Defining Masonry Heaters - A Discussion Paper

prepared for:

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INTRODUCTION

New advanced masonry fireplace designs have raised the issue of where the dividing line between masonry heaters and masonry fireplaces should be drawn. This discussion paper is intended to help delineate these issues for the Masonry Heater Association of North America (MHA) voting membership, since this is who the task of masonry heater definition rests with.

There are currently four definitions, none of them entirely adequate because they all lack a performance criterion. If MHA does not come up with a solid definition, then anything made of bricks and producing even a little bit of heat can be billed as a masonry heater.

Today, in 1997, emissions is a non-issue in masonry heater definition, since recent testing has shown that fireplaces can also be made to burn cleanly simply by ensuring flaming combustion and avoiding smoldering. Heat storage and efficiency should be the main criteria for defining masonry heaters.

Criteria for Defining Masonry Heaters

A range of criteria can be used to define masonry heaters. They can be performance criteria or prescriptive criteria.

Prescriptive criteria are often used in building codes. For example, for masonry fireplaces, "*the wall thickness at the firebox shall be 8" or greater*". Prescriptive criteria are easier to verify on-site by a building inspector.

Masonry heaters are better described with performance criteria, since it is performance that makes them unique, not appearance. For example, we can require a masonry heater to have a heat exchanger, but what if the heat exchanger in a particular design doesn't work? We are better off to specify what a heat exchanger should *do*, rather than how it should *look*. An example of a performance criteria would be "a *masonry heater must store at least 50% of the available heat that is released from the wood*".

Performance criteria include:

- Heat storage
- Efficiency
- Surface Temperature
- Emissions
- Burn rate

Prescriptive criteria include:

- Weight
- Firebox measurements
- Heat exchanger wall thickness
- Intended use and location

DISCUSSION OF EXISTING DEFINITIONS

(See Appendix for full text of existing definitions)

ASTM

The ASTM masonry heater definition is part of ASTM E1602-94, Standard Guide for Construction of Solid Fuel Burning Masonry Heaters. This Standard Guide was the result of eight years of effort by MHA members and other interested parties.

Due to the slow nature of the ASTM consensus standards process, the Standard Guide is not yet framed in rigorous code language. It is framed in near-code language, however. As a consensus standard, it is exactly that: a consensus of all the opinion in the industry and related fields. The final document was passed by a vote of all 60,000 ASTM members worldwide. ASTM assumes liability for its standards.

The intent of the masonry heater definition in the ASTM Standard Guide is clear: a masonry heater must

- store a “substantial” portion of the heat released from the wood fuel
- weigh at least 800 kg.
- be constructed primarily of masonry

What is “substantial heat storage”? In order to extend the definition into code language, we must define the term “substantial”. This is the main issue for the MHA membership to consider, and is discussed in detail later in this paper.

One and Two Family Dwelling Code (OTFDC)

MHA has recently applied for masonry heater-specific additions to the masonry fireplace section of OTFDC. Getting masonry heater-specific language added to the masonry fireplace section of the building code will be very helpful for custom heater builders, as well as their clients.

The proposed OTFDC definition is essentially an expanded version of the ASTM definition. It adds that a masonry heater’s intended use is as a main or significant supplemental heat source. To address some of the shortcomings of the prescriptive Colorado definition (below), it adds to the heater description that the gas path normally makes at least one 180 degree bend. In also states that a masonry heater is designed to be operated with the doors closed.

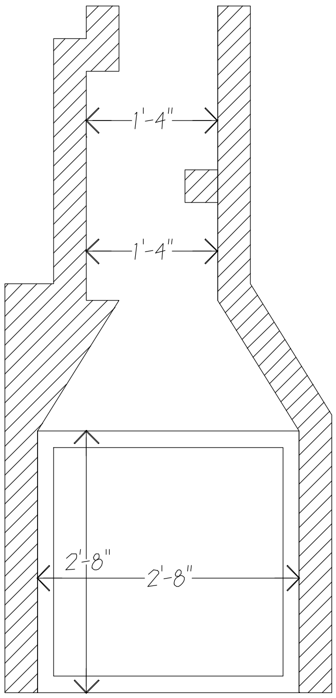

Figure 1. A 32” Masonry Fireplace with Two 16” Horizontal Flue Channels

Colorado

Colorado was the first state to ban fireplaces on the basis of air quality. An MHA Colorado Legislative Task Force, consisting of Walter Moberg, Tom Stroud, and Rick Crooks, negotiated an exemption for masonry heaters.

