New Jersey Inspectors Meeting
February 19, 2020

Agenda

Types of Gas Boilers
- **Condensing Boilers**
- **Non-Condensing Boilers**

Combustion Process

Effects of Condensing Flue Gases

Vent Categorization
- **a) Vent Materials and Temperatures**
- **b) Reference Installation & Operation Manuals**

UL Reference Standards

DOE 2021 Minimum Efficiency Standards

Gas Boiler Types

Boiler Types

Gas Atmospheric
Non-sealed combustion

Induced Draft
Sealed Cabinet
1 pipe vent or
2 pipe air intake & vent

Induced Draft
Non-sealed combustion
1 pipe vent

Boiler Types

Gas Boilers Designed To Condense

Modulating Premix Burner
Sealed Cabinet
2 pipe air intake & vent

Modulating Premix Burner
Sealed Cabinet
1 pipe vent or
2 pipe air intake & vent

Non-condensing boiler

- Operate at lower efficiencies with higher water temperatures
- Prone to the effects of negative pressure condition
- Need to ensure proper venting and ventilation conditions
- Typically fixed rate burners with boiler water temperature adjustment outdoor air reset capabilities
- Existing Heating System Considerations When Sizing
  - Heat loss zone by zone
  - Heat emitters (capacity is higher at higher water temperatures)
  - Number of zones (micro zones not typically an issue)

Condensing Boilers

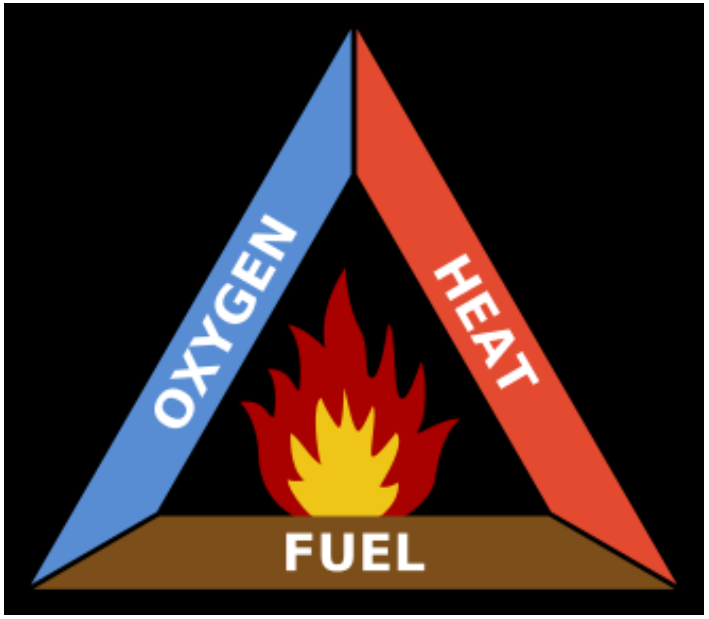
- Operate at higher efficiencies with lower system water temperatures
- Flue gases changing from a vapor to a liquid (condensing) give off latent heat energy. For every 1 lbs. of water vapor = 970 BTUH of latent (hidden heat)
- Boilers that are designed to condense utilize corrosion resistant heat exchangers and flue vent systems to cope with the acidic condensate being produced.

Condensing Boilers

- Sealed combustion designs provide the correct amount of air for the combustion and limit the effects of negative pressure.
- Modulating gas burners with boiler water temperature reset capabilities based on outdoor air temperatures. Deliver only the amount of energy necessary based on system demand
- Existing Heating System Considerations When Sizing
  - Heat loss zone by zone
  - Heat emitters (lower capacity at lower water temperatures)
  - Number of zones (micro zones)

Combustion

Combustion Triangle



Oxygen + Fuel + Heat = Combustion

Air + Nat/LP gas + Ignition Source HSI / DSI / Pilot

Air contains 21% Oxygen – 78% Nitrogen – 1% of other gases

Typical Combustion Ratio = 10 cubic feet of air to 1 cubic foot Nat gas (23 cubic feet LP)

