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Code Compliance report for: Site- Constructed Masonry Heaters



Prepared for Municipalities in:

The Province of British Columbia

by:

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Referenced Documents

- ASTM E-1602-03 (2010)
- CAN/ULC S610 Standard for Factory Built Fireplaces
- B.C. Building Code 2012
- ANSI/ASHRAE Standard 55-2010
- EN 15544 Austrian norm
- OENORM B8306
- CSA B365

CODE CONFORMANCE REPORT FOR SITE ASSEMBLED MASONRY HEATERS

Introduction

We have been retained by a group of specialist designer/builders of 'in situ' masonry heaters - to prepare a code compliance report setting out the case for compliance of these site constructed/assembled masonry heaters with the intent of the BC Building Code. This report sets out the general strategy for alignment of masonry heaters in British Columbia with the relevant codes and standards.

The aim is to promote the use of masonry heaters as a highly efficient and cost- effective alternative to conventional fire places and stoves.



Figure 1: Typical Contraflow Masonry Heater being fired (test phase only-hearth not completed)

Product Description

The masonry heater proposed in this application is a system accepted in Europe with a history of proven performance over centuries. This type of heater is taking hold in North America and there is a growing craft of builders who build these units in situ. It will be shown to comply with the intent of the technical requirements of the BC Building Code and other referenced standards in north America. The intent is not to comply with the Acceptable Solutions as, the prescriptive requirements of the BCBC apply to different types of solid fuel burning units.

As these relatively new units are significantly more fuel efficient and have benefits relative to comfort of the occupants, this report will inform building officials and others who may wish to ensure that they meet or exceed the intent of the BC Building Code.

Input from Local Builders

This report has been prepared in consultation with Pat Amos and Jeffrey Millerd: both builders on Vancouver Island, British Columbia.

Masonry heaters are constructed in situ as bespoke masonry units. The North American terms for these units stem from German names as follows:

- Kachel (clay tiled).
- Grundöfen (earth brick and mortar).

As the above categories differentiate the surface finish to the units, they both fall into the category of Masonry Heaters. The design and operation of the different types are identical.

Principle of Operation

While the use of masonry for fireplaces and chimneys is common place, the conventional fire place relies on relatively free combustion of the burning material through uncontrolled oxygen flow. Different controls may be used to make the fireplace more efficient; however, the bulk of the heat for the occupants is radiant heat from the fire. The vast amount of heat associated with hot gasses leaves via the chimney and is not captured and in fact will exit the building at relatively high temperature. As the fuel is quickly consumed, the fire has to be regularly stoked to add fuel and keep the occupants comfortable. Fireplaces may be served by either a masonry chimney or by a Factory Built chimney suitable for solid fuels and listed for that purpose.

Stoves such as the conventional Franklin stove rely on the heat transfer of the heat of combustion to the body of the stove. This is then transferred to the room by radiation and convection. Stove pipes were traditionally single pipe and therefore also functioned to help heat the room.



Figure 2: Traditional Wood Stove

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While there may be certain means- such as dampers- to control the rate of combustion much of the heat still leaves via the chimney and fuel still has to be regularly replaced. Stoves are typically hot to the touch and as such they present a risk to occupants and to adjacent combustibles. Ignition of adjacent combustible construction by stoves is common. Stove chimneys run very hot and can easily ignite combustible construction if sufficient clearances are not maintained. Use of factory-built chimneys listed for this purpose reduces this risk although chimney connectors are often single walled pipe and very hot to the touch.

Factory built fireplaces are designed to be minimize the external temperatures of the units through insulation. This enables them to be installed relatively easily in wood frame construction. Chimneys and spacers with stipulated clearances are provided to maintain suitable clearances to combustibles.



Figure 3: Zero clearance fireplace

The above conventional systems have a distinct separation between the unit which burns the fuel and the chimney. As previously discussed, some systems have a separate connector pipe to connect the fireplace or stove to a chimney.

