

Venting and Chimney Best Practices for Cordwood Gasification and Pellet Boilers

*Webinar presented in support of
Renewable Heat NY*



AIA approved course:
RHNYWEB32017
1.0 LU credits

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Appropriate Designs
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New York State Energy Research &
Development Authority (provider #I034)

**Venting and Chimney Best Practices for
Cordwood Gasification and Pellet Boilers**

RHNYWEB32017

Nov 16, 2017

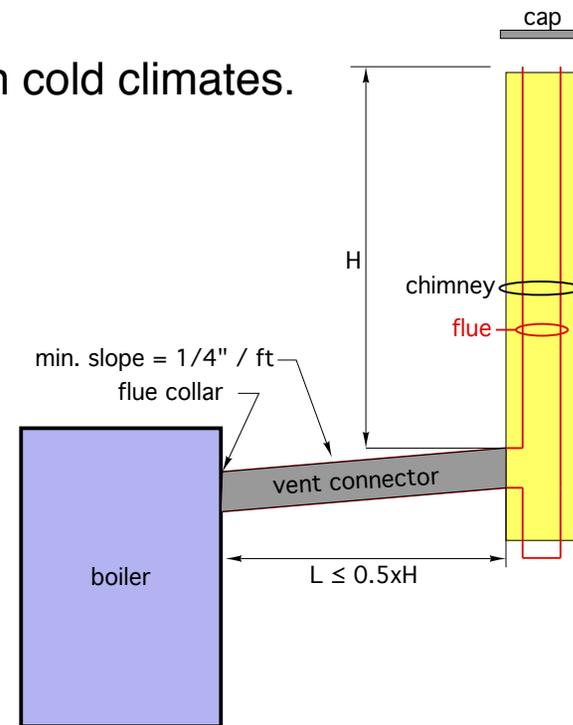


Venting and Chimney Best Practices for Cordwood Gasification and Pellet Boilers

Description: Biomass boilers operate differently than gas-fired or oil-fired boilers. At times they can create positive pressure in the venting system. A venting system designed for a fossil fuel boiler, but used with a biomass boiler, may not prevent leakage of combustion products. A properly designed vent connector and chimney can reduce the potential leakage. This webinar discusses the issues and hardware necessary to create a proper venting system for biomass boilers based on field experience with pellet-fired boiler and cordwood gasification boilers.

Learning Objectives:

1. Explain the effects associated with positive vent pressure.
2. Understand differences between vent connector piping options.
3. Understand advantages of UL-103HT chimney systems.
4. Understand the limitations of exterior masonry chimneys in cold climates.
5. Describe the function of draft regulators.



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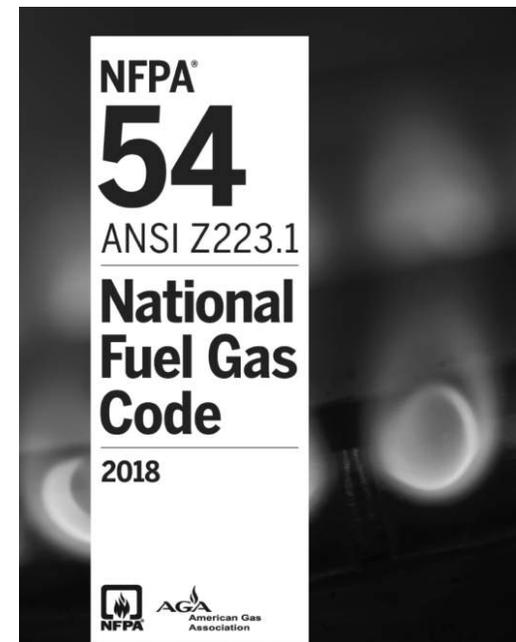
Air Supply to Boiler

Air supply to boiler

The space where the biomass boiler is located require air for:

1. Combustion
2. Flue gas dilution
3. Ventilation to prevent excessive temperature in boiler room

Most biomass boilers are designed to draw combustion air from the space around them. Some can be equipped with fresh air intake duct, but they are not “sealed combustion.”
The fresh air is ducted into the boiler jacket (for preheating).



Be sure there are no chlorine-based chemicals, solvents, detergents, halogens, or combustible chemicals in space with boiler. (Can cause severe corrosion if vapors enter combustion chamber). Don't dry washed clothing in mechanical rooms.

NFPA 54/2018: No outside air required to boiler space if:

Space volume $> 50 \text{ ft}^3$ per 1000 Btu/hr *input* rating of all combustion equipment in space, AND air changes per hour known to be greater than 0.4 ACH (natural air changes per hour).

If ACH (natural air changes per hour) of space is known:

- minimum unconfined space volume (ft^3) = $21/\text{ACH}$ per 1000 Btu/hr fuel input rating*
- If appliance is fan-assisted minimum unconfined space volume (ft^3) = $15/\text{ACH}$ per 1000 Btu/hr fuel input rating*

* formulas cannot be used for known ACH > 0.6

Combustion air supply

When boiler room draws air from OUTSIDE:

NFPA 54/2018, National Fuel Gas Code:
If air comes directly from outside, and two openings are used: 1 in² free area per 4000 Btu/hr of fuel input rating of all appliances in the space.

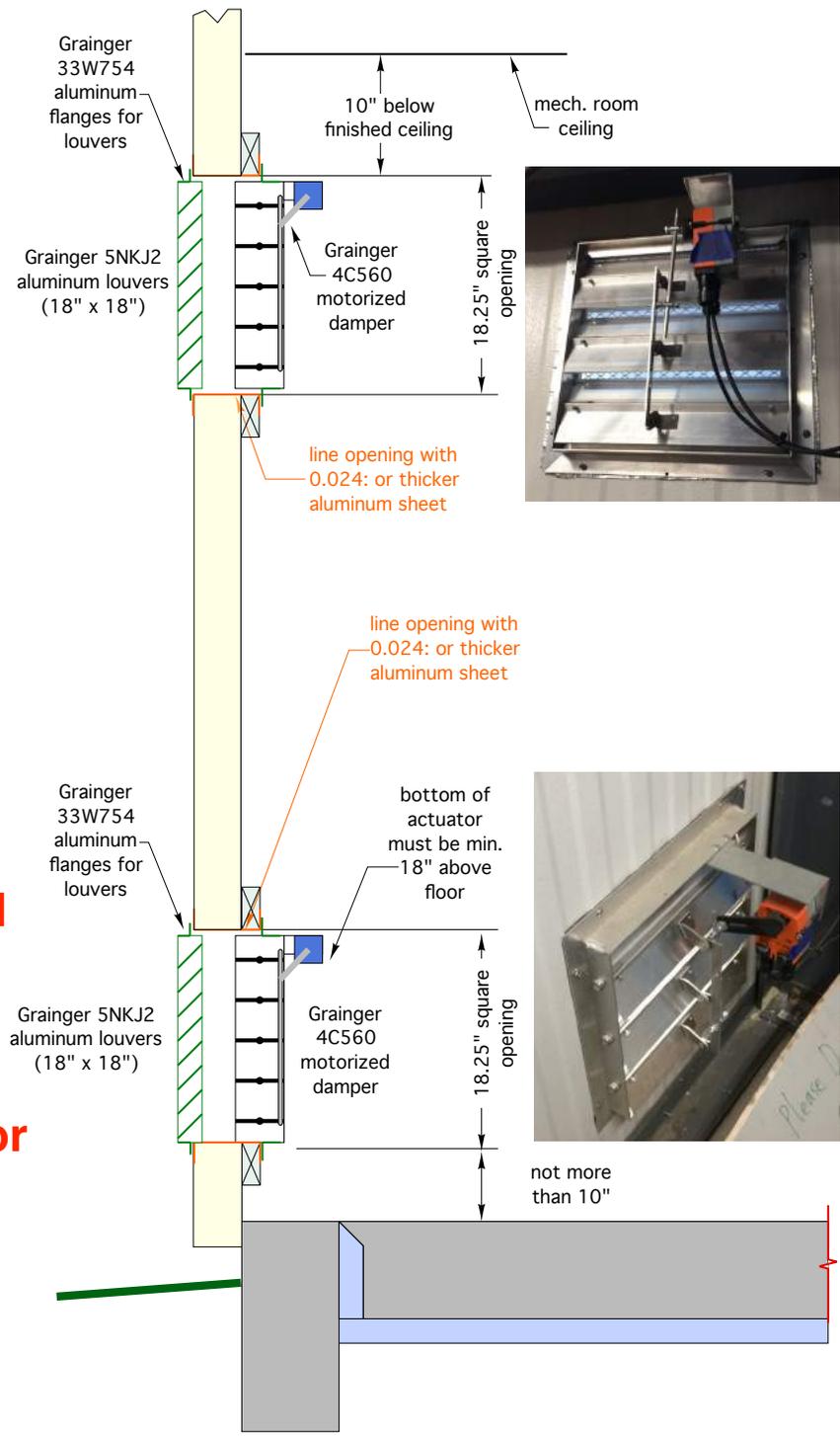
NFPA 54/2018, National Fuel Gas Code:
If air comes directly from outside, and one opening (within 12" of ceiling) is used: 1 in² free area per 3000 Btu/hr of fuel input rating of all appliances in the space, and not less than sum of cross section areas of all vent connectors in the space.