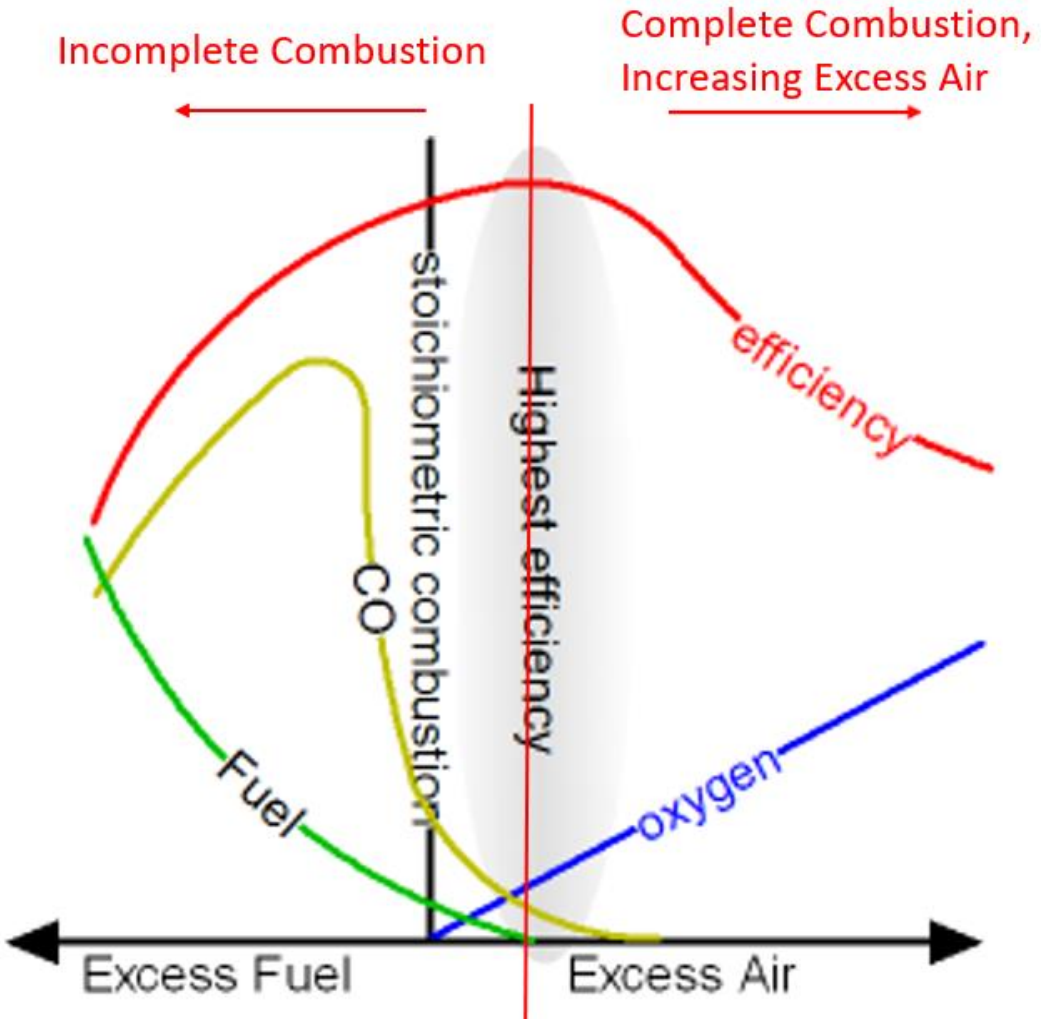
Combustion

Perfect Combustion –
Stoichiometric only occurs when the fuel is burned using only the theoretically perfect amount of air. Not achievable with currently available boilers.

Complete Combustion –
The fuel is burned using a minimum amount of excess air. Highest combustion efficiency with minimum polluting emissions.

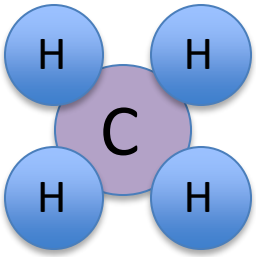
Incomplete Combustion –
Insufficient amount of air is supplied to the burner, unburned fuel, soot, smoke and carbon monoxide exhausts from the boiler. High polluting emissions, and flame instability.

Combustion

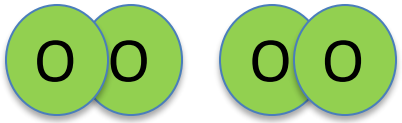

Incomplete Combustion
Complete Combustion,
Increasing Excess Air
stoichiometric combustion
Highest efficiency
efficiency
CO
Fuel
oxygen
Excess Fuel
Excess Air

Complete Combustion

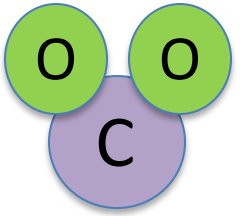
Methane
Natural Gas
Fuel



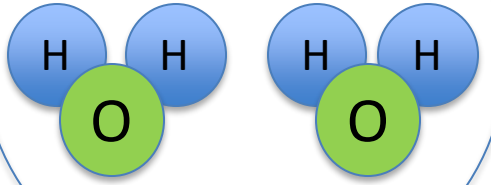
Oxygen



Carbon Dioxide



Water Vapor

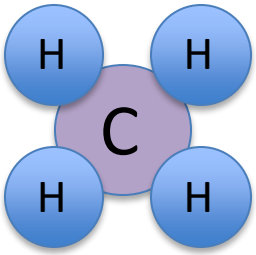


H2O (Water Vapor) from combustion process will condense at dew point temperatures