In masonry heaters the fire resistance of the masonry hearth is typically combined with masonry channels and the path from the firebox controlled to achieve an optimum residence time for the hot gases. This is balanced by the control of combustion air for burning and for buoyancy to help facilitate the movement of gases through the unit to final point of discharge from the building. The high mass of the construction of the masonry stove, as well as control of flue gas residence time through the unit, optimizes the capture of heat; this means that, at the point of discharge of gases, the temperature is significantly less than conventional appliances and/or fire place (maximum 200C). The path of travel of flue gases is illustrated as follows:

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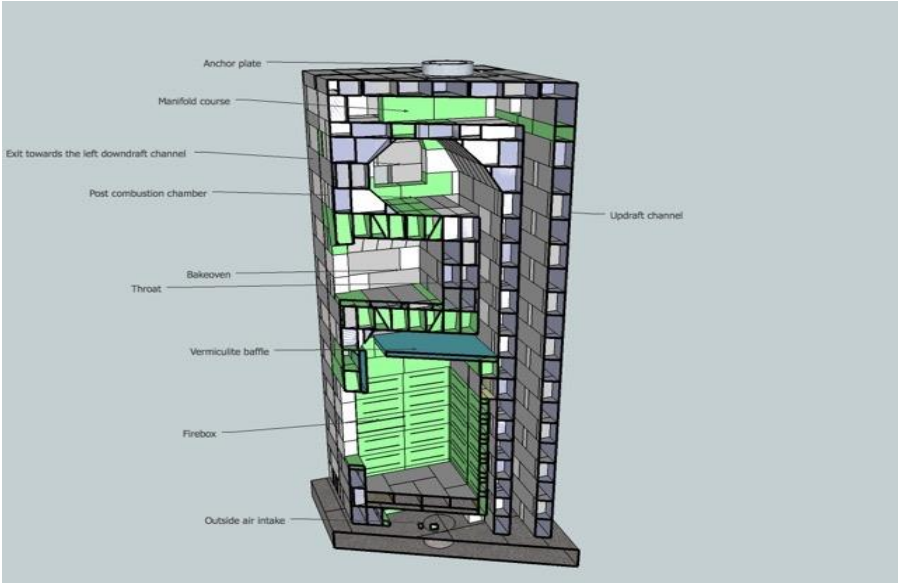


Figure 4: Typical path of flue gases through a Contraflow Masonry Stove. The point of entry to masonry channels is at a temperature of approximately 650C



Figure 5: Cut away section of masonry heater showing channels



Figure 6: Superimposed arrows showing flow direction on an actual unit.

Thermal Comfort

The ANSI/ASHRAE Standard 55-2010 defines thermal comfort as “that condition of mind which expresses satisfaction with the thermal environment and is assessed by subjective evaluation.”

Satisfaction with the thermal environment depends on several factors including the following:

- The rate at which energy is lost from the body of an individual to the surroundings. This is a function of the person’s metabolic rate, clothing and other factors detailed below. The higher the level of activity the greater the heat generated. For instance, a stationary person will tend to feel cooler than a person that is exercising.
- Ambient air temperature. This is the adjacent temperature as measured by a thermometer.
- Radiant temperature which is the weighted average temperature of the adjacent surfaces in the room (often referred to as Global Temperature)
- Air velocity (drafts/convection)

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- Relative humidity

These environmental factors are influenced and controlled by the building geometry and the heat transfer mechanisms used by different heating systems.

For optimum thermal comfort these factors must be in balance. Change or disturbing the balance has an impact on human comfort. For instance, excessive ventilation/drafts or other imbalances, as a result of heating systems cycling on and off can disturb the balance and thermal comfort of occupants

Any heating system design to achieve acceptable thermal comfort must consider all the above factors.

Masonry Heater Heat Transfer Mechanism

Heat from a hot burning fire is stored in masonry channels and released relatively slowly as mostly radiant heat over a longer period of time. The burn cycle depends on desired time intervals. Typical extended burn times using one fuel load per storage period - a maximum load of between 10 kg and 40 kg- are in the range of 8 to 24 hours.

Complete combustion occurs during very hot fires with the optimum temperature and air supply. Optimum burning includes efficient secondary combustion at a temperature of around 850-900C.

The air supply is critical. Too little air will not support combustion and too much will cool the temperature to a point where combustion cannot occur. For example, in windy conditions the flame of a match can easily be detached from a match stick due to disengagement of the flame from the fuel.

