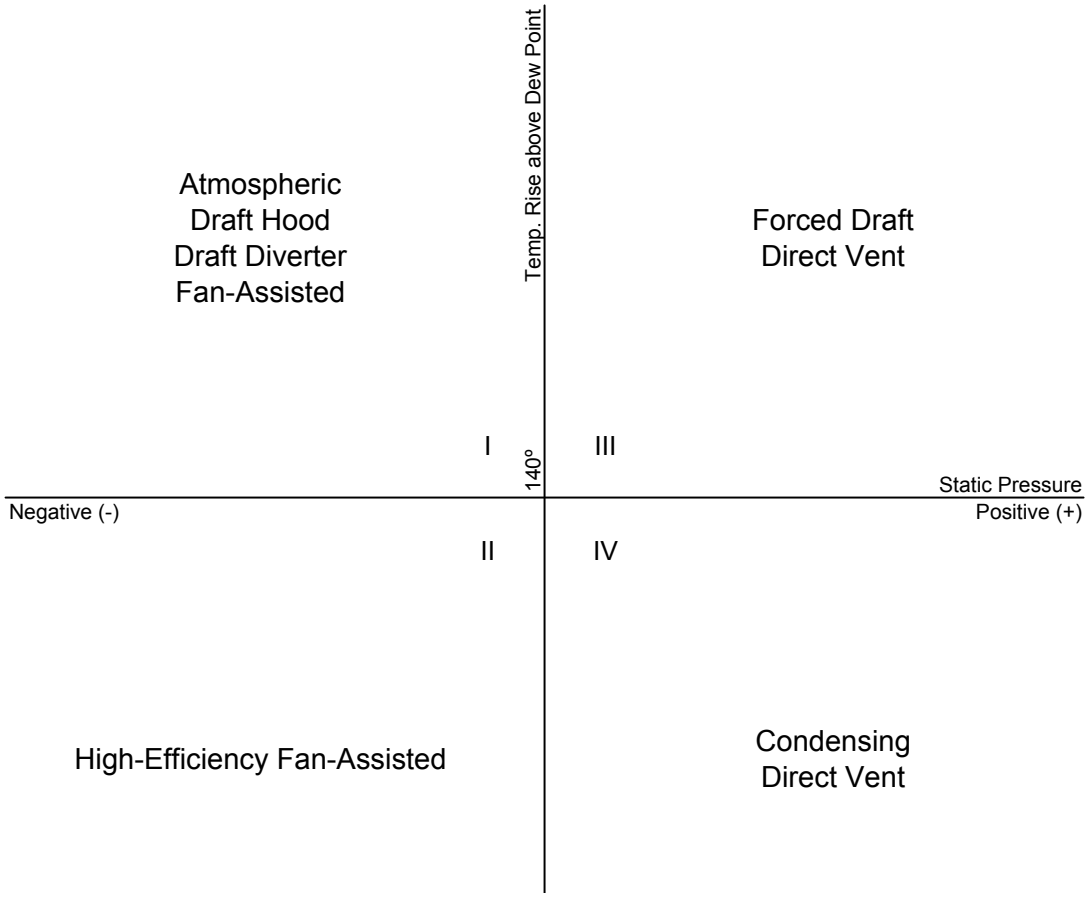
APPLIANCE CATEGORIES

The National Fire Protection Association (NFPA) classifies gas-utilization equipment into categories based upon the operating characteristics with respect to the vent system pressure and whether or not excessive condensation is generated in the vent system (NFPA 54-2006 12.2.2). **The categories pertain to any gas appliance whether it is a water heater, hydronic heater, steam boiler, unit heater, duct heater, etc.** The categories are classified as follows:

1. Category I: An appliance that operates with a non-positive vent static pressure and with a vent gas temperature that avoids excessive condensate production in the vent. (NFPA 54-2006 3.3.6.11.1)
2. Category II: An appliance that operates with a non-positive vent static pressure and with a vent gas temperature that may cause excessive condensate production in the vent. (NFPA 54-2006 3.3.6.11.2)
3. Category III: An appliance that operates with a positive vent static pressure and with a vent gas temperature that avoids excessive condensate production in the vent. (NFPA 54-2006 3.3.6.11.3)
4. Category IV: An appliance that operates with a positive vent static pressure and with a vent gas temperature that may cause excessive condensate production in the vent. (NFPA 54-2006 3.3.6.11.4)