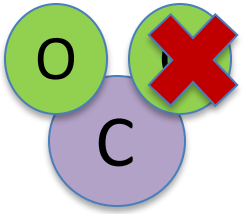
Incomplete Combustion

Carbon Monoxide

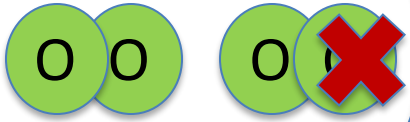
Methane
Natural Gas
Fuel



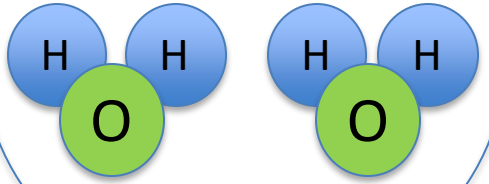
Carbon Dioxide



Oxygen



Water Vapor



Reduce the Amount
of Air/Oxygen

Carbon Monoxide CPSC Statics 2016

- **The Quiet Killer** – odorless, colorless gas which can cause sudden illness and death
- Symptoms are variable and nonspecific. Tension headache is common in mild CO poisoning. Other symptoms include flu-like without a fever and altered mental status
- For 2016: CPSC has records of 179 unintentional, CO poisoning deaths associated with the use of consumer products.
- Engine-Driven Tools (EDTs). This category includes generators, the single product associated with the most nonfire CO deaths. EDTs account for an estimated 78 deaths (44 %)
- Heating Systems were associated with the second largest percentage. An estimated 51 deaths (28%) were associated with some type of heating appliance.
- Gas heating accounted for the largest share of the deaths, and within the gas-heating equipment, liquid petroleum (LP or propane) and natural gas heating equipment were the major contributors.

Typical Combustion Readings

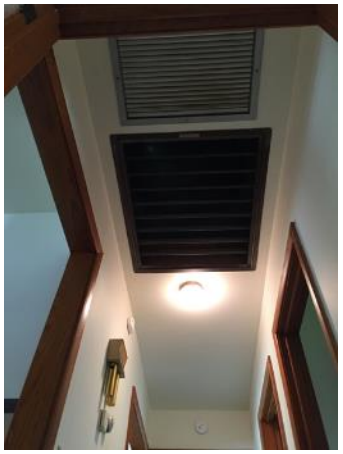
Boiler Type	Oxygen % O2	Carbon Dioxide % CO2	Carbon Monoxide ppm CO
Gas Boiler Atmospheric Burner	5.2% - undiluted 15.6% - diluted	7% to 9% - undiluted 3% - diluted	Less than 400 ppm
Gas Condensing Boiler Premix Burner	5.4% 6.3% to 4.3%	8.7% 8.2% to 9.3%	Less than 200 ppm

UL2034 Standards for Carbon Monoxide Detectors

400 ppm must alarm between 4 and 15 minutes
150 ppm must alarm between 10 and 50 minutes
70 ppm must alarm between 60 and 240 minutes

Venting & Ventilation

Venting and Ventilation are 2 parts of the same system without one you can't have the other.



Whole House Fan

Combustion conditions are not always the same and are influenced by draft, negative pressure situations, outdoor air temperatures and fuel supply

Negative Pressure Situations Can be Caused By Exhaust Fans, Whole House Fans and Externally Vented Kitchen Hoods among others

Condensation A Byproduct Of Combustion

What Are the Effects?

Condensing Boilers?

Can All Boilers Condense?

YES!

