Code Gaps and Future Research Needs for Combustion Safety

2012 Expert Meeting

Larry Brand

Gas Technology Institute

PARR
The Partnership for Advanced Residential Retrofit

April 29-30, 2013
Building America
Technical Update Meeting
Denver, Colorado

Building AMERICA®
U.S. Department of Energy

Code Coverage

Fundamental Combustion Safety Related Coverage:

1. **Gas piping: allowed materials, sizing, installation, inspection and testing**
2. **Appliance Installation: clearances to combustible materials, combustion air, and testing**
3. **Appliance venting: allowed materials, vent type selection, sizing, installation, and testing**

Safety codes become requirements when adopted by the Authority Having Jurisdiction (governments or fire safety authorities)

Three Key Provisions For Combustion Safety in the Codes

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1. Combustion air requirements
2. Language on placing an appliance in operation
3. Vent sizing tables for atmospheric combustion and fan-assisted (Category I) equipment

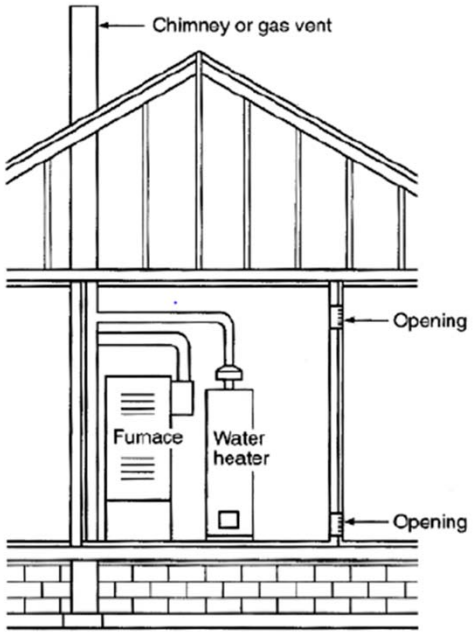
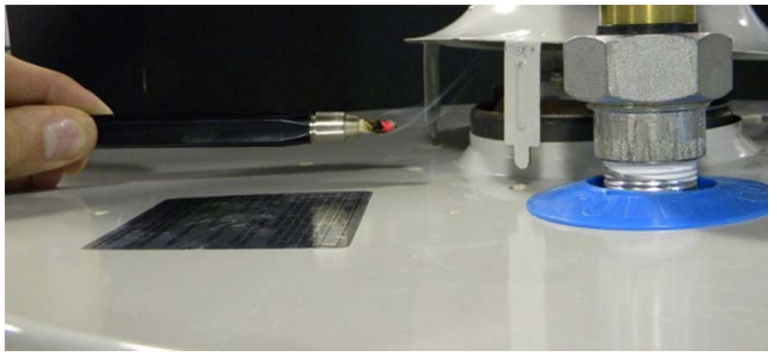


Table 13.2(a) Type B Double-Wall Vent

Number of Appliances:	Two or More
Appliance Type:	Category I
Appliance Vent Connection:	Type B Double Wall Connector

Vent CONNECTOR Capacity

Height H (ft)	Connector Rise R (ft)	Type B Double-Wall Connector Diameter — D in.																					
		3			4			5			6			7			8			9			10		
		Appliance Input Rating Limits in Thousands of Btu per Hour																					
		FAN		NAT	FAN		NAT	FAN		NAT	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	Min	Max	Max	Min	Max	Max	Min	Max	Max
6	1	22	37	26	35	66	46	46	106	72	58	164	104	77	225	142	92	296	185	109	376	237	128	466	289
	2	23	41	31	37	75	55	48	121	86	60	183	124	79	253	168	95	333	220	112	424	282	131	526	345
	3	24	44	35	38	81	62	49	132	96	62	199	139	82	275	189	97	363	248	114	463	317	134	575	386
8	1	22	40	27	35	72	48	49	114	76	64	176	109	84	243	148	100	320	194	118	408	248	138	507	303
	2	23	44	32	36	80	57	51	128	90	66	195	129	86	269	175	103	356	230	121	454	294	141	564	358
	3	24	47	36	37	87	64	53	139	101	67	210	145	88	290	198	105	384	258	123	492	330	143	612	402
10	1	22	43	28	34	78	50	49	123	78	65	189	113	89	257	154	106	341	200	125	436	257	146	542	314
	2	23	47	33	36	86	59	51	136	93	67	206	134	91	282	182	109	374	238	128	479	305	149	596	372
	3	24	50	37	37	92	67	52	146	104	69	220	150	94	303	205	111	402	268	131	515	342	152	642	417
15	1	21	50	30	33	89	53	47	142	83	64	220	120	88	298	163	110	389	214	134	493	273	162	609	333



Combustion Safety Expert Meeting

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Expert Meeting

U.S. Department of Energy, Energy Efficiency and Renewables, Building America Program

Partnership for Advanced Residential Retrofit (PARR)

PARR
The Partnership for Advanced Residential Retrofit

Topic: "Best Approach to Combustion Safety in a Direct Vent World"