The Colorado process was adversarial in nature. The regulation hinges on a so-called “MHA masonry heater definition”, that was drafted essentially to satisfy state regulatory lawyers, who considered the ASTM definition to lack rigor. It is a prescriptive definition, based on making firebox and flue length measurements. At a minimum, it only requires a horizontal flue run the same length as either the firebox height or width (whichever is greater). For example, for a 32” x 32” fireplace firebox, a 16” horizontal zigzag is all that is required to meet the Colorado definition (See Figure 1., left, for one possible interpretation). I expressed a written concern at the time[1] that this definition not be used as a precedent in other jurisdictions.

Both a Moberg fireplace and a modified Buckley Rumford fireplace have been approved in Colorado as masonry heaters. To meet the minimum Colorado definition, a standard masonry fireplace does not require much modificaton, as Figure 1 illustrates. This clearly emphasizes the need for establishing the dividing line between masonry fireplaces and masonry heaters, and the need for an MHA Masonry Heater Definition that has been sanctioned by a vote of the membership.

Washington

Washington state passed a fireplace regulation in 1996, after negotiations with an industry Technical Advisory Group, or TAG. Although it is a fireplace regulation, it includes a masonry heater definition based on the Colorado definition. I sent a letter of objection to Paul Tiegs at the time[2], and believe that we should apply to Washington state to have this definition changed.

An MHA Masonry Heater Definition is required before that can take place.

R-2000

R-2000 is a Canadian voluntary housing performance standard. The performance criterion is that the house shall have 50% of the energy consumption of a conventionally built house. The R-2000 program has been very successful in Canada since its inception more than ten years ago. It is also influential - many of its pioneering provisions have migrated into the National Building Code.

Masonry heaters inadvertently were excluded from R-2000 when a woodstove air consumption standard was imposed. To remedy this situation, Canadian MHA members entered a consultation and negotiation process with R-2000, and a masonry heater rule resulted that addresses masonry heater definition and installation. The process included a Canadian government funded study of masonry heater air consumption issues, carried out by Lopez Labs[3].

Main points include:

- Masonry heater must meet ASTM definition
- Neither heater or chimney may penetrate the house envelope (no outside chimneys)
- Heater operation must specifically preclude the possibility of open door use (no open fireplaces)

DISCUSSION OF MASONRY HEATER CRITERIA

1.) Heat Storage

Heat storage is the main feature that distinguishes masonry heaters from woodstoves and fireplaces. It is the key element that allows a fast burn rate, thus simultaneously optimizing wood combustion yet not overheating the heated space. This is a key point and cannot be overempathized. A high heat release rate in the firebox accompanies the high burn rate, but because of a limited loading door size and internal flue gas heat exchange channels, only a fraction of the available heat is released to the space during the burn.

Little data is available on the relative amount of heat storage of masonry heaters compared to other appliances. Test data is needed before firm conclusions can be drawn. Before appropriate testing can be conducted, two things are necessary:

- a definition of heat storage
- a test method for heat storage.

Heat Storage Definition

The amount of heat theoretically available for storage can be defined as the higher heating value (HHV) of the fuel, minus the stack loss during the burn. The actual amount of heat stored can be defined as the theoretical amount minus the amount released to the heated space during the burn phase. Almost all of this instantaneous heat release will occur through the loading doors. We can express heat storage as a ratio, (actual)/(theoretical maximum), and term it heat storage fraction (HSF).

Heat Storage Test Method

By definition, all heat storage takes place during the burn. Given the reasonable assumption that all of the immediate heat release occurs through the loading doors, it follows that measuring the heat release during the burn will allow us to calculate the amount of heat storage. If we cover the loading doors with a well insulated, low mass black chamber, then all of the heat released through the doors will be transferred to the air in the chamber. We can move air through the chamber with a fan and measure the airflow rate and air temperature rise. This will determine the instantaneous heat output.