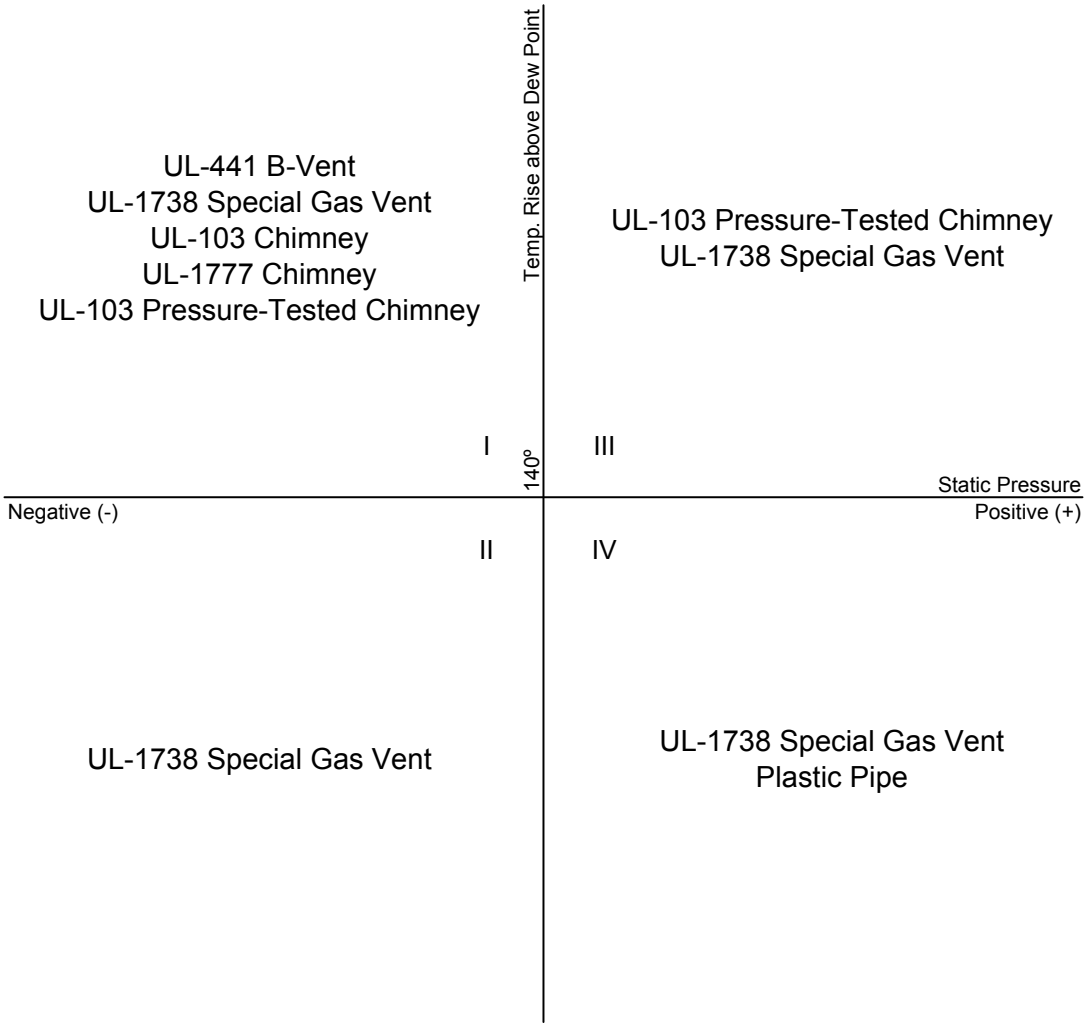


NOTES

1. Appliances listed for use with B-Vent are considered Fan-Assisted when following the NFPA Sizing Tables (See "Chimney and Gas Vent System Design").
2. Building Heating Appliances (BHA) with power burners that require a negative outlet pressure can be considered Fan-Assisted when following the NFPA 54 Sizing Tables (See "Chimney and Gas Vent System Design").
3. Domestic water heaters with power burners or BHAs with power burners that are also used for heating domestic water are considered Category III appliances unless listed for use with B-Vent.
4. Appliances with power burners that are used for industrial applications are considered Category III appliances unless listed for use with B-Vent.