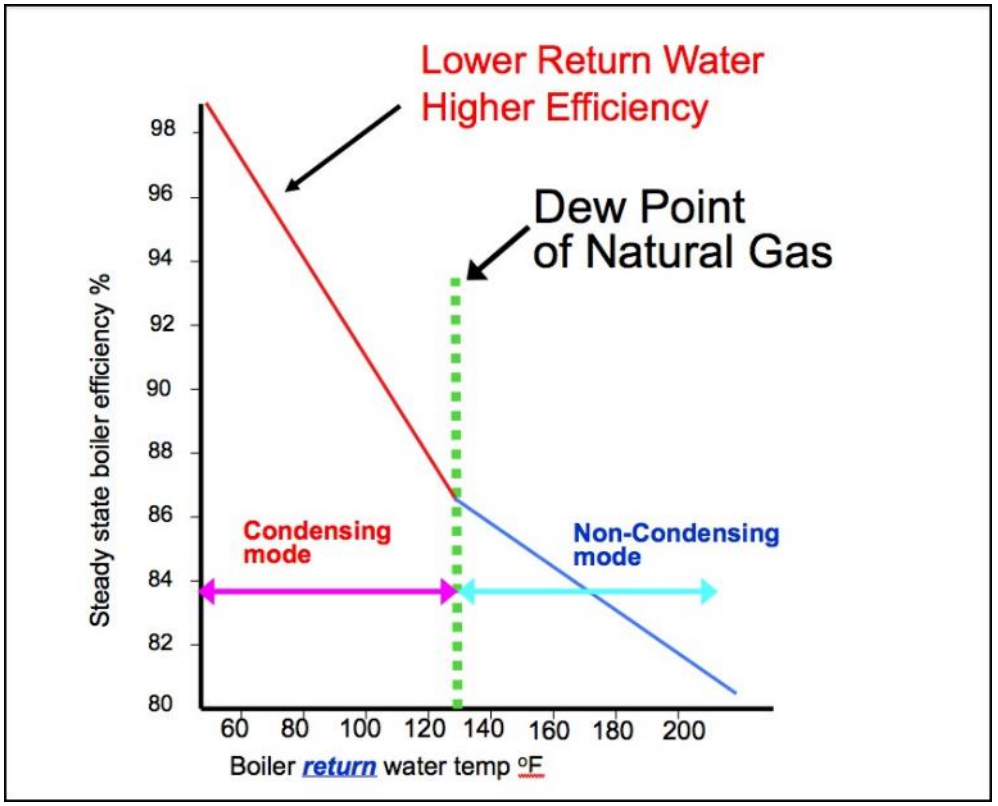
Are All Boilers Designed to Condense?

NO!

And if condensation occurs within a boiler OR vent system that has not been designed to handle condensate this can lead to dangerous life threating operation

What Causes The Condensation?

H2O (Water Vapor) from combustion process will condense at dew point temperatures

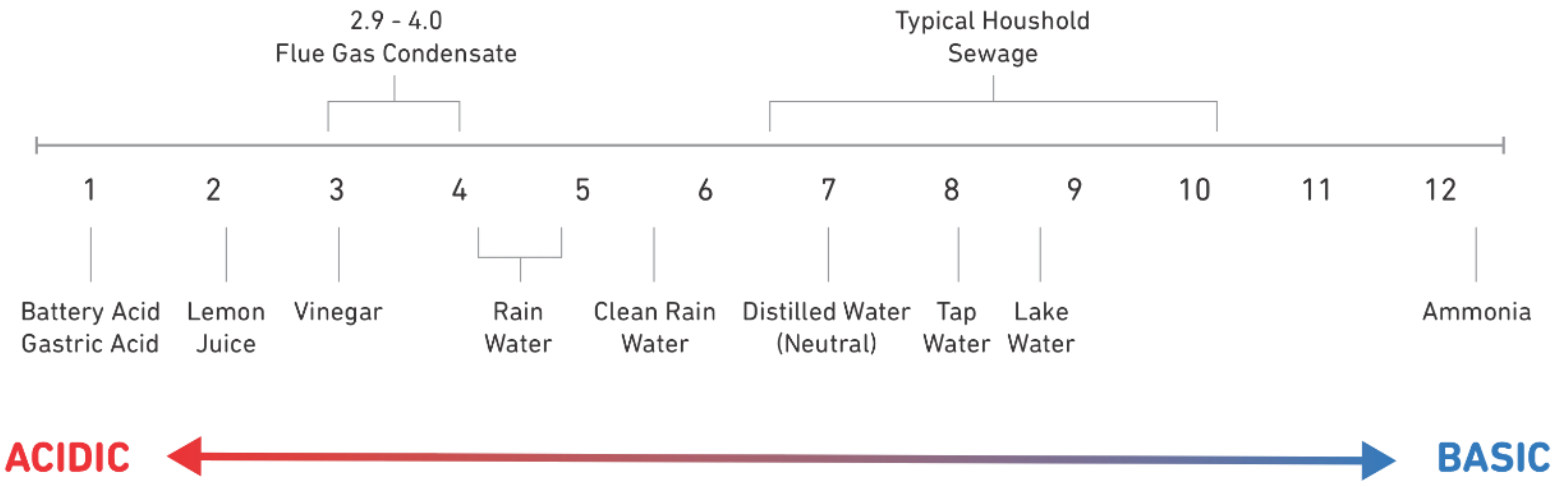


Typical Flue Temperature with 160 inlet & 180 outlet boiler water temperatures
80% AFUE – 305 F 82% AFUE – 275 F 84% AFUE – 190 F
95% AFUE – 115 F

The Acidic Nature of Condensate

When hydrocarbons combust, they produce carbon dioxide gas and water, but fuel is rarely pure hydrocarbons. It always contains some impurities, namely Sulfur and it is this Sulfur that causes the most problems. When any of these hot gasses come in to contact with water vapor, they react to form acids.