The air supply must be adjusted to the amount of wood during a burn cycle. The air supply in any location must take into account the elevation of the site (above sea level) and temperature of air in the design location.



Figure 7: Cast iron clean out frame door not attached)- fire brick plug in core.

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The theoretical amount of air to burn 1 kg of wood (at 15% moisture) is 4 cubic meters. The theoretical amount of air needed for optimum burning can be determined and then must be adjusted for safe continuous operation.

A masonry heater is essentially a highly efficient heat-retaining fireplace constructed mostly of masonry and/or ceramic materials. Hot gases generated during the fast and complete combustion of a fuel load in a firebox equipped with air tight door pass through a series of channels or chambers, saturating the masonry mass with heat. The mass then radiates heat into the area around the masonry heater for up to 24 hours.

As a heat-storage device with a high thermal mass, masonry heaters offer steady heat output with typically one to two full loads of fuel per day only. Masonry heaters are, in general, low heat output devices because the amount of heat produced from a single load is distributed evenly over a long period of time. High efficiency and low emissions make masonry heaters an ideal choice for heating energy-efficient houses with renewable fuels such as wood.

A heavy masonry heater works best when used on an everyday basis for a considerable period of time. As a slow-response system with a high thermal mass, a masonry heater takes several full loads of fuel to heat up to its normal operating temperatures from a cold state due to thermal inertia; as such, masonry stoves are not suitable for occasional use in the cold season.

Masonry heaters are often built using a double-wall system meaning that the stove has a complete refractory core containing a firebox and heat exchanging channels or chambers, and a separate outer facing constructed of masonry, Cobb (unfired clay) or ceramic materials.

One of the main differences between open fireplaces and masonry heaters is that the latter are much more efficient heating units: capturing the heat. In contrast with the -largely aesthetic- function of conventional fireplaces, the main purpose of a masonry heater is to generate and deliver as much heat as possible with the minimum amount of fuel. The overall performance and environmental benefits are significant over conventional fireplaces and other heating units.

External walls opposite conventional open-fronted fireplaces rarely get warm; on the other hand, the external surface of masonry heaters gets saturated with heat and reaches average surface temperatures in the range of 80 Celsius tapering off at the end of the heating cycle. The walls of the room are maintained at a higher temperature than with conventional fireplaces. The main benefit is thermal efficiency and occupant comfort.

The Benefits of Masonry Heaters

- Stable radiant energy over long periods of time
- Optimum thermal comfort
- High efficiency compared to conventional appliances/fireplaces and stoves because of complete combustion and heat retention

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- Lower operating costs compared to conventional fuels such as oil or gas.
- Higher safety- through containment compared to open fireplaces- very low risk of flying sparks/accidental ignition. Surface temperatures are safe to the touch.
- Lower flue gas output temperatures and therefore less risk of chimney fires compared to stoves
- Safe operation maintained above the dew point to minimize potential corrosion problems.
- Excellent containment of fire due compared to open fireplaces owing to inherent fire resistance of materials used in construction.

Construction of Masonry Heaters

Masonry heaters are not a fixed design. Manufactured components such as the feed and viewing door assembly, ash clean-outs and adapters for chimney connectors are supplied by European component manufacturers or custom fabricators. Since the size of the dwelling and heat requirements can vary, a North American standard- ASTM E 1602-3- provides guidelines for the designer/builder to create a unit that will function properly. Refer to the analysis for conformance to the ASTM standard later in this report.

The construction of a masonry heater requires a suitable foundation. Heavier designs typically require the foundation to be constructed up from the basement or crawl space on a similar basis to a brick oven. This is typically undertaken by the client prior to the construction of the masonry heater in accordance with the weight requirements provided by the designer/builder of the unit. Footings for this purpose have to conform to 9.15 of the BC Building Code.

The masonry heater is not intended to be used to support the weight of the chimney which is used to vent the gases. If a masonry chimney is used, it shall be constructed on its own foundation, built as per BC Building Code requirements. A masonry heater can be connected to a masonry chimney in accordance with CSA B 365 and BCBC requirements.