For wood louvers:
 Free area = opening area / 0.25

For metal louvers:
 Free area = opening area / 0.75



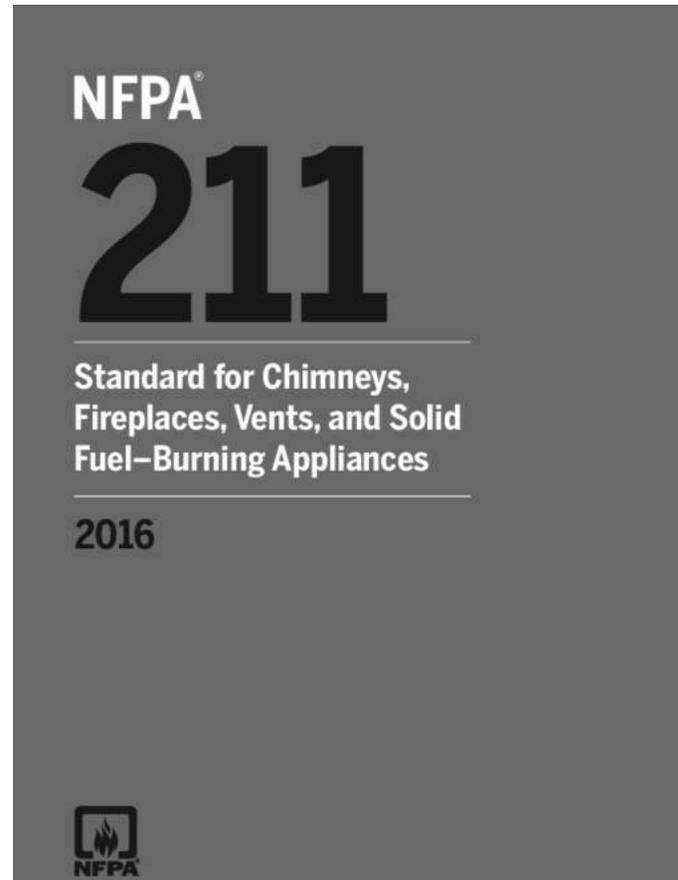
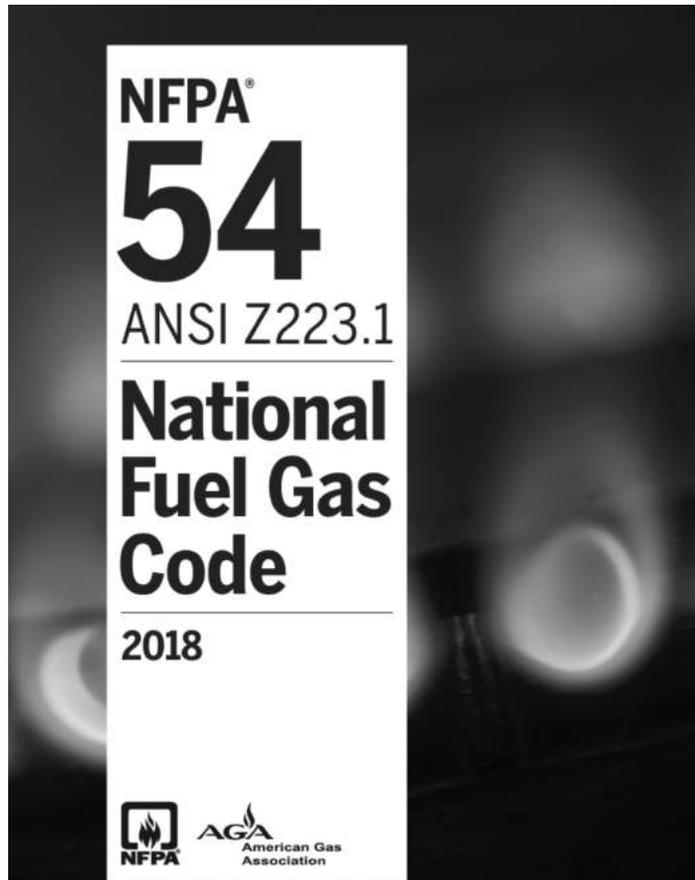
If motorized louvers are used they must be verified prior to burner operation.



Chimney options

NFPA 54 / National Fuel Gas Code (2018), and NFPA 211 (2016) are general references.

Much of the NYS Mechanical code dealing with chimneys & venting is based on these standards.



Free online access: <http://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards>

Chimneys for pellet and cordwood gasification boilers

Class A “all fuel” chimney (UL103-HT) 1000 °F continuous, 2100 °F, 10 minute. (stainless inner & outer wall, insulated) is recommended by most boiler manufacturers. (NFPA 211)

Opinions vary on the practicality of side wall venting: Most biomass boiler manufacturers don't recommend side wall venting.

Some available products:

<http://www.olympiachimney.com/ventis-class-a-all-fuel-chimney-pipe>

<http://www.selkirkcorp.com/~media/selkirk/reference-documents/common/file/product-literature/chimney/ultratemp-514/brochure--all-fuel-chimney-buyers-guide-mbafcbg.pdf>

<http://www.duravent.com/Product.aspx?hProduct=1>

http://www.hartandcooley.com/files/assets/files/1371500382_HartandCooley_TLC_Catalog_0613.pdf



Image source: Hart & Cooley



Image source: Selkirk



Image source: Simpson Duravent

Chimneys for biomass boilers

For commercial buildings, stack heights should be consistent with good engineering practice to minimize the wake effects caused by buildings or terrain on emissions. (see www.epa.gov/ttn/scram/guidance_permit.htm for some EPA documents on good engineering stack height and modeling).