Condensate expelled from a condensing boiler is acidic, with a pH between 3 and 4.



Problems and dangerous situations will occur if a non-condensing boiler begins to condense

- Acidic condensate will corrode the heat exchanger and block off the flue passage
- Acidic condensate in the vent piping will also corrode the venting materials and masonry chimney

The Acidic Nature of Condensate

As traditional gas boilers have become more efficient the vent temperatures have decreased

Special attention concerning chimney construction and venting systems

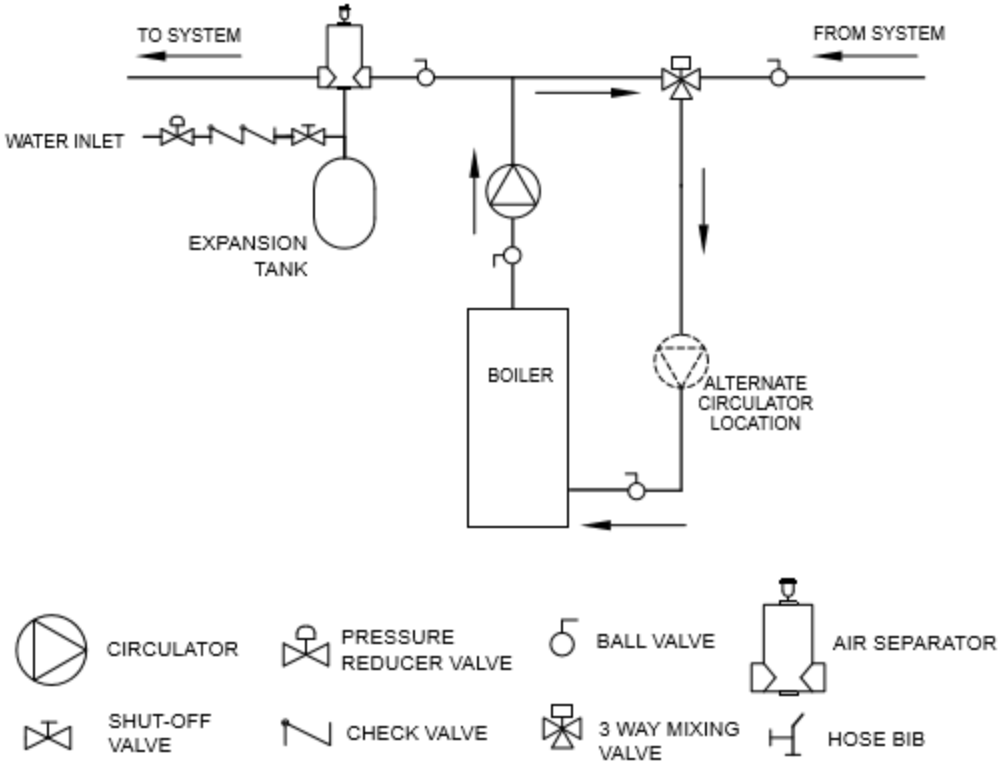
The Acidic Nature of Condensate

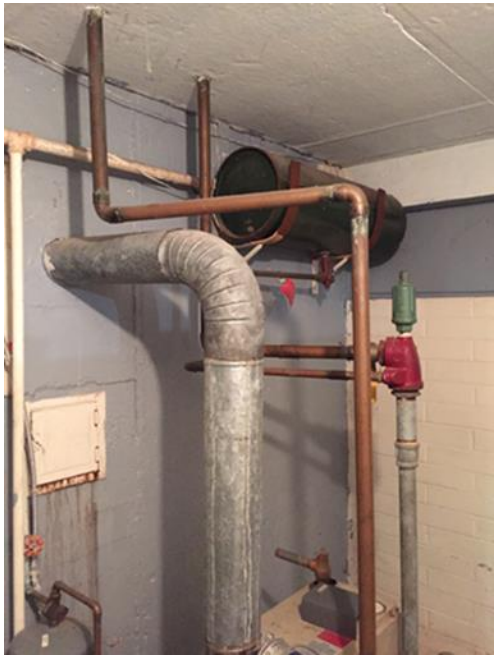
What you can't see

What Can Happen

An Old in-floor heating system using copper tubing in the concrete slab. Bypass piping line was not installed by the contractor. The bypass piping is necessary to maintain the boiler return water above 140F. This was not done, resulting in very low return water temperatures in the boiler and flue vent.