The masonry heater unit can also be connected to a factory-built chimney suitable for use with solid fuels and conforming to the CAN/ULC S629 standard. If the factory-built chimney is connected to the top of the masonry heater directly, the appropriate adapter provided by the chimney manufacturer must be used, and the weight of the **chimney supported by the building structure** using the required support straps. A single wall steel pipe or Listed double wall chimney connector can be used to connect the masonry heater to a chimney system as per CSA B 365 and Code requirements. In this case the structural load on the masonry heater is typically not a concern and the factory- built chimney is independently supported.

The construction of the hearth or floor protection which is set out in the BC Building Code may be a tiled (or other decorative finish) – and should be undertaken as part of the contract. The hearth requirements are covered in 9.22.5.1 of the BC Building Code and include a hearth that is non-combustible- 400 mm in front and 200mm on each side- of the fireplace opening. This can be subject to final inspection by the

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authority having jurisdiction but may not be part of the masonry stove installation per se. Our recommendation however is that the installer be responsible for delivering a complete unit.

The construction of the masonry stove is illustrated in the following photographs.



Figure 8: The 'Core' of the heater constructed of firebrick and refractory mortar is separated from the 'Skin' of the heater by cardboard and ceramic fibre.



Figure 9: The entire 'Core' of the heater is completed prior to facing the heater. Note: clean outs are visible on the side of the bench as well as below the firebox and above the oven.

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The construction of the heater is typically double-walled and is built from the inside out of refractory brick based on the calculated dimensions for the firebox and flue. The distinguishing feature of the heater is the flue gas pattern previously described and the residence time of the gases.

The exterior wall of the unit is constructed from masonry, including unfired clay plaster known as Cob. "Cob" is a generic term that covers various ways of combining earthen materials to achieve differing effects for different purposes. It is a combination of sand and clay-rich site soil mixed with straw to make adobe bricks and/or lay up one cob (lump of dirt) at a time. When cob is prepared for a heater facing it is carefully mixed specific combinations of materials that compose a multi-layered facing. Ratios of various types of sand, clay, fibre, sodium silicate, and in some applications insulative materials such as vermiculite and perlite very much affect the properties and qualities of the material.

In utilizing cob/earthen plasters as facing for clay brick cores, the following three distinct layers have been distinguished:

□ **'Scratch coat' or 'shape coat'.**

This is the first layer (or sub-dermis if you will) applied directly to the brick/refractory core. It is typically 0.5" thick but thickness may vary as it helps to create the final profile of the unit. Its make-up is typically 3 parts concrete sand, 1 part fine masonry sand, 3 parts clay slip (60% clay, 40% water) and 2 to 3 parts of finely chopped straw and/or shredded and sifted horse manure. In higher heat-accumulating regions of the heater body, such as close proximity to a bypass flue, the organic fibres are typically replaced by fiberglass mesh. In these locations one may also add vermiculite or perlite to the blend. The role of fibres in this coat is to prevent cracking while drying. Their inclusion is especially important when adding vermiculite as it is quite hygroscopic and wants to contract as it dries.

□ **'Brown coat'.**

This is the second layer (dermis), up to .75" thick. This is a blend of clay, sand and fibre, with a higher fibre content. Whereas the scratch coat is more of a filler or thermal buffer, this coat offers more structural, tensile, and shear strength. In areas of the heater where potential load transfers are amplified, a layer of fiberglass mesh may be embedded in this brown coat.

□ **'Finish plaster' (epi-dermis).**

This is a smooth durable surface .125" to .25" thick. It may be applied in one or two layers. Recipes can vary, but it typically consists of 20 to 50 grit sharp sand, clay, and glues such as milk or animal blood proteins, wheat paste, or store-bought wall paper glues such as Roman 880. The mix may also include horse and/or cow manure which adds fibrous strength and extra binding (due to the digestive-tract tannins

For heaters with benches that are designed to be sat upon, surface hardeners such as hardening oils, Carnuba wax, or water glass can be applied to the finish plasters' surface. Care must be taken to make sure the maximum surface temperature of the bench does not destabilize the oil's polymer chains.

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Figure 10: Cob-skinned Grundofen with heated bench and backrest.