plume drifting toward school

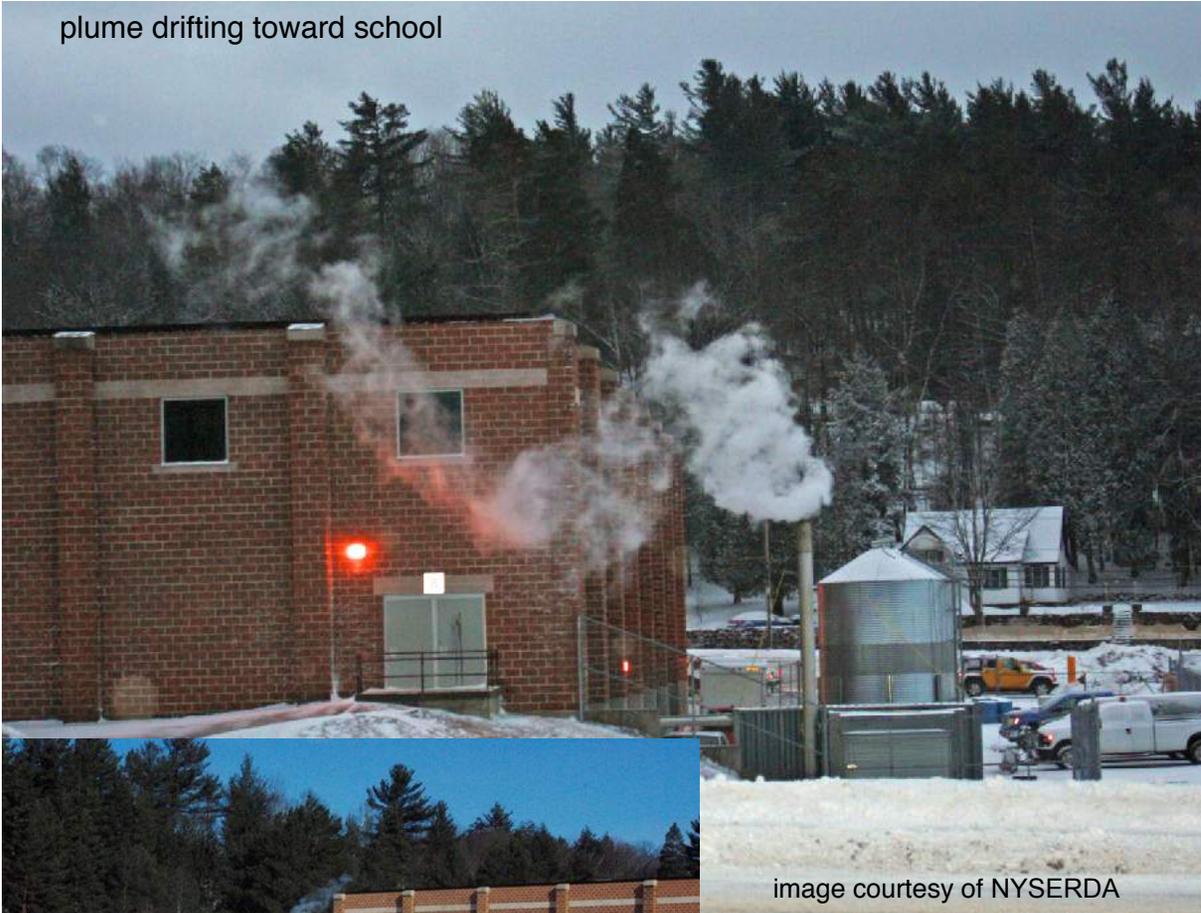


image courtesy of NYSERDA

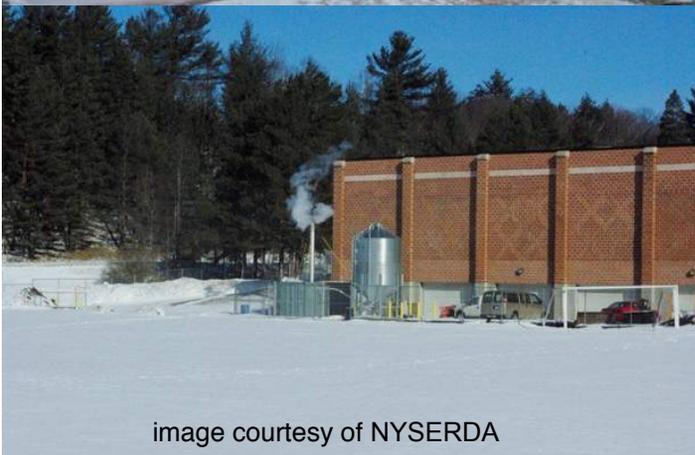


image courtesy of NYSERDA

Good entrainment of plume



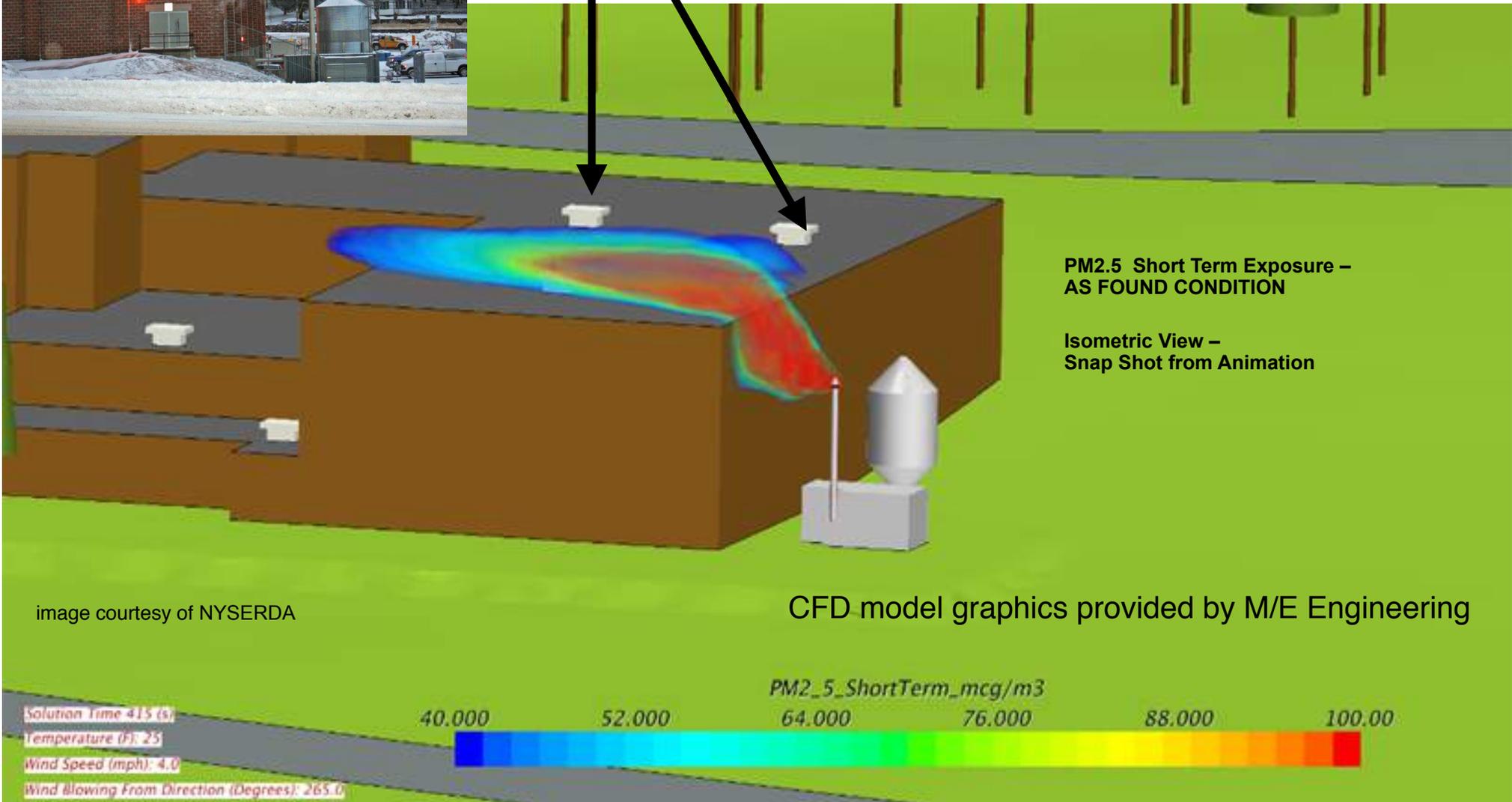
Computational fluid dynamics (CFD) modeling in chimney wake relative to building(s).

plume drifting toward school



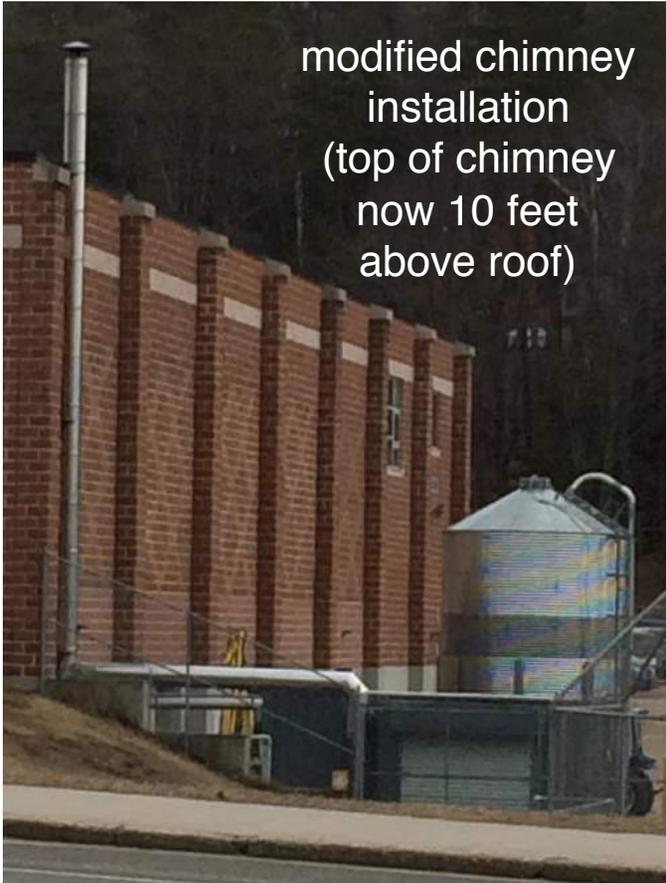
Ventilation air intakes on roof

Note that chimney wake “hugs” flat roof line.