Bypass Piping With Mixing Valve





What Can Happen

Condensation occurred in both the boiler and venting system

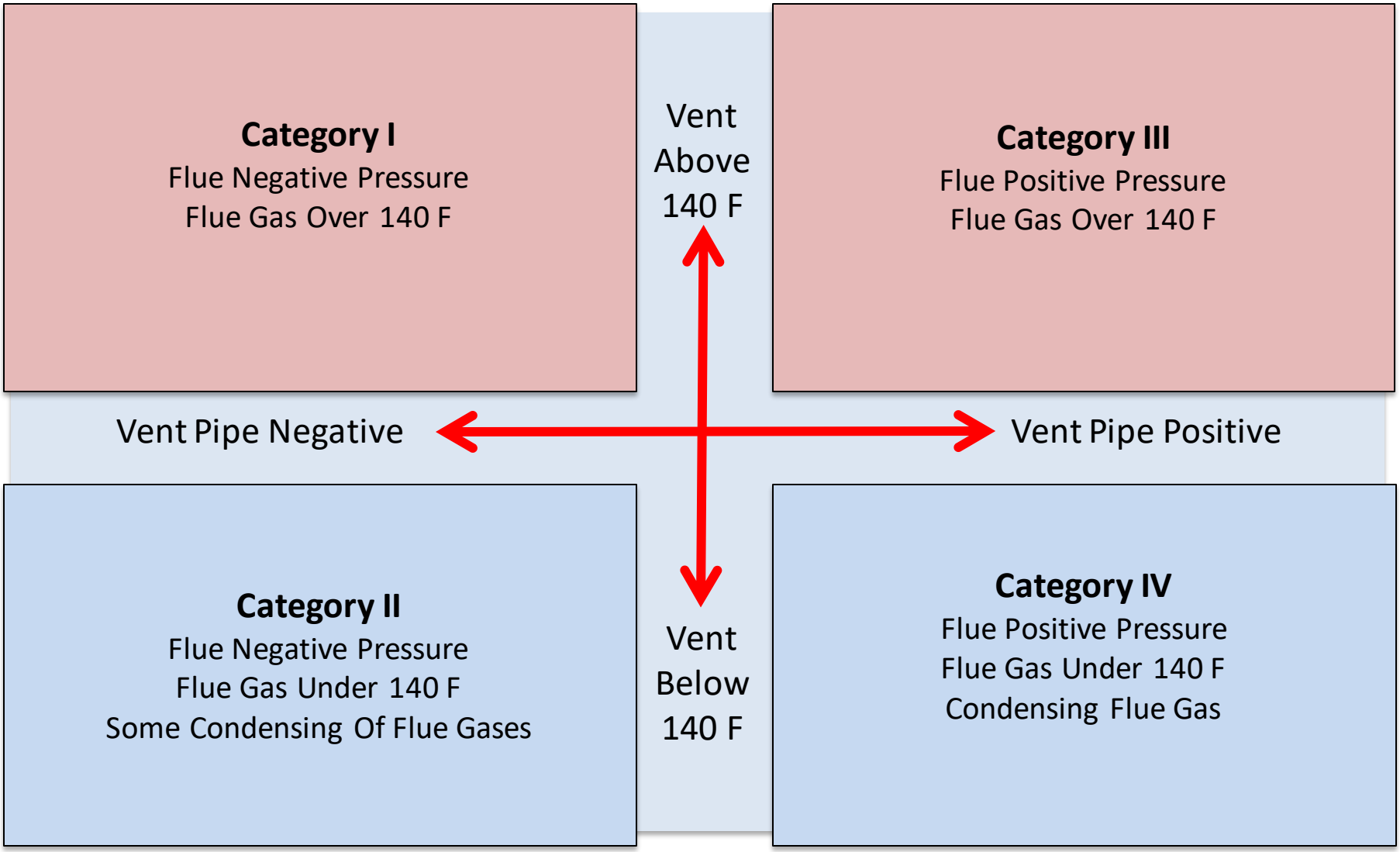
HEX blockage and resulting flame rollout. Carbon Monoxide

If condensation occurs within a boiler OR vent system that has not been designed to handle condensate this can lead to dangerous life threating operation

Vent Categories

An industry standard used to classify a gas-fired appliance according to its venting type with consideration to its vent gas temperature and vent pressure

Traditional Vent Categories



Product Vent Categories

Category I

Flue Negative Pressure
Flue Gas Over 140 F

Category III

Flue Positive Pressure
Flue Gas Over 140 F

Boilers can sometimes be listed as both category I & III, depending upon how the boiler is installed

Category I & III

Table 2 - Combustion Air and Vent Pipe Fittings
Category I (Chimney Vent)

Item	Material	Standards
Vent Pipe & Fittings	Type B Vent	UL 441, ULC S605
	Masonry Chimney - must conform to proper sizing and materials	National Fuel Gas Code, ANSI Z223.1/ NFPA 54
Combustion Air	Stainelss Steel, PVC, CPVC, PP, Aluminum	ANSI/ASTM D2564, ANSI/ASTM F493, UL 1738/ULC636-08