Figure 11: Connector plate for chimney (chimney to be independently supported)

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Codes and Standards

Some specific provisions of the BC Building Code have been reviewed to assess the adequacy of construction compared to the construction of a standard fire place. These are summarized in the following table:

BCBC Reference	Requirement	Comments
9.22.1.2.(2)	Steel lintel required over fireplace openings, reinforced concrete or masonry arch	This is similar to ASTM C155 - 97(2013)
9.22.1.4	Combustion air to comply with CAN/CSA-A405-M	This applies
9.22.2.1	Every fireplace to have fire brick liner	Fire chamber is built of solid refractory material
9.22.2.2 (1) and (2)	Sides and back to have fire brick liner min. 50mm back and sides and 25mm for floor.	Floor is built with solid refractory material, underneath fire proof material and concrete blocks- exceeding these dimensions
9.22.2.2 (2)	High temp mortar to conform to CAN/CGSB-10.3 Air-Setting Refractory mortar	Conforming mortar to be used.
9.22.2.2(3)	Offset joints required between the firebrick liner and the backing masonry	This is not required as all material is solid refractory bricks
9.22.2.3	Are steel liners used? If so they shall conform to CAN/ULC-S639-M	There are no steel liners; fire box is solid refractory material.
9.22.3.(1)	Back and sides incl. firebrick liner shall be min. where a metal liner or a firebrick liner less than 51mm is used.	There are no liners; all material is solid refractory
9.22.3.1.(2)	When steel fireplace liner is used with air circulations chamber, back and sides shall be solid 90mm masonry of 190 mm hollow masonry.	This does not apply. Code mentions solid masonry but this system uses refractory bricks.
9.22.4	Min fireplace chamber depth to opening- min 300mm	Masonry heaters are not open as fireplaces typically are.

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BCBC Reference	Requirement	Comments
9.22.6	Throat of fireplace to be equipped with damper capable of covering full area of throat opening	Some masonry heaters do not dampen the exit to the flue gas or have a throat. Some units have dampers equipped with min. 5% gas leak hole.
9.22.7.1	Sides of smoke chamber not less than 45 degrees to vertical.	Walls of masonry heaters are designed for horizontal and/or downward draft.
9.22.7.2	Masonry walls surrounding smoke chamber to be not less than 190mm except 140mm on exterior wall.	Hotter regions of Masonry heaters use refractory brick core with an airgap between the smoke chamber and outer shell. Below 500C expansion is less critical.

ASTM E1602-3 (2010)

This is a generic standard that addresses various types of masonry heaters including Russian/Finnish and Swedish heaters and enables a realistic comparison of the proposed system as it includes Kachelofen/Grundofen (German) heaters. The standard does not regulate design per se but it does include excellent guidelines that are useful in the evaluation and assessment of masonry heaters.

The ASTM E 1602-3 standard does not describe the performance and calculation process. All heaters use the same basic design principles: *see MHA-net.org*

However, the guide provides dimensions for site constructed masonry heater components and clearances that have been derived by experience and found to be consistent with the safe installation of those masonry heaters. It is not restricted to a specific method of construction, nor does it provide all specific details of construction. The guide states that:

"...construction of masonry heaters is complex, and in order to ensure their safety and performance, construction shall be done by or under the supervision of a skilled and experienced builder of masonry heaters. This guide does provide the principles to be followed for the safe construction of masonry heaters."

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The principles issues relevant to this design are as follows.

Issue	ASTM Recommendation	Comment
Foundation	Foundation/walls to meet local building codes	2012 BC Building Code applies
Clearance from foundation	Min 50mm	To be provided.
Clearance from fuel loading door	1200mm	Except for doors an engineered clearance system may be used. See excerpt from standard Fig 4 below. 48 inches required. This is to provide the required space for fuel loading and to protect furnishings and other materials from radiant heat from heater door.
Clearance from sides, rear and front	100mm	To be provided
Clearance to ceiling	Min 200mm	From top of capping slab
Extension of wythes to ceiling	Insulate and vent top of masonry heater above the heat exchange channels to reduce static heat build-up.	This applies to any concealed space that may otherwise be un-ventilated.
Wing walls of heater	Wing walls located at corners of a masonry heater for the purpose of forming a room divider shall be a minimum of 100 mm (4 in.) in length and a maximum of 100 mm (4 in.) in thickness and be constructed Wing walls located more than 200 mm (8 in.) from a corner of the masonry heater shall be a minimum of 200 mm (8 in.) in length and a maximum of 100 mm (4 in.) in thickness and be constructed with non-combustible materials.	If used these requirements have to be met
Firebox Floor	The firebox floor shall be a minimum thickness of 100 mm (4 in.) of non-combustible material and at least the top 50 mm (2 in.) shall be refractory material.	The firebox floor is refractory material min. 15mm thick.