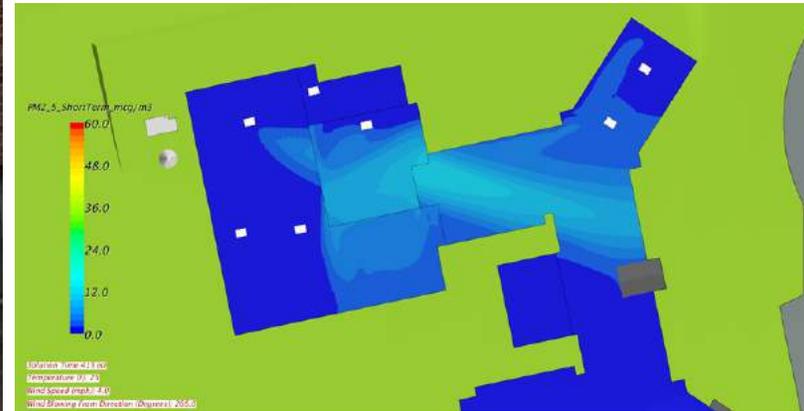
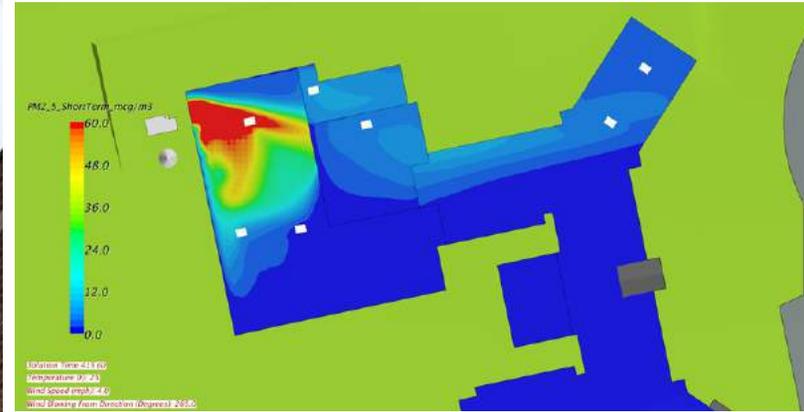


Lesson learned

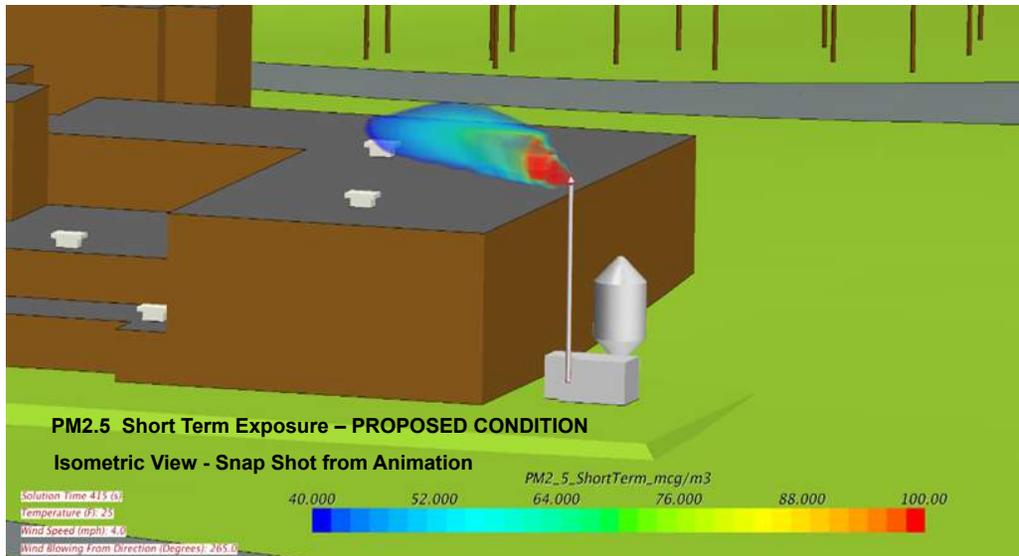
image courtesy of NYSERDA



PM2.5 Short Term Exposure – AS FOUND CONDITION



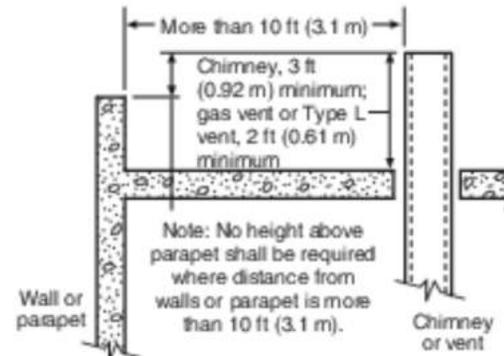
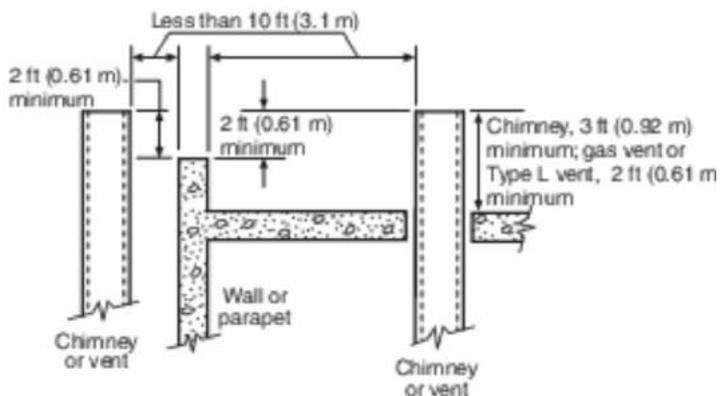
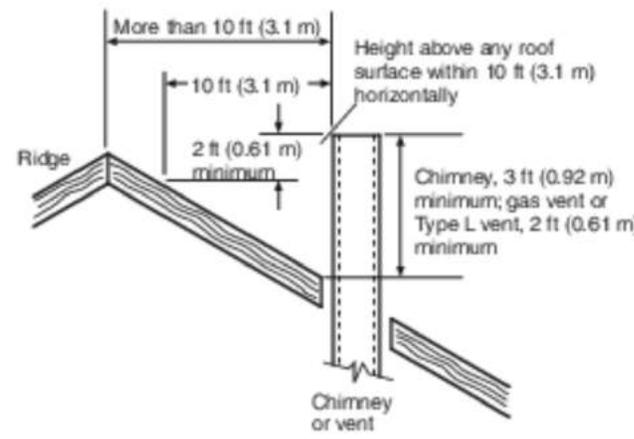
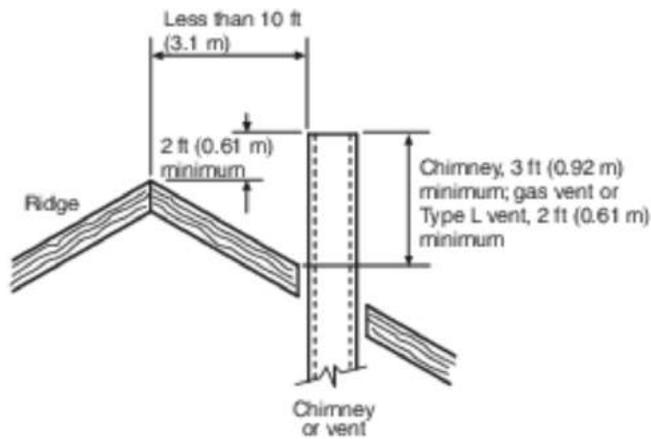
PM2.5 Short Term Exposure – PROPOSED CONDITION



CFD model graphics provided by M/E Engineering

Code requirements on chimneys

1. Top of chimney min. 2 feet above anything within 10 foot radius, and at least 2 feet higher than ridge, wall or parapet if within 10 feet of ridge, wall, or parapet. (503.5.4), NFPA 211
2. Top of chimney min. 3 feet above where it penetrates the roof. (503.5.4), NFPA 211
3. **Cannot connect a vent from a solid fuel appliance to same flue serving a gas-fired appliance (503.5.7.1)**



chimney < 10 ft from roof ridge

chimney > 10 ft from roof ridge

Check with boiler manufacturer on *minimum* chimney heights.