It should be noted that this proposed test would be fairly simple to perform. Aside from the insulated box, the only apparatus required are a variable speed fan, two thermometers, a Pitot tube, and a draft gauge (manometer). In addition, a standard stack loss test is performed, using Orsat apparatus that can be obtained for under $100.00.

An alternate method might be to use a point-and-shoot infrared thermometer. These instruments have recently become affordable, and make it possible to take large numbers of surface temperature readings very easily. It would be simple to do a time-temperature record of the whole heater surface, as well has the loading doors. Thus, the heat output of the heater and the doors could be calculated directly, without doing a stack loss. Lopez is currently (February 97) doing tests on this.

Appliance Comparison

We know what a traditional masonry heater is and what a traditional masonry fireplace is. In between are a number of "advanced masonry fireplaces". We need to draw a line between masonry heaters and non masonry heaters, but don't know exactly where to draw this line. For comparison purposes, we can define an appliance range with a traditional masonry heater at one end and a standard masonry fireplace at the other. We can do this, in terms of actual appliances for which data is available, as follows (the relative ranking of the appliances marked "(?)" is unknown):

Table 1. Categorization of 6 Tested Appliances

Category	Specific appliance	Description
Masonry Heater	Tempcast	conventional masonry heater with heat exchange channels and firebox doors conforming to accepted design rules
?	Frisch-Rosin (modified)	advanced masonry fireplace with substantial heat exchange channels and large airtight ceramic glass doors
?	Moberg	advanced masonry fireplace with some heat exchange channels and large airtight ceramic glass doors
?	Frisch-Rosin (unmodified)	advanced masonry fireplace with no heat exchange channels and large airtight ceramic glass doors
?	Buckley-Rumford (unmodified)	advanced masonry fireplace with no heat exchange channels, with optional large airtight ceramic glass doors (i.e., open fireplace burn mode is not specifically excluded)
Masonry Fireplace	Standard Code Fireplace	conventional masonry fireplace with optional non-airtight doors

Although we don't know the HSF, we know that, in terms of HSF, a Tempcast is a masonry heater. We also know that, in terms of HSF, a standard code fireplace is not a masonry heater. Since a main criteria for a masonry heater definition will be defining a threshold HSF value, we can define the (as yet unknown) Tempcast HSF value to be on the masonry heater side of the threshold, and the standard code fireplace value to be on the fireplace side (Table 2).

Table 2. Heat Storage Comparison for 5 Appliances (Note: invalid without data)

Appliance	Heat Storage Fraction, HSF	Is it a Masonry Heater?
Tempcast	?	Yes
Frisch-Rosin, modified	?	?
Buckley-Rumford, modified	?	?
Moberg	?	?
Standard Code Fireplace	?	No

Discussion

A number of factors will affect HSF. The main parameter by far will be heat loss through the loading doors during the burn. Therefore, firebox shape and size, and door size will be key elements affecting heat storage. For an appliance to operate as a masonry heater, a fast burn rate is required. To withstand the accompanying thermal stress, door glass must be ceramic instead of the tempered glass found on conventional fireplaces. Ceramic glass is more transparent to infrared radiation than tempered glass, so the heat loss through the glass will be significant.

Firebox shape and size is also an important factor. Certain firebox designs such as the Rumford and the Rosin were in fact originally created to maximize the amount of heat radiation from the firebox opening. These firebox designs could, in fact, have a lower HSF than a standard masonry fireplace with airtight glass doors, which has a deep firebox and a lower opening.

2.) Efficiency

Appliance efficiency is another criterion that we can use to define a masonry heater. They are marketed as advanced, high performance appliances, so it is reasonable to include a minimum efficiency requirement as part of a masonry heater definition.

A credible database on masonry heater and masonry fireplace performance has been developed over the last 6 years. Main data sources are Virginia Polytechnic Institute (VPI)[4,5], OMNI Environmental[6,7,8,9,10,11], and Lopez Labs[12,13,14,15,16,17,18,19].