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Issue	ASTM Recommendation	Comment
Hearth Extensions	Masonry heaters shall have hearth extensions of brick, concrete, stone, tile, or other approved non-combustible material properly supported.	This has to be coordinated with the owner and completed on site. Wooden forms have to be removed on completion.
Closed Door Fireboxes	The hearth extension shall be at least 500 mm (20 in.) in front of the facing materials and at least 300 mm (12 in.) beyond each side of the masonry heater opening.	Masonry stoves have closed door fireboxes and hearth extensions as described in the B.C.B.C should be provided. Non-combustible construction has to be utilized.
Where the firebox opening is less than 0.6 m ² (6 ft ²),	The hearth extension shall extend at least 400 mm (16 in.) in front of the facing materials and at least 200 mm (8 in.) beyond each side of the firebox opening.	The worst case applies depending on the size of the firebox.
Clean-out openings	At chimney base and for all heat exchange channels. Situate the opening to facilitate inspection, cleaning, and maintenance heater.	All channels can be cleaned out. Clean out openings are pre-manufactured.
If Ash dump or grate provided	Provide tight-fitting cover of Non-combustible material, 3 mm (1/8 in.) minimum thickness, at the base of the ash pit.	The bottom of the fire chamber is min. 60mm below the door opening.
Outside Combustion Air	Provide a duct with a minimum cross-sectional area of 7700 mm ² (12 in. ²). Provide a duct with a minimum cross-sectional area sufficient for combustion. When introducing air into firebox air is introduced into building at level below fire box. Rodent screen required.	This is essential. Area to be at least equal to chimney cross section.

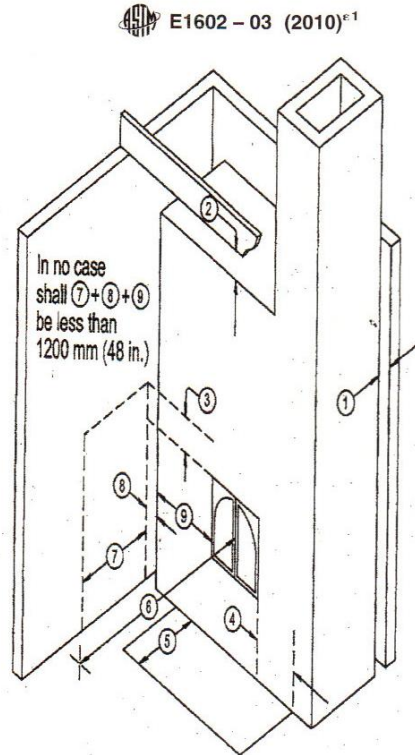
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Issue	ASTM Recommendation	Comment
Ash Pit Located in Foundation	When outside air is introduced into the firebox via the ash pit, introduce the air duct through the upper region of the ash pit wall. Ducts to be non-combustible and arranged so that ash will not enter ducts.	Ducts are non-combustible fitted with rodent screens.
Heat exchange channels	To be built with refractory materials laid in refractory mortar.	Refractory brick is used. Masonry units are laid with full mortar joints.
Capping slab	Capping slab shall be of at least 57 mm (2 1/4 in.) in actual thickness above the uppermost heat exchange channels.	This is built up of refractory slabs or a suitable castable refractory product. ICC anchor plate for the factory-built chimney should be mounted on the capping slab. The Capping Slab is airtight and gas proof.
Gas slot	A gas slot shall have a cross-sectional area of at least 1/30 of the firebox floor area and a height of 30 mm (1 1/4 in.).	Refers to diagrams in the standard for different heaters.
Shut-off Damper(s)	One or more shut-off dampers may be installed near the juncture of the masonry heater and chimney or in the chimney	Air and fire dampers provided-fire damper will maintain minimum draft (around 5% is unrestricted)
Chimney type	Use low-heat type masonry chimney or factory-built residential type chimney that meets the requirements of UL 103 HT.	Factory built chimney is used. The correct BC standard is CAN/ULC S629.