Most biomass boilers have draft inducing fans

Situation: Boiler starts up (draft fan on) but little if any draft established in cold chimney.

Exterior masonry chimney are the worst due to large / cold thermal mass.



Causes: Temporary POSITIVE pressure in vent connector piping.

Leads to: Leakage of flue gases and fly ash between joints in vent connector piping, boiler air intake, barometric damper.



This chimney was, at one time, venting both an oil-fired boiler and a pellet boiler.

A violation of NYS Mechanical code, section 801.11



*The fix.
UL-103 HT
chimney for
pellet boiler*

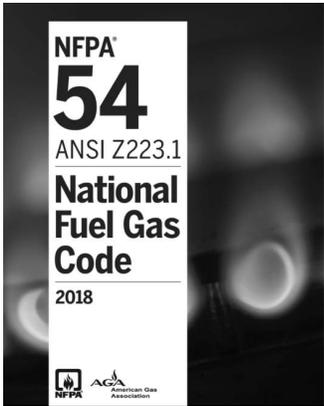


Exterior masonry chimneys have minimum allowable combustion appliance input ratings depending on climate

Table 13.2(g) Exterior Masonry Chimney

		Number of Appliances:		Two or More				
		Appliance Type:		NAT + NAT				
		Appliance Vent Connection:		Type B Double-Wall Connector				
Minimum Allowable Input Rating of Space-Heating Appliance in Thousands of Btu per Hour								
Vent Height H (ft)	Internal Area of Chimney (in. ²)							
	12	19	28	38	50	63	78	113
Local 99% winter design temperature: 37°F or greater								
6	0	0	0	0	0	0	0	NA
8	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0
15	NA	0	0	0	0	0	0	0
20	NA	NA	NA	NA	NA	184	0	0
30	NA	NA	NA	NA	NA	393	334	0
50	NA	NA	NA	NA	NA	NA	NA	579
100	NA	NA	NA	NA	NA	NA	NA	NA
Local 99% winter design temperature: 27°F to 36°F								
6	0	0	68	NA	NA	180	212	NA
8	0	0	82	NA	NA	187	214	263
10	0	51	NA	NA	NA	201	225	265
15	NA	NA	NA	NA	NA	253	274	305
20	NA	NA	NA	NA	NA	307	330	362
30	NA	NA	NA	NA	NA	NA	445	485
50	NA	NA	NA	NA	NA	NA	NA	763
100	NA	NA	NA	NA	NA	NA	NA	NA
Local 99% winter design temperature: 17°F to 26°F								
6	NA	NA	NA	NA	NA	NA	NA	NA
8	NA	NA	NA	NA	NA	NA	264	352
10	NA	NA	NA	NA	NA	NA	278	358
15	NA	NA	NA	NA	NA	NA	331	398
20	NA	NA	NA	NA	NA	NA	387	457
30	NA	NA	NA	NA	NA	NA	NA	581
50	NA	NA	NA	NA	NA	NA	NA	862
100	NA	NA	NA	NA	NA	NA	NA	NA
Local 99% winter design temperature: 5°F to 16°F								
6	NA	NA	NA	NA	NA	NA	NA	NA
8	NA	NA	NA	NA	NA	NA	NA	NA
10	NA	NA	NA	NA	NA	NA	NA	430
15	NA	NA	NA	NA	NA	NA	NA	485
20	NA	NA	NA	NA	NA	NA	NA	547
30	NA	NA	NA	NA	NA	NA	NA	682
50	NA	NA	NA	NA	NA	NA	NA	NA
100	NA	NA	NA	NA	NA	NA	NA	NA
Local 99% winter design temperature: 4°F or lower Not recommended for any vent configurations								

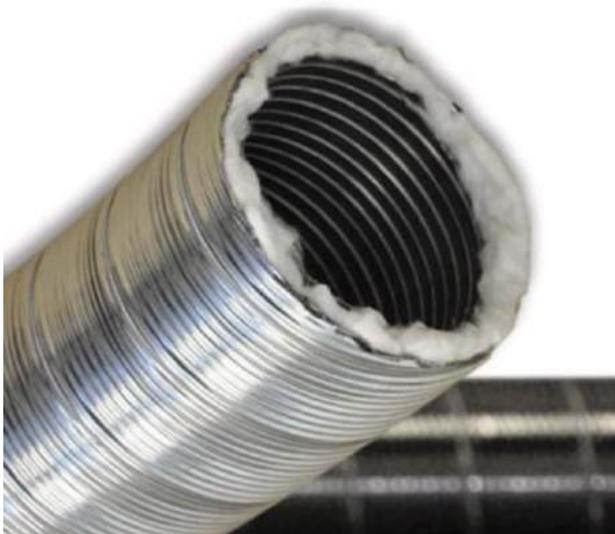
For SI units, 1 in. = 25.4 mm, 1 in.² = 645 mm², 1 ft = 0.305 m, 1000 Btu/hr = 0.293 kW, °C = (°F - 32) / 1.8.
Note: See Figure F2.4 for a map showing local 99 percent winter design temperatures in the United States.



Lining existing masonry chimneys with sealed *stainless steel* liners.