Table 3. Efficiency Comparison for 5 Appliances

Appliance	Overall Efficiency, %	Data Source
Tempcast	61.8	OMNI
Moberg	53 (? to be confirmed)	OMNI
Frisch-Rosin (unmodified)	57.9	OMNI
	52.1	Lopez
Buckley-Rumford	* (indeterminate)	OMNI, Lopez
Standard Code Fireplace	26.5 (Rosin with doors)	Lopez

The database on masonry heater and masonry fireplace efficiency, while credible, is not large. In terms of number of discrete burn tests performed, the largest fraction of available data for both masonry heaters and masonry fireplaces has been generated at Lopez Labs. Lopez Labs was in fact originally formed by MHA members to address the lack of a database and the high per test cost of generating data at an US-EPA accredited lab. While we have enough data on which to base some conclusions, there are still areas of controversy.

All efficiency data available is based on US-EPA style stack loss measurements. This leads to some technical problems[20] when determining efficiencies for appliances that have high amounts of dilution air, such as fireplaces. Therefore, data for fireplaces has higher margins of error than data for masonry heaters (Reference 18). Shelton et al. (Reference 20) have suggested 400% excess air as a limit for obtaining accurate efficiency data via the stack loss method. An example error analysis using Lopez data is provided in Appendix 2.

The second issue is ambient (outside) air temperature. Most of the data in the database, regardless of laboratory, has been generated at relatively high (greater than 60F) ambient air temperatures. With colder air, as one would find in most realistic heating situations in North America, high excess air appliances suffer a much higher efficiency penalty than appliances that operate near the optimum excess air level for domestic wood combustion of approximately 150 - 300%. Therefore, reported efficiencies for fireplaces in the literature (Table 3) are probably consistent, but too high.

3.) Emissions

Emissions has been the main regulatory focus in residential wood combustion (RWC). Masonry heaters, without exception, burn cleanly. Just exactly how cleanly is a matter for research and debate. From a regulatory perspective, the US-EPA limit of 7.5 g/h of particulate matter (PM) emissions has become the accepted benchmark for clean burning in the United States and Canada.

A significant database of masonry heater and masonry fireplace emissions data has been generated in the last 6 years. Both appliance types are “non-affected facilities” in the US-EPA woodstove standard, and have had to develop “equivalent” test methods to establish “equivalent” compliance. US-EPA so far has ruled that only field test data under actual in-home use conditions is acceptable. MHA, Western States Clay Products Association (WSCPA), OMNI and Lopez Labs have been the main players in developing this field testing database, and this effort has been described elsewhere (Reference 15).

Table 4. Emissions Comparison for 5 Appliances

Appliance	Particulate Emissions, g/kg (Douglas Fir, except Tempcast, Poplar)	Data Source
Tempcast	3.0	OMNI
Moberg	3.8	OMNI
Frisch-Rosin (unmodified)	2.2	OMNI
	1.5	Lopez
Buckley-Rumford (unmodified)	4.8	OMNI
	4.0	Lopez
Standard Code Fireplace	24.9 (conventional, open)	OMNI
	10.4 (Rosin, open)	OMNI
	8.1 (Rosin, with doors)	Lopez
	11.5 (open, dimensioned lumber)	VPI

As John Gulland points out[21], emissions, in particular the most harmful emissions, are produced by smoldering. In other words, the whole emissions issue is obscured (no pun intended) by the smoldering component. If we acknowledge this unique and complex aspect of wood combustion explicitly, it adds an extremely useful context to the emissions debate.

Since masonry heaters by definition are designed to burn fast and not smolder, they burn cleanly. In fact, they do so without much effort, unless there are fundamental design errors. An example of erroneous design is the use of underfire combustion air, which recent testing (References 7, 15) has shown to raise particulate emissions significantly during the cold start phase. Even with underfire air, masonry heaters are still comfortably under the US-EPA limit.