CHIMNEY AND GAS VENT MATERIALS

Each appliance category requires a particular chimney or gas vent. Many chimneys and vents are offered with various insulations and outer jacket materials. The critical component of the product is the inner wall. **To be certain that the proper chimney or vent material is specified, always reference the appliance manufacturer's installation instructions.**



SPECIFIC MATERIALS

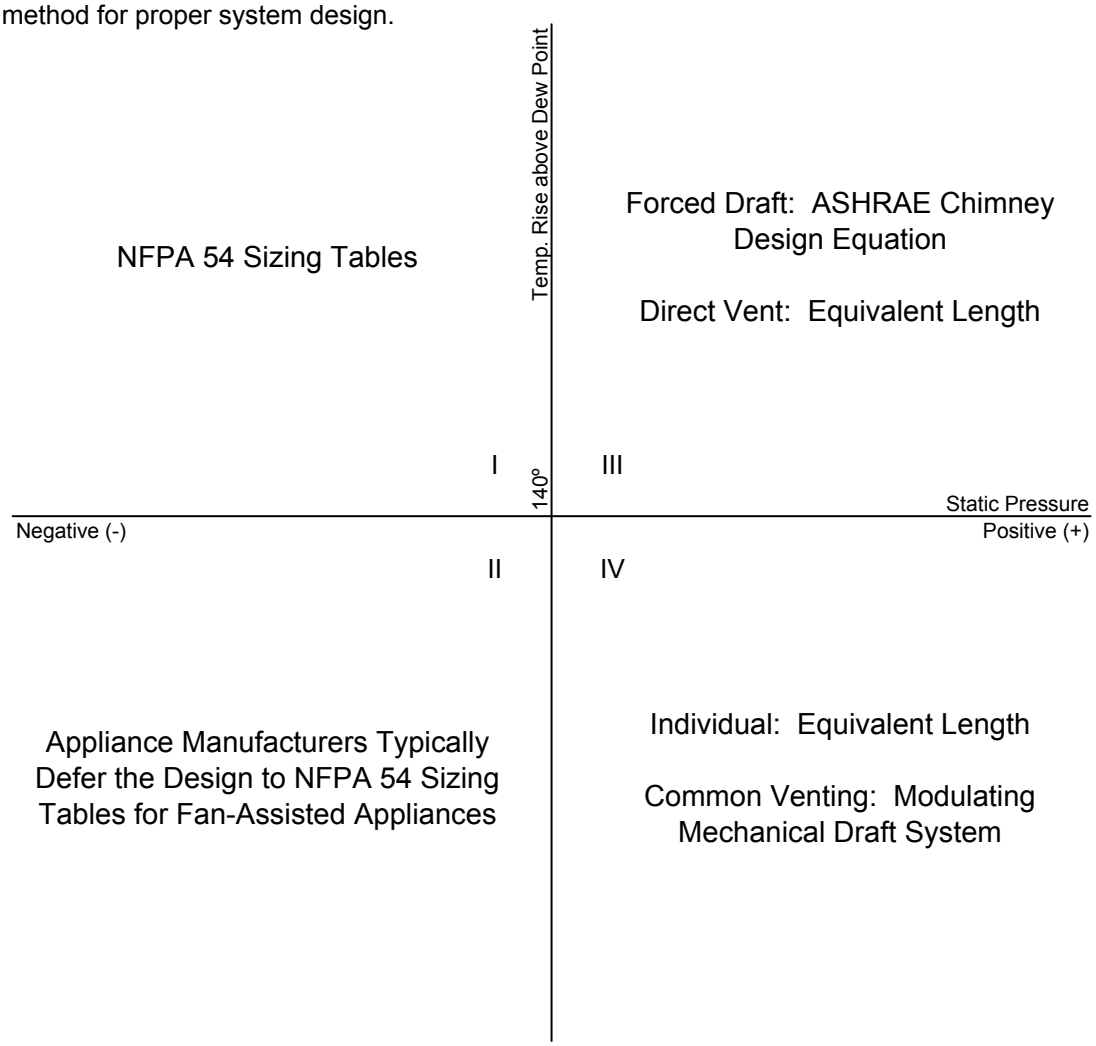
1. UL-441 B-Vent - Double-wall construction. Aluminum inner wall, galvanized steel or galvalume outer jacket, and a 1/4", 1/2" or 1" air space between the walls. Male-female connection secured with sheet metal screws; not gas or liquid tight.
2. UL-1738 Special Gas Vent - Single- or double-wall construction. AL 29-4C stainless steel inner wall, aluminized steel or 430 stainless steel outer jacket, and a 1" air space between the walls. Male-female connection sealed with silicone and secured with locking strap; gas and liquid tight to 3-15"W.C.
3. UL-103 Chimney - Double-wall construction. Various stainless steels available for the inner wall, various steels available for the outer jacket, and 1" fiber insulation between the walls. Male-female connection; not gas or liquid tight.
4. UL-1777 Chimney - Clay tile, firebrick, ceramic tile, corrugated steel, single wall steel, etc. Not gas or liquid tight.
5. UL-103 Pressure-Tested Chimney - Double-wall construction. 304 or 316 stainless steel inner wall, aluminized steel or 304 stainless steel outer jacket, and a 1" air space, 1" fiber insulation, or 2" fiber insulation between the walls. Flanged connection sealed with silicone and secured with V-bands; gas and liquid tight to 60"W.C.
6. Plastic Pipe - Schedule 40 or 80 CPVC or PVC.