pre-insulated stainless steel liner



stainless steel rigid liner pipe joined with stainless steel pop rivets



images courtesy of Olympia Chimney



Always brace chimneys on metal roofs subject to snow slides

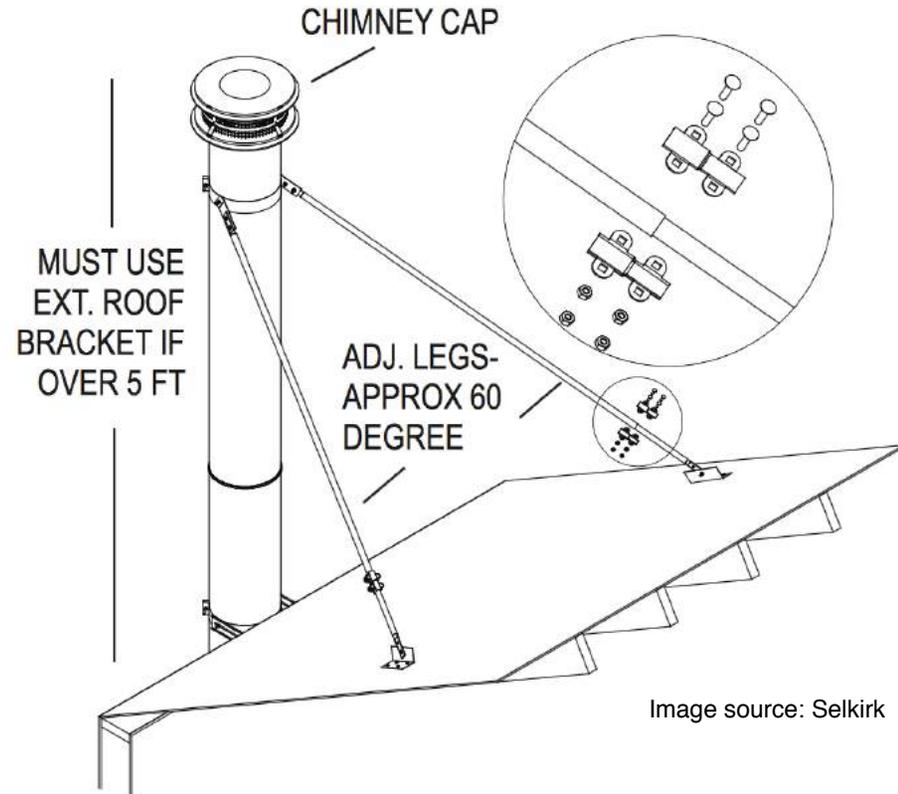
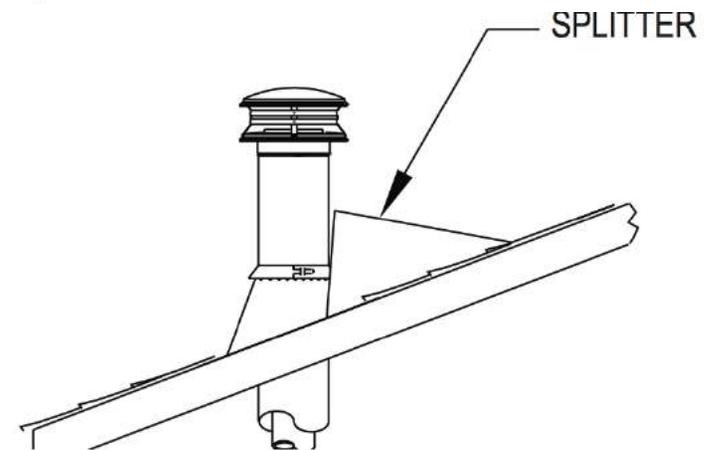
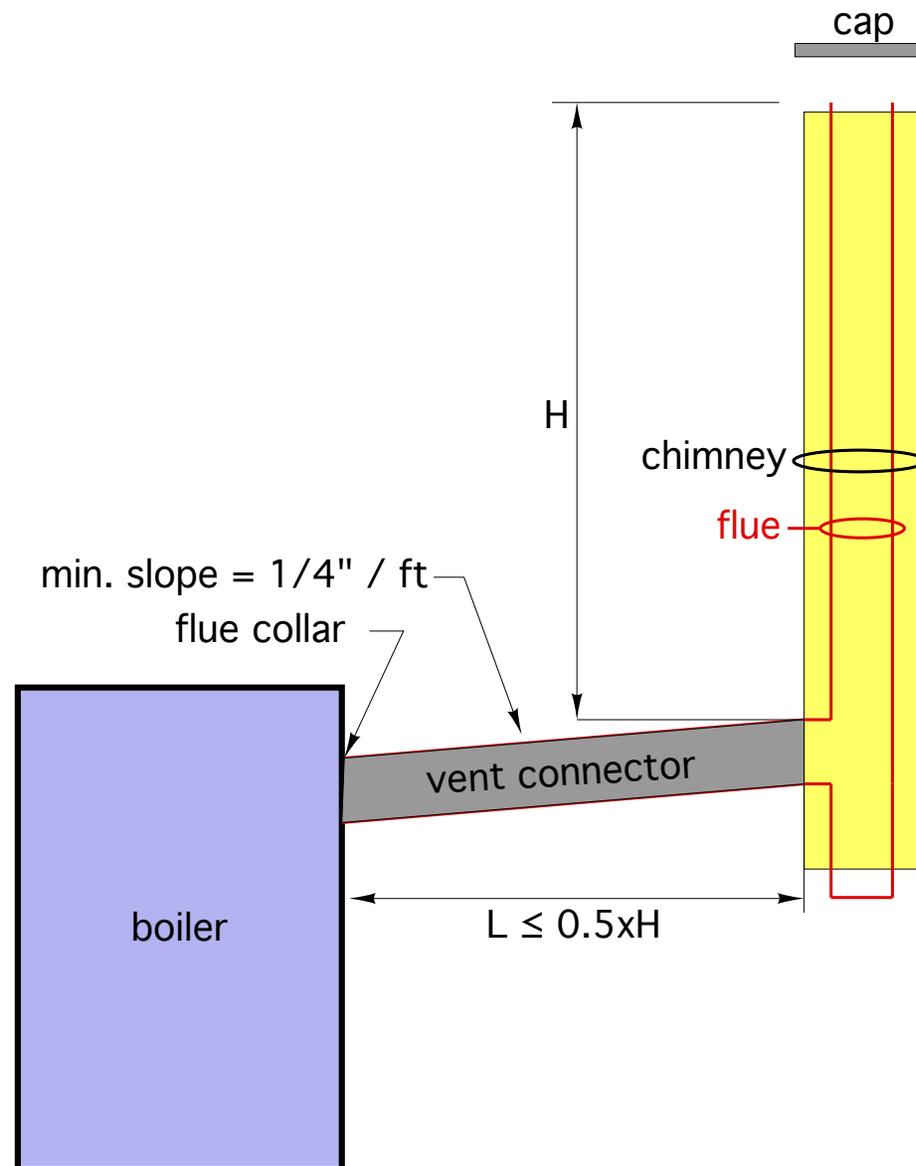


Image source: Selkirk

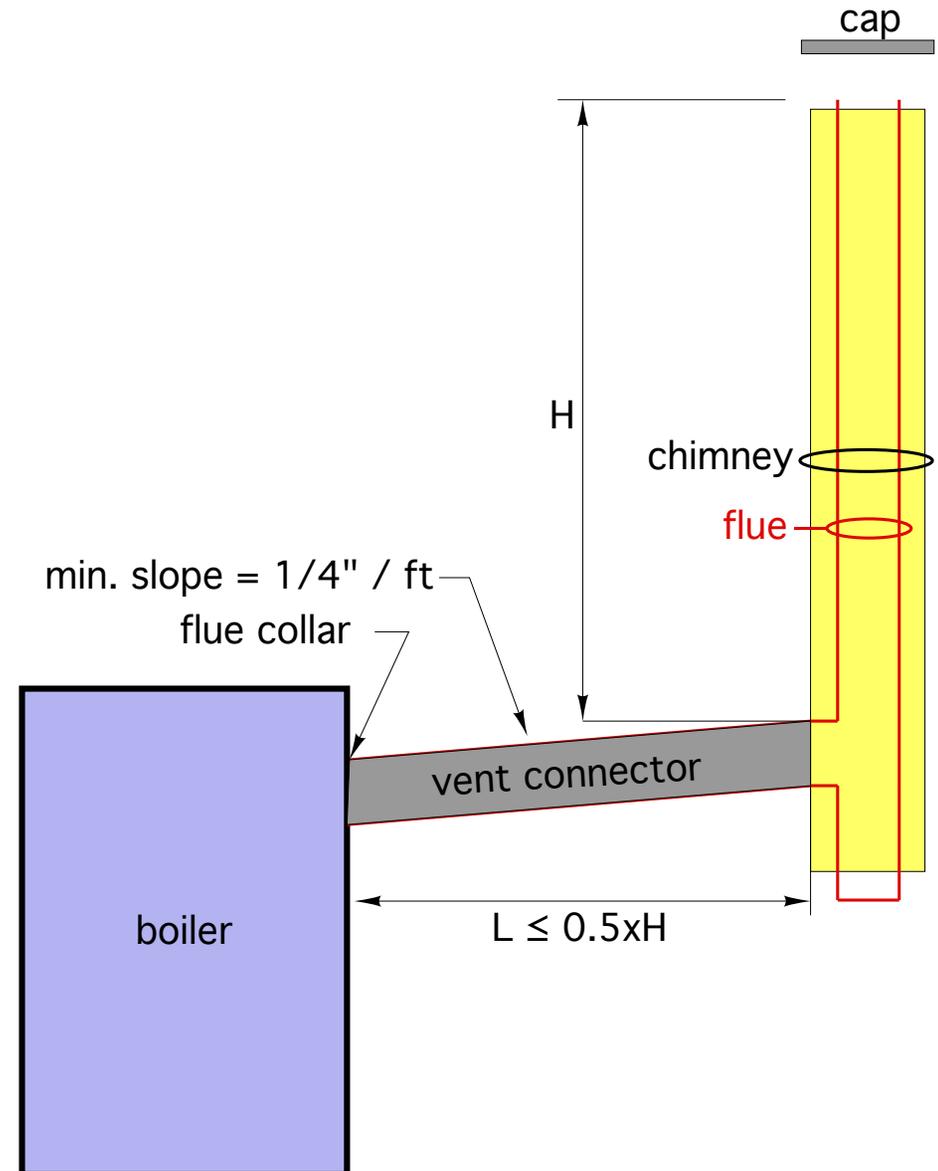


Vent connectors



General NFPA requirements for vent connectors:

- Horizontal length of vent connector from solid fuel appliance to chimney not more than 50% of chimney height above the connector.
- Cross sectional area of flue for *interior chimney* (below roof line) not more than 3x appliance vent connector cross sectional area.
- If one or more walls of chimney exposed (below roof line) the cross sectional area of flue not more than 2x appliance vent connector cross sectional area.
- Minimum upward slope of vent connector = 1/4" per foot.
- Minimum clearance to combustibles for single wall vent connector = 18 inches (there are ways to reduce this clearance with shielding).
- Minimum clearance to combustibles for double wall vent connector = 6 inches.



NYS code allows solid fuel appliances to be vented through 24 gauge (minimum thickness) galvanized steel piping.

Recommendation is to **avoid use of galvanized steel connectors** due to potential leakage of ash and flue gas at seams.



RTV silicone. Will eventually separate from galvanized pipe

Single wall welded seam stovepipe (22 gauge) can be used.