The preamble to the US-EPA woodstove regulation recognizes the inherent clean burning nature of masonry heaters:

> The 800 kg cutoff was established as an easy means of excluding the high-mass fast-burn wood-burning appliances known as “Russian stoves” or “European tile stoves.” These devices typically operate at hot, fast burn rates and cannot be dampened. It is also unlikely that they are capable of meeting the 5 kg/hr minimum burn rate. *The intent of the committee was to exempt from the standards these appliances which rely on clean-burning air-rich conditions and which have high combustion efficiencies. It should be noted, however, the exclusion does not apply to appliances which exceed the 800 kg threshold only because of masonry or other materials which are not sold by the manufacturer as integral parts of the appliance*[22]. (emphasis added)

Emissions from both a conventional masonry fireplace or an advanced masonry fireplace can vary dramatically, depending on operator influence, since a fast burn is not the only option available. The operator can maintain a brisk, bright fire until the charcoal phase, or (typically, for the owner of a conventional fireplace (Reference 6)) allow smoldering to occur. This is a very real problem with the current “US-

EPA audited blind in-home field testing” protocol, since simple operator coaching by the manufacturer can have a much greater effect on emissions performance than any claimed appliance superiority.

Most of the recent work at Lopez Labs has been a study of fueling protocol effects on appliance performance. A Lopez protocol for describing fueling parameters in detail has been developed. Only a small amount of work in this area has been done elsewhere to date.

Emissions is an unimportant component of masonry heater definition. A reasonably well-designed masonry heater burns cleanly without much effort.

Reduced burn rates that try to emulate fireplaces might be a problem, but this is outside the realm of established masonry heater practice. This is an issue, however, for advanced masonry fireplaces.

4.) Burn Rate

A high burn rate goes hand in hand with heat storage. Again, heat storage allows a burn rate to be used that is higher than that required to supply the immediate heating needs, in contrast with conventional metal woodstoves. All woodburning appliances have a *critical burn rate,* a rate below which flaming combustion changes to smoldering combustion. In conventional US-EPA certified stoves, the critical burn rate threshold is reduced by means of elaborate, precisely tuned secondary air systems and associated techniques. This is necessary because the appliance is required to target the immediate heating need of the space over a wide range of heat outputs. In modern houses, the average heat requirement is often quite low. Burning wood cleanly AND slowly is difficult.

With fireplaces, burn rate has traditionally not been an issue, because fireplace performance has not been investigated with modern methods until recently. Ten years ago, there was no reliable data on masonry fireplace emissions, efficiency or usage patterns under actual in-home conditions. Advanced masonry fireplace design is still in its infancy. Many questions remain unanswered, and more test data is needed. If advanced fireplaces make claims to be masonry heaters, they must be able to make those claims based on performance, and performance claims must be backed with test data obtained under a variety of operating conditions.

In the meantime, it seems reasonable to maintain the US-EPA “non-affected facility” criterion of a minimum 5 kg/hr burn rate as a definition requirement for masonry heaters.

5.) Firebox Measurements

The relationship between firebox dimensions and heat exchange flue length was used as the basis for the Colorado masonry heater definition. At the time, there was a need for a narrow legalistic definition to satisfy the requirements of the state’s regulators and their lawyers, who had no familiarity with masonry heater principles and disputed them with some vigor.

A Moberg fireplace and a modified Buckley Rumford fireplace have been accepted by Colorado as meeting their masonry heater definition. Clearly, this emphasizes the need to define where the dividing line between fireplaces and masonry heaters actually is.

6.) Heat Exchanger Configuration and Wall Thickness

Masonry heaters are primarily heating appliances. In order to function properly, overall wall thickness must be within certain limits. If the masonry facing around the heat exchangers is too thick, then it is impossible to reach the required surface temperatures. Instead, the thermal lag (thermal time constant) increases beyond the accepted useable period of 24 hours. In other words, there is too much heat storage.