CHIMNEY AND GAS VENT SYSTEM DESIGN

There are few methods for designing chimney and vent systems for today's gas-utilization equipment. **Never design a chimney or vent system upon an appliance's outlet diameter. It is always good practice to increase each appliance's vent connector at least one size to minimize pressure loss and increase theoretical draft.** Only Category I and II appliances may be common vented naturally; all other configurations require the use of mechanical draft for safe operation.

1. NFPA 54 Sizing Tables - The Sizing Tables are based upon establishing draft (negative pressure) in the chimney or vent system as soon as possible and minimizing wet time (condensation). The Sizing Tables are required for Category I appliances and occasionally referenced for Category II appliances. Sizing Tables are provided for both the vent connector and the common vent.
2. Equivalent Length - Some Category III and most Category IV appliance manufacturers provide guidance on the maximum equivalent length of the vent systems serving the equipment where fittings are assigned linear values.
3. Chimney Design Calculation - This method is used for appliances whose manufacturers do not offer guidance or where mechanical draft is utilized.

NOTE: If a negative pressure is desired for the chimney or vent system, the NFPA Sizing Tables are the best method for proper system design.



DESIGN RESTRICTIONS

ASHRAE clearly states that the chimney design equation is a steady-state model – the equation is based on a moment in time and does not consider ambient temperature changes, modulating burners, or cold starts. **Therefore, ASHRAE's chimney design equation is not the best method to design a negative pressure chimney or vent system.** Based upon thorough testing, NFPA 54 has established several limitations when designing negative pressure chimney and vent systems:

Horizontal Vent Connectors, Manifolds, and Offsets

1. The total horizontal length of a vent plus the horizontal vent connector length serving draft hood-equipped appliances shall not be greater than 75 percent of the vertical height of the vent. (NFPA 54-2006 12.7.3.2)
2. The maximum vent connector horizontal length shall be 18 inches for each inch of connector diameter. (NFPA 54-2006 13.2.2)
3. The length of a common vent connector manifold shall not exceed 18 inches for each inch of common vent connector manifold diameter. (NFPA 54-2006 13.2.4)
4. The horizontal length of the common vent offset shall not exceed 18 inches for each inch of common vent diameter. (NFPA 54-2006 13.2.6)