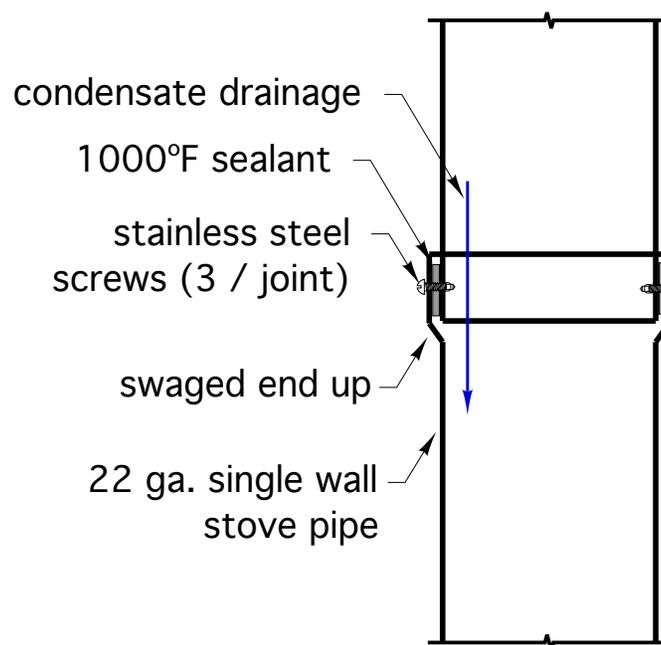
- Seal joints with high temperature (1000 °F rated) black silicone sealant



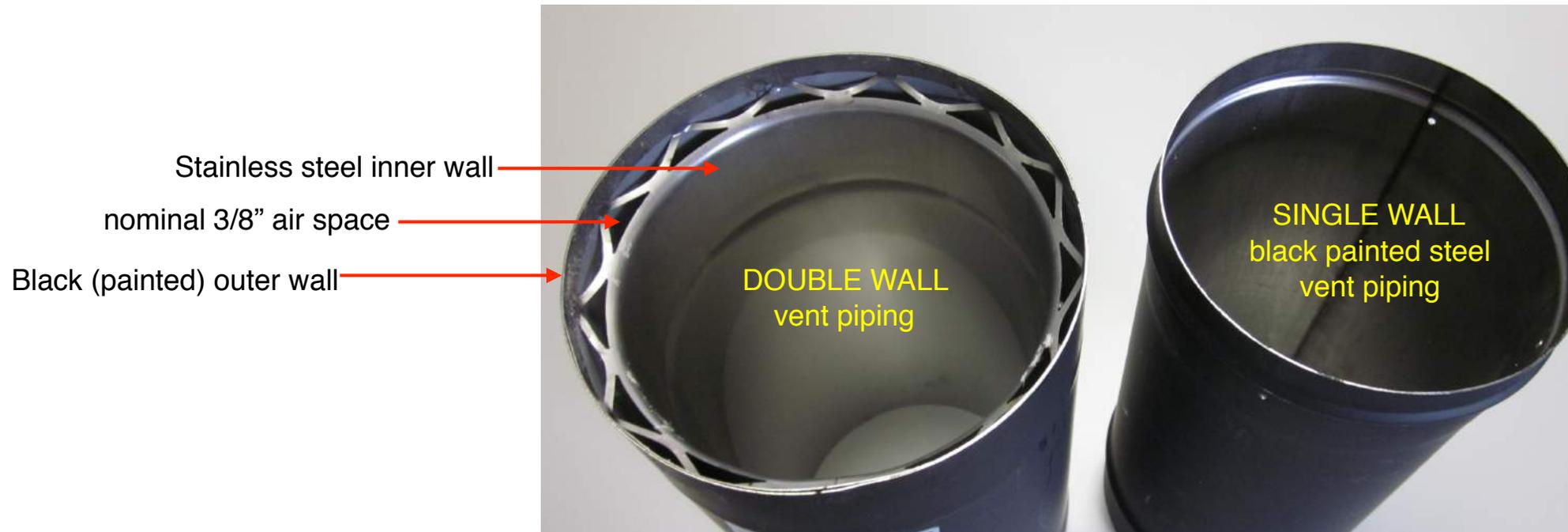
- Always join pipe so that any interior condensate, moving down pipe, remains in pipe.



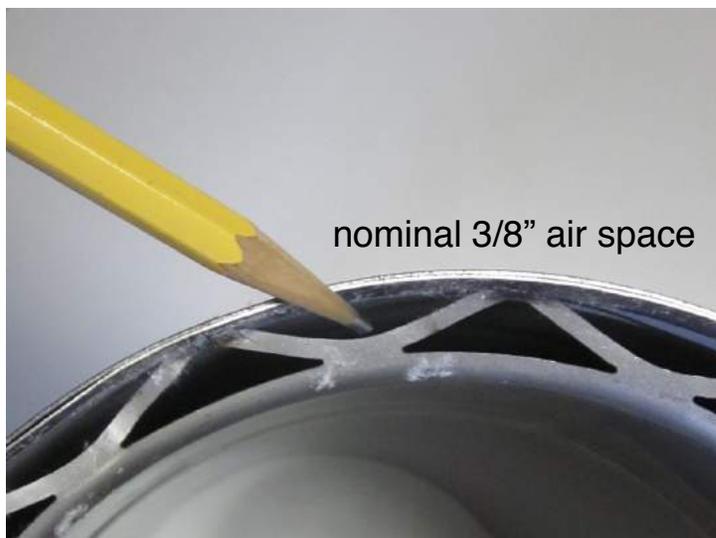
- Secure all joints in **single wall vent connector piping** with **stainless steel sheet metal screws**.



Double Wall vent connector piping allows 6" clearance to combustibles and lower surface temperature.



- Inner wall remains at higher temperature, resulting in less creosote potential.
- Outer wall remains at lower temperature, resulting in safer installation.
- Both single and double wall pipe should be *installed in proper direction* (see arrow on pipe).
- Outer wall of section should be mechanically joined with 3 screws (usually provided with pipe)



Unsealed seams in vent connector piping can leak flue gas and ash



Draft Regulation

Pellet boilers and cordwood gasification boilers are designed for **regulated** negative pressure in vent connector

Froling pellet boilers: Draft at flue connector to be -.05 to -.1 “water column (WC) range.

Econoburn cordwood boilers: Draft at flue connector in the -0.02" to -0.05” WC range.

Maine Energy Systems pellet boilers: Draft at flue connector in the -0.02" to -0.04"WC range.

From Froling cordwood gasification boiler manual

CAUTION

ADJUSTMENT OF THE FLUE DRAFT HIGHER THAN 0.12 INCHES WATER COLUMN (30 Pa) COULD CAUSE A FIRE TO BURN OUT OF CONTROL AND AN UNSAFE CONDITION!

- ☐ Maximum permitted setting: 0.12 inches WC (30 Pa)
Ideal setting: 0.04 inches WC (10 Pa)

Description		S3 Turbo	
		30	50
Flue gas temperature at nominal load	°C	170	170
	°F	340	340
Flue gas temperature at partial load	°C	110	110
	°F	230	230
Flue gas mass flow at nominal load	kg/h	76	122
	lb/h	167	270
Flue gas mass flow at partial load	kg/h	43	65
	lb/h	95	143
Required feed pressure at nominal load	Pa	8	8
	in WC	0.03	0.03
Maximum permissible feed pressure	Pa	30	30
	in WC	0.12	0.12
Flue pipe diameter	mm	150	150
	inches	6	6

Any boiler vented to a chimney requires draft regulation.

Draft regulators **limit how much negative pressure the venting system can create** (relative to atmospheric pressure).