When: Thursday June 28, 2012; 9 a.m. to 3 p.m. Central, (post-ASHRAE)

Where: CPS Energy Oak Room #1, 145 Navarro Street, San Antonio Texas

Dial-in Number: 877-917-2509 Passcode: 8739836

WebMeeting: https://www.mymeetings.com/nc/join.php?i=PW6551078&p=8739836&t=c

Description: : The Department of Energy Building America program focuses on reducing energy consumption in the nation's housing stock through smart integration of energy efficient design and upgrades. The target is a 50% energy savings captured through application of many measures including reduction in air infiltration, equipment upgrades, and thermal envelope improvements. Combustion safety testing is an important part of the test-in and test-out process in new construction and retrofit (upgrade) projects when direct vent appliances are not used and houses are being tightened to reduce energy losses through air infiltration. Where combustion safety testing identifies excessive spillage or continuous back-drafting, remedial measures are required.

Expert Meeting Presenters

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Name	Affiliation
Larry Brand	Gas Technology Institute
Paul Cabot	American Gas Association
Dan Cautley	Energy Center of Wisconsin
Jim Cummings	Florida Solar Energy Center
Jim Fitzgerald	Minnesota Center for Energy and the Environment
Paul Francisco	University of Illinois
John Jones	Building Performance Institute
Vi Rapp	Lawrence Berkeley National Laboratory

Key Takeaways AGA Presentation

1. The National Fuel Gas Code is the recognized ANSI code and its combustion air and venting requirements are the basis for codes adopted by most jurisdictions in the U.S. for installation and operation of gas appliances.
2. Combustion air guidelines were revised in 2001 to account for lower infiltration rates in newer homes. It may be appropriate to revisit these assumptions as houses are built tighter (gap).
3. Annex G in the code (safety inspection) only applies to furnaces and boilers and it should be expanded to include water heaters (gap).
4. Annex G draft spillage test is conducted for each appliance first operating separately and then repeated with all appliances operating in the same location. The written procedure is somewhat vague (gap).
5. NFGC and ASHRAE 62.2 should reference each other with regard to combustion air requirements and vent safety testing (gap).

Key Takeaways ASHRAE 62.2

1. Appliances should first be installed to code to minimize depressurization-induced backdrafting.
2. Typically, appliances can handle 5 Pa of depressurization, but this number needs to be verified (gap).
3. The largest contributors to depressurization are leaky HVAC ductwork and the larger exhaust systems – kitchen fans, dryers, and fireplaces.
4. There are several approved methods to comply with ASHRAE 62.2 – exhaust-only ventilation is not required.
5. Field data on exhaust fan flow rates and house depressurization level is needed to verify assumptions (gap).
6. A risk assessment tool to determine if exhaust-only ventilation is inappropriate for a particular house is needed to avoid creating an issue with atmospheric appliances or fireplaces (gap).
7. Organizations with combustion safety testing protocols and other combustion air code language should reconcile their different approaches so that the needs of all stakeholders are addressed. Of particular importance is a common approach to addressing the full range of factors that can influence proper venting, given the variety of conditions found in older homes.

Key Takeaways BPI Presentation

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1. None of the BPI standards supersede codes or manufacturers installation instructions.
2. If BPI standards are too stringent, there is a mechanism to change them. However, pre-and post-testing of all appliances must be completed.
3. The NFGC tests for spillage after five minutes of operation and the BPI test is conducted after one minute of operation. The NFGC and BPI test are based on different datasets and there is an opportunity to harmonize (gap).
4. CO limit for appliances is based on a Colorado study, not the ANSI appliance certification testing. There may be an opportunity to harmonize. More testing is required (gap).
5. BPI recommends more testing in the field on actual installations in actual homes. Manufacturers should be a part of the field testing to set performance limits for certification (gap).

Key Takeaways MnCEE Presentation

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1. The NFGC venting tables are not used properly in the field (a venting portable computer application would be useful). Need a better way to check the existing vent for compliance (gap).
2. The NFGC should provide depressurization guidance followed by a pass/fail spill test (gap). In the Airport study even if the vents were sized properly, 82% of atmospheric vents failed the spillage test at 5 Pa of depressurization.
3. More field data is needed to determine the effect of ambient temperature on depressurization, whether to use 5 minutes or 1 minute for the spillage test, appropriate door position, and the impact of kitchen ventilation (gap).
4. The only way to assure absolute safety is to require direct vent natural gas appliances and seal systems from the house.
5. The risk associated with failing the combustion safety test needs to be better characterized (gap). The risk associated with tightening houses may exceed the benefits.

Key Takeaways FSEC Presentation

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1. Tightening homes to extreme levels saves very little energy (payback can exceed 50 years), but can create substantial problems: combustion safety and risk of very poor indoor air quality if mechanical ventilation systems fail. Even in cold climates (e.g., Chicago), the payback period is very long and the risks are very real.
2. The proposal is to limit house leakage levels to approximately 5 ACH_{50} for climate zones 1-3, 4 ACH_{50} for climate zones 4-5, and 3 ACH_{50} for climate zones 6-7.
3. The actual annual energy savings associated with tightening homes below to the limits above needs to be determined by field data collection and analysis along with measuring key components of indoor air quality (gap).