Boiler is provided with a 3" vent connection, 3" x 4" or larger increaser must be field installed for chimney applications

Table 3 - Combustion Air and Vent Pipe Fittings

Type	Item	Diameter	Min Lenght	Max Lenght	Material	Standards
Direct vent	Vent	3"	5 ft	65 ft	AL294C Stainless Steel, Aluminum	UL1738, ULC S636
	Air intake	3"	5 ft	65 ft	Stainelss Steel, PVC, CPVC, PP, Aluminum	ANSI/ASTM D2564, ANSI/ ASTM F493, UL 1738/ULC636-08
Category III	Vent	3"	5 ft	65 ft	AL294C Stainless Steel, Aluminum	UL1738, ULC S636

Boiler appliance adapter is required to connect the specific venting system for Category III applications

Product Vent Categories

Category II

Flue Negative Pressure
Flue Gas Under 140 F
Some Condensing Of Flue Gases

Category IV

Flue Positive Pressure
Flue Gas Under 140 F
Condensing Flue Gas

Condensing boilers are Category IV

Category IV

Vent Material Options			
125 & 150		**165 & 205**	
1	4" / 2" [100 mm / 60 mm] polypropylene coaxial.	1	5"/3" [125 mm/80 mm] polypropylene coaxial.
2	3" [80 mm] polypropylene twin pipe. Shall be polypropylene on BOTH intake and exhaust.	2	3" [80 mm] polypropylene twin pipe. Shall be polypropylene on BOTH intake and exhaust.
3	2" [60 mm] polypropylene twin pipe. Shall be polypropylene on BOTH intake and exhaust.	3	2" [60 mm] polypropylene twin pipe. Shall be polypropylene on BOTH intake and exhaust.
4	3" [80 mm] flexible polypropylene for chimney exhaust vent, shall have rigid 3" [80 mm] polypropylene on air intake.	4	3" [80 mm] flexible polypropylene for chimney exhaust vent, shall have rigid 3" [80 mm] polypropylene on air intake.
5	3" [80 mm] Twin pipe CPVC. PVC optional on intake ONLY.	5	3" [80 mm] Twin pipe CPVC. PVC optional on intake ONLY.

* Note: Adapters and fittings used with all vent systems shall be from same manufacturer and compatible with the vent pipe. See list for approved Manufacturers.

⚠WARNING

ABS/PVC venting shall not to be used this product.

Use of DWV plumbing pipes to vent this boiler shall be prohibited.

Use of cellular core PVC (ASTM F891), cellular core CPVC, or Radel® (polyphenolsulfone) in venting systems shall be prohibited.

Covering non-metallic vent pipe and fittings with thermal insulation shall be prohibited.

Failure to follow these instructions could result in death or serious injury.

Always check the IOM **and local codes** for venting material options! Venting options depend upon the specific boiler design/model

Category IV

⚠ WARNING

Use of cellular core PVC for venting flue gas could result in death, or serious injury.

Table 4 - Combustion air and vent pipe fittings must conform with the following:		
Item	Material	Standards
Vent Pipe and Fittings	PVC schedule 40	ANSI/ASTM D1785
	PVC - DWV	ANSI/ASTM D2665
	CPVC schedule 40	ANSI/ASTM D1784/ F441
	SDR-21 & SDR-26 PVC	ANSI/ASTM D2241
	ABS-DWV	ANSI/ASTM D2661
	Schedule 40ABS	ANSI/ASTM F628
	PP (Polypropylene) Pipe and Components	UL 1738 ULC S636-08
Pipe Cement/ Primer	PVC	ANSI/ASTM D2564
	CPVC	ANSI/ASTM F493
	Schedule 40 ABS	ANSI/ASTM D2235
• IPEX is approved vent manufacturer in Canada listed to ULC-S636. • IPEX System 636 Cements and Primers are approved in Canada listed to ULC-S636.		
Use of cellular core PVC (ASTM F891), cellular core CPVC, or Radel®, (Polyphenolsulfone) in venting systems shall be prohibited.		

Always Check the IOM **and local codes** for allowable Venting Materials!

UL Standards

UL Standards

UL 441 – Standards for Gas Vents

- Standard for type B and BW gas vents.
- Intended for venting gas appliances equipped with draft hoods to burn only gas.
- Type B vents are also intended for use with other Category I appliances that specify they are for use with Type B gas vents.

UL 1738 – Standard for Safety USA

- Standard for venting systems for gas-burning appliances.
- Venting systems covered by these requirements are intended to be used with Category II, III and IV appliances that have been installed in accordance with NFPA 54 and codes such as the BOCA National Mechanical Code, the Standard Mechanical Code, the Uniform Mechanical Code **and local codes**

Specifically addresses the construction requirements, test performance criteria, marking requirements and Installation and maintenance instructions of the vent system.