At 68F room temperature, the heat output from a vertical radiant panel is given in Table 5, below. The last column compares the heat output for a typical North American masonry heater with 100 ft^2 of radiant surface, constructed with different wall thicknesses:

Table 5. Surface Temperature versus Heat Output for a Vertical Radiant Panel

Surface Temperature, degrees Fahrenheit	Heat Output, BTU/hr. per sq. ft. of Surface	**Heat Output, kW per $10m^2$ of Surface ($10m^2$ = 100 ft^2)**
80	33	1.0
120	105	3.1
160	200	6.0

Table 6. Comparison With German Wall Thickness Standards for Masonry Heaters[23]

Construction Style	Wall thickness at Firebox, cm.	**Heat Output, kW per $10m^2$ of Surface**
“heavy”	12.0 - 14.0 (= 4 ¾ - 5 ½ in.)	7.0
“medium”	10.5 - 12.0	10.0
“light”	8.0 - 9.5	12.0

Clearly, if we build a heater with a typical surface area of 100 sq. ft. (the surface area that is adjacent to the firebox and heat exchange channels), fire it with a design fuel charge, and it only reaches a surface temperature of 80 degrees F., then we have a heater with unacceptable performance. For the client, spending $10,000 to achieve a 1kW output would be a waste of money, from a heating standpoint. It would also be unethical for a builder to imply that he is providing the client with a masonry heater.

To prevent this, a serious masonry heater such as the Tempcast uses a maximum overall wall thickness at the heat exchangers of around 7”. If we get much thicker than 8”, surface temperature performance will suffer. For an advanced masonry fireplace to be a masonry heater, it must be able to demonstrate an acceptable minimum surface temperature under normal operation. 120ºF (50ºC) is a reasonable minimum, and is well below comparable European standards (Table 6).

A masonry heater definition, based on performance, should be prescriptive in specifying the maximum overall wall thickness that is allowable at the heat exchange channels. Experience tells us that a heater with 12” thick walls is not a serious heating appliance. Therefore, a reasonable maximum allowable wall thickness would be 10”.

7.) Intended Use and Location

A masonry heater is a serious heating appliance, not just a decorative architectural element in the house. Because it is a radiant heating system, location is important. Central location is best. If it is located on an outside wall, it must not penetrate the insulated house envelope.

Any masonry appliance that penetrates the house envelope, as is typical for conventional masonry fireplace, should be defined as not being a masonry heater. The Canadian R-2000 regulation for masonry heaters (see Appendix) goes one step farther by prohibiting the use of outside chimneys.

PROPOSED WORDING FOR MHA MASONRY HEATER DEFINITION

A masonry heater

- is a heating system of predominantly masonry construction having a mass of at least 800 kg (1760 lb), excluding the chimney and foundation.
- is designed to burn at a burn rate greater than 5 kg/hr. Burn rate is defined as the weight of fuel charge divided by the burn time. Standard masonry heater types, as illustrated in ASTM E1602-94, shall be deemed to attain this value.
- is deemed to have a particulate emissions level of less than 7.5 g/kg by virtue of a) the above design principle and b) the substantial existing database of test results.
- is designed to burn with the loading doors closed. An exception may be made for loading doors smaller than 1 ft^2 in area.
- is constructed of sufficient mass such that under normal operating conditions the external surface of the heater, except in the region immediately surrounding the fuel loading door(s), does not exceed 100°C (230°F).
- has a maximum overall wall thickness of 10" (250mm).
- *(Note this proposed provision would be simpler than mandating HSF measurements):*
  is capable of achieving a minimum average surface temperature of 50°C (120°F) with a design fuel load, on a design heating cycle. This measurement shall be carried out with an infrared thermometer such as a Raytek ST-2L or equivalent. A minimum of 10 equally spaced measurement points over the heater surface, excluding the heater top, shall be used. No measurement points shall fall within 6" (150 mm) of the loading doors.
- shall not penetrate the house envelope.
- *(this requirement becomes redundant, but may be desirable from a building code point of view)*:
  achieves heat storage by routing of exhaust gases through internal heat exchange channels in which the flow path downstream of the firebox includes at least one 180 degree change in flow direction, usually downward, before entering the chimney.

CONCLUSION

It is inappropriate to sell fireplaces to consumers and call them masonry heaters simply as a marketing device, or to circumvent fireplace bans.