Key Takeaways ECW Presentation

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1. Existing pass/fail testing is very simplistic, and may not accurately predict performance under typical operating conditions. We need long term monitoring of appliances under normal operation to determine the frequency of spillage, not just the 1 to 5 minute test period (gap).
2. The draft hood is the typical spillage site in atmospheric appliances. Use of direct vent/power vent appliances is one path to eliminating most spillage problems.
3. CO alarms should be required to address periodic events not found in the testing, and events associated with sources other than vented appliances.
4. We need to gather more information on human CO exposure and health effects related to spillage (gap).
5. More modeling is needed to determine the sensitivity of depressurization and spillage to environmental factors and events in the home (gap).

Key Takeaways LBNL Presentation

1. Appliance stress testing and field performance data are inconsistent. The first produces many failures and the second results in few incidents.
2. Field research is needed to determine how often backdrafting produces sub-critical hazards (gap).
3. Improving test methods may reduce risk if the correct variables are addressed.
4. A Contam model that adds environmental factors associated with vent performance may be a good tool to model the phenomenon. This is being investigated by LBNL.
5. Test results are needed to determine what remediation can be done in the field to produce an acceptable risk (gap).

Research Q&A and Gaps

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What are the risks associated with continued use of appliances that are near end of life or venting systems that do not meet the current mechanical codes?

Near end of life – inconclusive.

Do not meet the codes - Data from Cautley indicates that vent systems that are 30% below code requirements will cause backdrafting failures, and data from Fitzgerald show that $100 to $300 in tune up costs can reduce high CO levels in an atmospheric furnace to near zero. Clearly cleaning, tuning, and correcting vent deficiencies should be done before replacement is considered. If house depressurization is more than 5 Pa and only a water heater is present, replacement by a powered-vent or direct-vent appliance should be considered. Higher depressurization limits are permitted for an atmospheric furnace/boiler or common vented water heater and furnace/boiler.

Research Q&A and Gaps

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What data has been collected and what additional data needs to be collected to support the analysis that will lead to the development of a common standard for combustion safety?

Data from Cautley, Fitzgerald, Rapp, and others is provided in the slides showing that there is poor correlation between stress tests and field failures. More long-term field data in warm and cold climates with a variety of common and single-appliance vent scenarios should be collected. An important first step is to identify and correct improper vent sizing and installation so only the house depressurization conditions are being studied.

Research Q&A and Gaps

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How do field practices agree or disagree with the code coverage?

BPI/RESNET inspection practices differ from the National Fuel Gas Code in several important aspects: CO action limits, the test time for backdrafting after start-up, Combustion Air Zone definitions, and worst-case scenarios. Harmonization of the BPI procedures and the code would reduce confusion in the field. Also, data from Cautley, Fitzgerald, Rapp, and others is provided in the slides showing that there is poor correlation between stress tests and field failures, indicating a need to correlate field failures and inspection practices.

Research Q&A and Gaps

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

What low-cost or no cost options are currently available that satisfy the need for combustion safety in homes with low infiltration?

The vent should be inspected and modified so that it meets the sizing and installation requirements in the National Fuel Gas Code.

The combustion air provisions in the NFGC should be followed – adding openings or removing doors can improve combustion air supply.

Appliances should be cleaned and tuned to provide safe operation.

Power vented water heaters are available in the market to replace atmospheric gas water heaters.

ASHRAE 62.2 ventilation requirements can be met with other than exhaust-only systems.

Direct-vent gas-fired equipment is available for replacement where a higher price point is supported such as significantly improving the efficiency level of the equipment as an energy saving

Actions from the meeting (1)

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- Changes to inspection procedures being discussed by BPI industry task group:
  - Training on what to look for in the vent system – proper sizing, installation
  - No touch combustion testing
  - Use of appliance certification CO limits from ANSI standards
  - Combined spillage and CO measurement at 1, 2 and 5 minutes (covers cold start and warm start conditions)
  - Specifying actions to take by inspectors at 9, 35 and 70 ppm ambient levels of CO (notify, ventilate, evacuate)
  - On the agenda: depressurization testing

AGA	Ted Williams	GTI	Larry Brand	MnCEE	Jim Fitzgerald
BPI	John Jones	LBNL	Iain Walker	U of I	Paul Francisco
Consultant	Don Fugler	NCI	Jim Davis	14 other orgs	
Drysdale	Terry Clausing				

Actions from the meeting (2)

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- Discussion between ASHRAE 62.2 members and NFGC on harmonization language
- LBNL literature survey complete, field studies being developed
- Northern Star and PARR teams investigating simplified test procedures for Building America

References

- Combustion Safety Presentation from 2012 Stakeholders Meeting
  - Combustion Safety in the Codes, Austin Texas, March 2012
- 2012 Building America Expert Meeting Report
  - *Building America Expert Meeting: Combustion Safety,* DOE/GO-102013-3808, February 2013