UL Standards

UL 1777 – UL Standard for Safety Chimney Liners

- These requirements cover metallic and nonmetallic chimney liners intended for field installation into new or existing masonry chimneys that are used for natural draft venting of Category I gas-fired, Type L vented oil fired and solid-fuel-fired residential type appliances maximum continuous flue-gas outlet temperatures do not exceed 1000 F
- Chimney liners as covered by these requirements **are not intended** for use with Category II, III or IV gas burning appliances.

ULC Standards Council Of Canada

ULC S636 – Standards Council of Canada

- Standard for type BH gas venting systems.
- Standard covers the design, construction, and performance of gas venting systems intended for negative or positive pressure venting of gas-fired appliances.
    1) Class I venting – flue gas more than 135 C but not more than 245 C
    2) Class II venting – flue gas temperatures of 135 C or less. Further classified into four temperature ratings as follows:
        (a) up to and including 65 C (149F)
        (b) up to and including 90 C
        (c) up to and including 110 C
        (d) up to and including 135 C

Venting Materials & Temperatures

Vent Type	Category	Flue Pressure	Maximum Flue Temperature Continuous
Type B	Category I - Gas appliances	Negative	400 F
Type BW	Category I - Typically recessed gas heaters	Negative	400 F
Type L	Category I – Oil-fired and gas appliances	Negative	570 F
Polypropylene	Category II & IV – Gas appliances	Negative & Positive	**230 F**
PVC	Category IV - Gas appliances, use is determined by **local codes** and equipment manufacturer	Typically Used Positive	**140 F**
CPVC	Category IV - Gas appliances, use is determined by **local codes** and equipment manufacturer	Typically Used Positive	**200 F**

Should PVC Be Used For Venting?

PVC Manufacturer Position

CHARLOTTE PIPE AND FOUNDRY COMPANY

Should Plastic Pipe & Fittings Be Used to Vent Combustion Gasses?

Use of plastic pipe to vent combustion gasses produced by water and space heating equipment has become common practice among plumbers and builders. Some equipment manufacturers expressly recommend this practice. Occasionally, Charlotte Pipe is asked for its position on the use of plastic pipe and fitting products for this application.

Conclusion

At present there is little data available on the safety or durability of plastic pipe products used to vent combustion gases. The ASTM has not addressed this application, and the available data is insufficient for the plastic pipe and fitting industry to develop consensus specifications or guidelines. Equipment manufacturers are most knowledgeable about their own products and are best equipped to determine how their gas-fired heating equipment should be vented. Accordingly, Charlotte Pipe recommends that inquiries about the suitability of plastic piping systems to vent combustion gasses be directed to the manufacturer of the water or space heating equipment being installed.

Venting Materials Code Changes

2014 NYC Bans PVC Venting

503.4.1 Plastic Piping. Plastic piping used for venting appliances listed for use with such venting materials shall be listed and installed in accordance with the terms of its listing and the manufacturers' instructions. Installation shall be in accordance with the New York City Building Code. **PVC shall not be permitted.**

2016 NH State Code Proposed Change

12.5.3 Plastic Vent Joints. Plastic piping and fittings used to vent appliances shall be installed in accordance with the appliance manufacturer's installation instructions, *provided the maximum set point of a fixed or adjustable, water and/or flue gas, high limit setting of the appliance, does not exceed the safe operating temperature of the venting material selected*.

2018 MA State Code Proposed Changes

The Board is reviewing this matter with stakeholders, including installers and manufacturers of gas appliances as well as manufacturers of the pipes commonly used for venting. A draft code change is being proposed which would restrict the types of plastic pipes which can be used for venting in future installations. Once language has been formally approved for public hearings, notices and additional information will be provided at the Board's website: **www.mass.gov/dpl/boards/pl**.

New DOE Efficiency Standards

ECR international
EST. 1928
A Family of Heating & Cooling Brands.

DOE 2021 Efficiency Requirements

Boiler Type	New AFUE Requirement
Gas Fired Hot Water	84% AFUE
Gas Fired Steam	82% AFUE
Oil Fired Hot Water	86% AFUE
Oil Fired Steam	85% AFUE
January 15, 2021 – Last Date To Manufacture Boilers built prior to that date can continue to be sold	

New standards further reduce vent temperatures so care must be taken to ensure boiler and venting systems are adequate when replacing an Older Boiler

Home Fires NFPA Statics

- National Fire Protection Association (NFPA) has estimated an average of 52,050 fires involving heating equipment 2012 to 2016.
- Average of 490 civilian deaths.
- Space Heaters accounted for more than (44%) of home heating equipment fires but they were responsible for 86% of civilian deaths.

Fires in which the heating source was too close to combustibles were the largest share of deaths, injuries and property damage.

Thank You