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Issue	ASTM Recommendation	Comment
Chimney Connector	The chimney connector shall be accessible for inspection and cleaning. Chimney connectors shall be airtight and fitted with airtight joints. Where differential movement can take place between a masonry heater and chimney, make provision for this movement in such a way as to maintain the integrity of the connector joints.	This has to be provided and be accessible for cleaning.

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NOTE—Clearances from combustible walls or framing may be reduced with an engineered protection system, other than in front of fuel-loading doors.

FIG. 4 Clearances to Combustibles

- (1) 100 mm (4 in.) to combustible framing from masonry heater.
- (2) 200 mm (8 in.) to ceiling.
- (3) 200 mm (8 in.) minimum extent of side wall heat shield above firebox door.
- (4) 300 mm (12 in.) hearth extension (sides).
- (5) 500 mm (20 in.) hearth extension (front).
- (6) 1200 mm (48 in.) in front of fuel-loading doors to combustible framing.
- (7) extent of mandatory heat shield in front of masonry heater; required only when clearance to combustible material from fuel loading door ((8) + (9)) is less than 1200 mm (48 in.).
- (8) 100 mm (4 in.) minimum clearance from side wall of masonry heater to heat shield (if used) or combustible framing.
- (9) distance from fuel-loading doors to side wall of masonry heater.
- (7) + (8) + (9) The sum of these must be greater than or equal to 1200 mm (48 in.).

Figure 12: Excerpt from ASTM E-1602-03 (2010). PICTURE DOES NOT REFLECT ALL Types of MASONRY HEATERS BUT SHOWS REQUIRED CLEARANCES FOR REFERENCE PURPOSES ONLY

Analysis

It is clear from the comparison with BC Building Code requirements for fireplaces that fireplace requirements do not reflect the vastly superior construction and efficiency of masonry heaters. The ASTM E-1602-3 standard is much more suitable for the comparison as it includes European and other stoves in the scope of the standard.

The ASTM standard is a generic guideline and although it is not used to carry out the design of such systems, it sets out a method of assessment of masonry heaters and the requirements in the above table can be used to assess the field installations of masonry heaters.

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This analysis has demonstrated that based on:

- the robust nature of the construction,
- Comparison with BCBC requirements for open fireplaces and
- Comparison to the generic ASTM standard, masonry heating systems described herein meet and far exceed the level of safety intended by the 2012 BCBC- particularly in comparison with the level of performance of recognized conventional systems such as conventional fireplaces and stoves.

Summary

The construction of masonry heaters should be as outlined in this report. They meet and exceed the intent of the BC Building Code for fireplaces accepted with open fronted construction for heating rooms. It is anticipated that, based on this report, the building code authority/authority having jurisdiction will accept installation as exceeding the intent of the BC Building Code for open fireplaces.

As this report provides a thorough analysis to set the case for code conformance, it is proposed that an Alternative Solution will not be required for individual installations nor that individual field review by us will be required. This is based on the fact that this report demonstrates compliance with the intent of the BCBC 2012. Installers should maintain a photographic record of the installation for resolution of any outstanding issues with the building inspector.

It should be noted that if a new foundation is required then a Letter of Assurance and Field Review will be required from a structural engineer registered in the province of BC.

Factory Built chimneys shall be suitable for use with solid fuels and shall conform to the CAN/ULC S629 standard. The chimney installation shall conform to the installation instructions for the chimney system and the CSA B365 Installation standard.

The above report is consistent with sound principles of fire protection engineering.

Respectfully submitted by:

A handwritten signature in black ink, appearing to read "John T. Iverson", with a long, sweeping horizontal stroke extending to the right.

John T Iverson BSc (hons) PEng CP FSFPE MIFE