Even though many heater masons are also fireplace masons, the masonry heater industry's role is not to fight the masonry fireplace industry's battles. We must avoid the danger of accepting a lowest common denominator and thereby penalizing those manufacturers and builders who reserve the term "masonry heater" for truly high performance appliances. Before accepting masonry fireplaces, including advanced masonry fireplaces, as masonry heaters, one might pose the question: "Is there a benefit for the masonry heater industry, its clients, or the environment?"

The primary focus for masonry heaters should be appliance performance, since this is where masonry heaters excel. We should aim to set high standards for heat storage fraction (HSF), efficiency, surface temperature and emissions.

Masonry heaters should be defined in terms of these performance standards.

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APPENDIX:

1.) Full Text of Existing Masonry Heater Definitions

ASTM Masonry Heater Definition

3.2.14 masonry heater—a vented heating system of predominantly masonry construction having a mass of at least 800 kg (1760 lbs.), excluding the chimney and heater base. In particular, a unit designed specifically to capture and store a substantial portion of the heat energy from a solid fuel fire in the mass of the appliance through internal heat exchange flue channels; enable a charge of solid fuel mixed with an adequate amount of air to burn rapidly and more completely at high temperatures in order to reduce emission of unburned hydrocarbons; and be constructed of sufficient mass and surface area such that under normal operating conditions, the external surface of the heater (except in the region immediately surrounding the fuel loading door(s)), does not exceed 100ºC (230ºF).

From:
Standard Guide for Construction of Solid Fuel Burning Masonry Heaters
ASTM Designation: E 1602 - 94

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215-299-5400

Proposed One and Two Family Dwelling Code (OTFDC) Masonry Heater Definition

A masonry heater is a heating system of predominantly masonry construction having a mass of at least 800 kg (1760 lbs.),excluding the chimney and foundation, which is designed to absorb a substantial portion of the heat energy from a rapidly-burned charge of solid fuel by:

a) routing of exhaust gases through internal heat exchange channels in which the flow path downstream of the firebox includes at least one 180 degree change in flow direction, usually downward, before entering the chimney, and

b) being constructed of sufficient mass such that under normal operating conditions the external surface of the heater, except in the region immediately surrounding the fuel loading door(s), does not exceed 100°C (230°F).

Note: Three characteristics distinguish the masonry heater from the masonry fireplace: first, it is designed to be operated with its tight-fitting loading door(s) closed; second, it is intended to function as the primary or a significant supplementary heating system for a house; and third, the chimney serving the heater is not usually supported by the body of the heater, but rather is located behind or beside the masonry heater where it may share a common wall with the heater facing.

Reason: This definition is provided on the assumption that some users of the code may not be familiar with the characteristics of masonry heaters and so that the code user has context for the provisions referring to masonry heaters.

Colorado Masonry Heater Definition

substantially the same as Washington definition, below

Washington State Masonry Heater Definition

MASONRY HEATER is a wood burning device designed and intended for domestic space heating or domestic water heating, which meets the following criteria:

1. An appliance whose core is constructed primarily of

manufacturer-built, supplied or specified masonry material (i.e., stone, cemented aggregate, clay, tile or other non-combustible non-metallic solid materials) which weigh at least 1,760 pounds (800 kg);

2. The firebox effluent travels horizontally and/or downward through one or more heat absorbing masonry duct(s) for a distance at least the length of the largest single internal firebox dimensions before leaving the masonry heater; Where, for the purposes of this subparagraph:

2.1 Horizontal or downward travel distance is defined as the net horizontal and/or downward internal duct length, measured from the top of the uppermost firebox door opening(s) to the exit of the masonry heater as traveled by any effluent on a single pathway through duct channel(s) within the heater (or average net internal duct length for multiple pathways of different lengths, if applicable). Net internal duct length is measured from center of the internal side or top surface of a duct, horizontally or vertically to the center of the opposite side or bottom surface of the same duct, and summed for multiple ducts or directions on a single pathway, if applicable. For duct channel(s) traversing horizontal angles of less than ninety degrees from vertical, only the new actual horizontal distance traveled is included in the total duct length.

2.2 The largest single internal firebox dimension is defined as the longest of either the length or width of the firebox hearth and the height of the firebox, measured from the floor of the combustion chamber (hearth) to the top of the uppermost firebox door opening(s).