Table for Item 2, 3, & 4 - 18 Inch per Inch Rule

Diameter	3”	4”	5”	6”	7”	8”	9”	10”	12”	14”	16”
Max. Offset	4.5’	6’	7.5’	9’	10.5’	12’	13.5’	15’	18’	21’	24’

Area of Chimney, Connector, and Manifold

1. Vent connectors shall not be increased in size more than two sizes greater than the listed appliance categorized vent diameter, flue collar diameter, or draft hood outlet diameter.” (NFPA 54-2006 13.2.24)
2. For single appliances, the flow area of the vertical vent shall not exceed seven times the flow area of the listed appliance categorized vent area, flue collar area, of draft hood outlet area.” (NFPA 54-2006 13.1.9)
3. With two or more appliances, the flow area of the largest section of vertical vent or chimney shall not exceed seven times the smallest listed appliance categorized vent areas, flue collar area, or draft hood outlet area.” (NFPA 54-2006 13.2.18)

Table for Item 2 & 3 - Seven Times Area Rule

Outlet Dia.	3”	4”	5”	6”	7”	8”	9”	10”	12”
7x Area	49.48	87.96	137.44	197.92	269.92	351.86	445.32	549.78	791.68
Equiv. Dia.	7”	10”	13”	15”	18”	21”	23”	26”	31”

Category Mixing and Stack Pressurization

1. Vent connectors serving Category I appliances shall not be connected to any portion of a mechanical draft system operating under a positive static pressure, such as those serving Category III or Category IV appliances. (NFPA 54-2006 12.11.4.2)
2. Forced draft systems and all portions of induced draft systems under positive pressure during operation shall be designed and installed so as to prevent leakage of flue or vent gases into a building. (NFPA 54-2006 12.4.3.3)
3. Vent connectors serving equipment vented by natural draft shall not be connected to any portion of mechanical draft systems operating under positive pressure. (NFPA 54-2006 12.4.3.4)

PROTECTION FROM EXCESS NATURAL DRAFT

Natural draft (negative pressure) becomes excessive due to tall chimneys, oversized chimneys or cold ambient temperatures. To maintain good appliance efficiency, a constant draft is needed. Excess natural draft allows the burner to deliver too much air reducing the fuel-to-air ratio and creating a leaner burn, which adversely effects the appliance's efficiency; flame failure and heat exchanger failure are other possibilities as well. The two methods to maintain a constant draft are:

1. Barometric damper - A barometric damper is device designed to offload natural draft for any appliance upstream of its location. A barometric damper is typically placed perpendicular to flow in each appliance's connector although other locations are occasionally beneficial. Barometric dampers can only offload ~0.3"W.C. before the excessive natural draft acts upon the appliance. In colder climates, the limits of a barometric damper are typically reached with a 50' chimney or vertical vent. For gas-utilization equipment, listed barometric dampers are double-acting, which limits the application to negative pressure chimney and vent systems.
2. Modulating damper system - A modulating damper system consists of a microprocessor-based control panel, high-speed direct-drive modulating actuator and a multi-, opposed-blade damper. The damper is placed downstream of the appliances so only one damper is needed per manifold. The system maintains a constant pressure in the vent or chimney system to ensure safe and efficient operation of the appliances. As with any damper, flow is required to create pressure drop; in extreme circumstances a barometric damper is needed to allow flow into the chimney or vent system. The system has been tested and proven to increase appliance and building efficiency.

MECHANICAL DRAFT

Typically mechanical draft is designed into a chimney or vent system when safe operation cannot be obtained via natural draft. In most situations, modulating mechanical draft systems may be used to enhance the efficiency of the appliances by maintaining a constant draft. Two types of mechanical draft exist:

1. Termination-mounted - The chimney fan is placed at the termination to ensure that the whole chimney or vent system is negative. A termination-mounted chimney fan can be used with all vent or chimney materials. A termination-mounted chimney fan is the easiest installation for existing problem jobs.
2. Inline - A power venter is placed in the mechanical room to lessen the wiring length. The vent or chimney material on the discharge side of the power venter must be gas and liquid tight to ensure that flue gas does not spill into the building.

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