Excessively negative vent pressure (up to 10X normal) will draw too much air through the boiler's combustion system, resulting in:

- Wasted heat up the flue
- Potential for uncontrolled combustion rate

The weight on the damper blade is adjusted to determine the negative pressure at which the blade moves



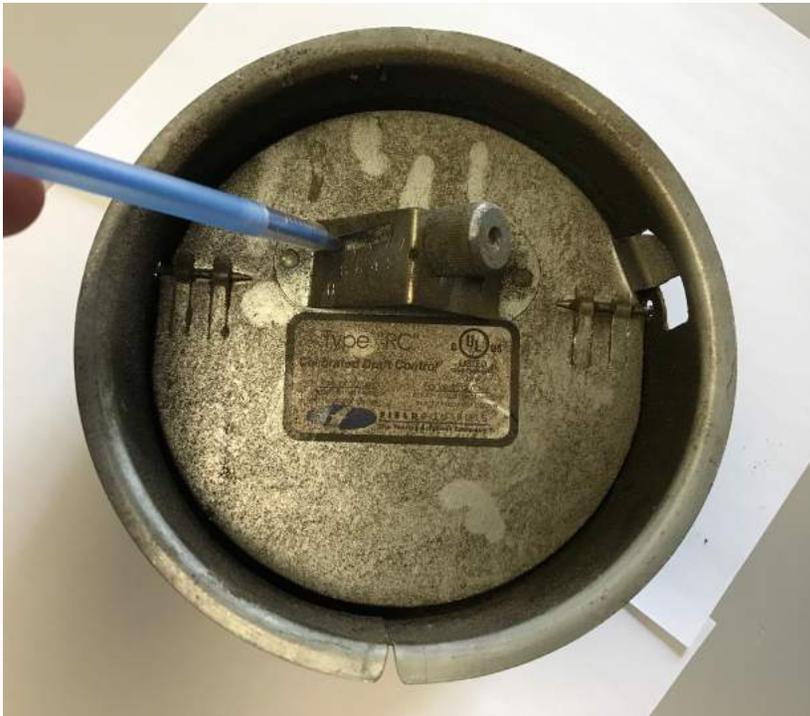
adjustable weight



Flue gas and ash leakage at barometric dampers

Standard barometric dampers cannot seal against positive pressure inside venting system

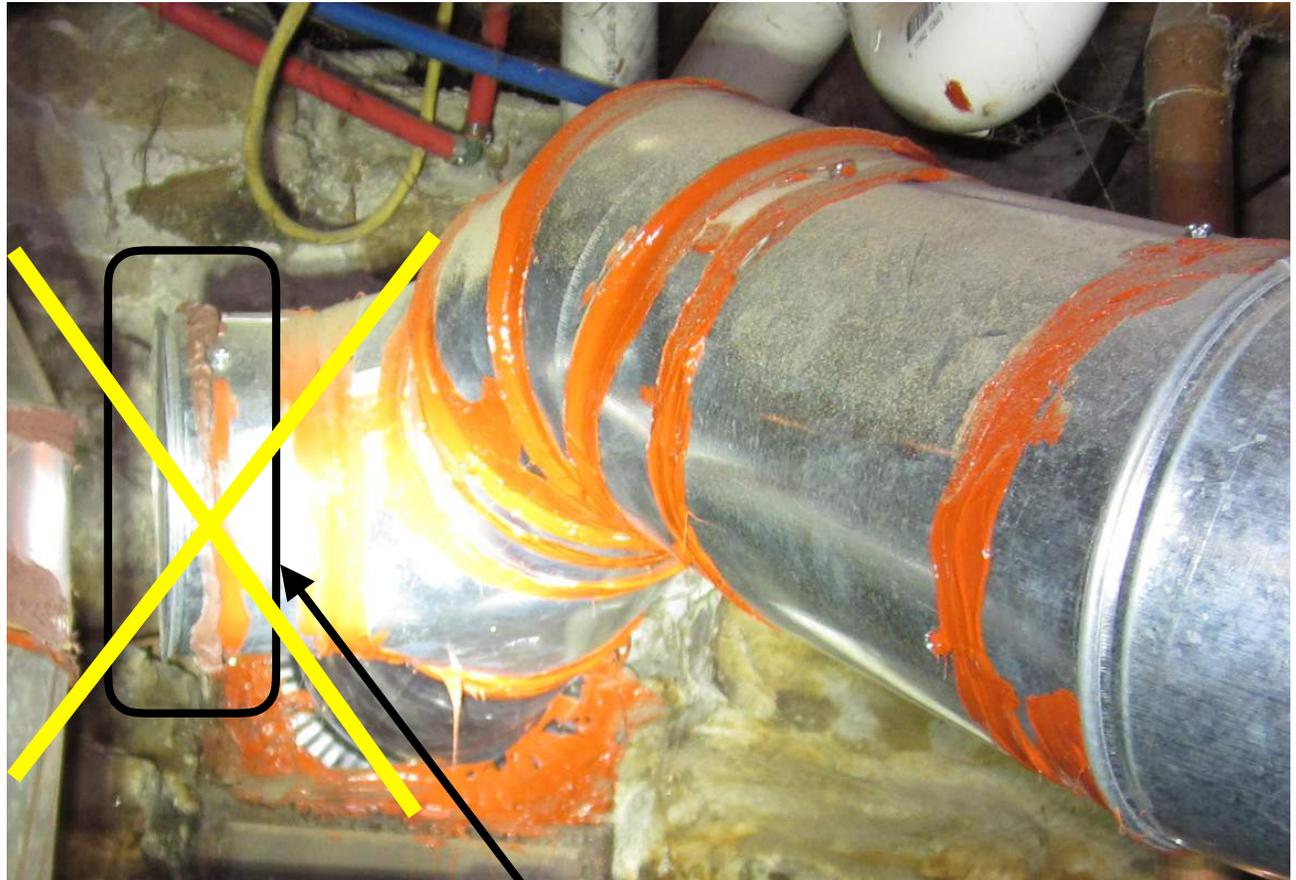
This is a typical barometric damper



The solution is NOT to omit the draft regulator...



Pellet boiler stack - galvanized pipe - no draft regulator



Standard barometric damper was removed and opening sealed because of ash and flue gas leakage.

Solution is positive pressure sealing draft regulators



**gasketed
openings**

European approach
using **draft regulator**
(not a barometric
damper) that seals
against back pressure.



Postive pressure sealing draft regulator installed on pellet boiler



outside of damper
relatively clean



some fly ash present
inside damper

Positive pressure sealing damper available in US

S280 Tigex® 150 Draft Stabilizer

Stainless steel design fights soot, moisture, and corrosive chemicals. Gas tight 1100°C superwool seal ensures no leakage of exhaust fumes, and quiet function - the damper flap opens and closes quietly during operation as there are no metal parts hitting each other. Easy to install. Self-cleaning door axel. Incredible quality - the top of the line!



Tigex® 150
Draft Stabilizer



Adapter for round flue pipe

<i>Finish Color</i>		<i>Description</i>
<i>Stainless</i>	<i>Black</i>	
S280	S280-2	Tigex® 150 Draft Stabilizer
S280-130	S280-132	Adapter for 5" round flue pipe
S280-150	S280-152	Adapter for 6" round flue pipe
S280-180	S280-182	Adapter for 7" round flue pipe
S280-200	S280-202	Adapter for 8" round flue pipe

<http://www.westwoodproducts.com>

1-800-442-1630

This damper is not currently UL listed. we're working it....

Thanks for attending today's webinar

Upcoming RHENY training opportunities



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Check the Renewable Heat NY website (under training opportunities) for latest information on scheduled events.

WEBINARS:

February 20, 2018 1:00 PM Eastern time, 1.0 AIA continuing education credit

Title: Control concepts for cordwood gasification and pellet boiler systems (presented by John Siegenthaler, P.E.)

Description: This webinar discusses several control strategies associated with cordwood gasification and pellet boiler systems. Topics will include boiler protection, boiler firing based on thermal storage tank conditions, staging of biomass and auxiliary boilers, and preventing unintentional energy flows in system.

May 10, 2018 1:00 PM Eastern time, 1.0 AIA continuing education credit

Title: Critical measurements to verify operation of biomass boiler systems (presented by Khaled Yousef P.E.)

Description: This webinar discusses instrumentation and measurement techniques to verify proper operation of biomass boilers. It covers lessons learned from measurement and verification work on a wide range of biomass heating systems.

September 20, 2018 1:00 PM Eastern time, 1.0 AIA continuing education credit

Title: Situations to Avoid with biomass boiler systems (presented by John Siegenthaler P.E.)

Description: This webinar discusses many lessons learned through plans review, on-site inspection, and monitoring a wide range of biomass boiler system. These lessons, when applied, can eliminate potential issues at the design stage, and thus save time and money during subsequent install and commissioning.

FULL DAY Training Workshop:

Spring (March) 2018 location and date TBA (Tentative Ithaca, NY)

Fall (October) 2018 location and date TBA (Tentative Adirondacks)



Questions?

Credit(s) earned on completion of this course will be reported to **AIA CES** for AIA members. Certificates of Completion for both AIA members and non-AIA members are available upon request.

This course is registered with **AIA CES** for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