R-2000 Requirements for Masonry Heaters

Masonry heaters must exhibit the following characteristics in order to be eligible for use in R-2000 homes:

- Outside combustion air must be supplied directly to the unit, with sizing meeting local codes or as per CSA B415.
- Conform to ASTM Standard Guide for the Construction of Solid Fuel Burning Masonry Heaters E1602 - 94. In it a masonry heater is described as: a vented heating system of predominantly masonry construction having a mass of at least 800 kg excluding chimney and heater base. In particularly, masonry heaters are designed specifically to (1) enable a charge of solid fuel mixed with an adequate amount of air to burn rapidly and more completely at high temperature, and (2) to capture and store a substantial portion of the resulting heat energy in the mass of the appliance through internal heat exchange flue channels, and (3) to gradually release the stored energy to the space to be heated.
- Exhibit no underfire air during the ignition phase of the burn.

- The appliance must have gasketed firebox doors or milled doors that are specifically designed for use in masonry heaters and prevent combustion product spillage. Pivoted dampers shall be permanently labeled so as to indicate their proper position during operation.
- The appliance should not be designed, manufactured or installed so that it can be used as an open fireplace. This may be achieved by limiting interior chimney size to 70 sq. in. (0.042 m^2) or using other approved methods.
- The chimney and masonry heater must not penetrate a wall exposed to an unheated space. If installed against an insulated outside wall, a vented 100mm airspace is to be maintained between the heater facing or chimney and the wall.
- Basement installation is not recommended. If a “downdrafting” heater (as described in ASTM E1602 - 94) is specified, then a bypass damper must be provided and at least 1m of refractory liner provided after the damper.
- There must be a carbon monoxide (CO) alarm in the room where the masonry heater is installed. The alarm may operate by battery or be hard wired.
- All units shall be installed by personnel designated by the manufacturer of a modular unit or by qualified masons having taken the Wood Energy Technical Training (WETT) course or other approved courses.

2.) Stack loss sensitivity comparison using Lopez data:

One of the Lopez flue gas analyzers is a German TESTO 342. It is widely used there by sweeps and furnace technicians (Germany has mandatory furnace efficiency testing). It uses a chemical oxygen cell, has a microprocessor controlled autocalibration routine, and comes with calibration certificates for the following accuracies:

Temperature above 100C: +/- 0.5%

Oxygen : +/- 0.2 Vol. % absolute

Adding and subtracting these error levels to representative Lopez data we get the following:

Heat-Kit Test D-12: (upper end of measured efficiency range)

	Stack Oxygen %	Excess Air %	Stack Temp °F	Overall Efficiency %	Error
Value from Test	12.76	257	401	71.29	
Add 0.2% O_2				70.88	
Add 0.5% Temp				69.90	
Subtract 0.2% O_2 and 0.5% Temp				72.63	3.8%

Heat-Kit Test D-04: (middle of measured range)

	Stack Oxygen %	Excess Air %	Stack Temp °F	Overall Efficiency %	Error
Value from Test	14.56	330	385	67.41	
Add 0.2% O_2				66.76	
Add 0.5% Temp				65.54	
Subtract 0.2% O_2 and 0.5% Temp				69.20	5.4%

Frisch Rosin Test B-09: (Rosin fireplace with glass door and Frisch air supply - middle of measured range)

	Stack Oxygen %	Excess Air %	Stack Temp °F	Overall Efficiency %	Error
Value from Test	16.51	476	420	55.31	
Add 0.2% O_2				55.83	
Add 0.5% Temp				52.10	
Subtract 0.2% O_2 and 0.5% Temp				58.23	11.1%

Rosin Test FC-A01: (Rosin fireplace with glass door and standard 2 “cowbell” air supply - middle of measured range)

	Stack Oxygen %	Excess Air %	Stack Temp °F	Overall Efficiency %	Error
Value from Test	19.21	1234	343	26.10	
Add 0.2% O_2				18.63	
Add 0.5% Temp				14.87	
Subtract 0.2% O_2 and 0.5% Temp				34.94	76.9%