Date:

July 30, 2014

From:

Dan Givens
President
Masonry Heater Association of North America

Re:

Supplementary Information to MHA NSPS Comments Regarding Proposed Certification of Masonry Heaters via Computer Simulation

Prepared by: MHA Technical Committee

Background:

In the NSPS Public Comments, Tulikivi stated the following:

(May 5, 2014 comments, page 7)
Computer simulations:

Tulikivi welcomes the addition of computer simulations as an alternative certification pathway for masonry heaters (**§ 60.5487(b)(3)** & **§ 60.5488(c)(1)**). The proposed simulation method ASTM WK26558, based on European standard EN15544 is limited in its application to heaters that use fireclay or chamotte, both of which greatly differ from soapstone (the primary building material of a Tulikivi) in density and heat conductivity. Additionally, this method does not take into account the gas flow direction and therefore underestimates the heat transfer coefficient of a down drafting heat exchanger, a design element present in all Tulikivi heaters[18]. ASTM WK26558 is inappropriate to Finnish contra-flow masonry heaters such as those Tulikivi manufactures, making the proposed methodology ineffective for Tulikivi until a more comprehensive simulation program is developed.

In our May 5, 2014 Comments, MHA stated the following:

6. The dimensioning standard approved for alternative certification needs to be adapted to North American market conditions

ASTM WK26558 is based on the European standard EN15544. The purpose of this standard is to guarantee the proper function of a custom built masonry heater during the most critical phase of the burn (maximum flue gas oxygen depression) and under the worst possible operating conditions (cold heater, half load, high outside temperature, low atmospheric pressure, high air moisture). This is done by ensuring that :
1) the volume of the firebox allows sufficient residency time to the combustion gases in its hottest zone ;
2) air flow velocity generates sufficient turbulence to proper mixing of air and combustion gasses ;
3) resistance and draft are properly balanced throughout the system (from the air intake to the chimney).

Additionally, the standard guarantees the emissions of a functional heater to be under certain limits.
Being originally developed in Austria, this standard is designed for Austrian types of heaters (Kachelofen and Grundofen), built with local refractory materials (chamotte) and operated according to local practices which involve multiple small firings. It comes as no surprise that to be operational in North America, this standard needs to be adapted to our local market conditions.

We propose to develop a revised & extended standard which addresses the limitations of EN15544 :

- allow the use of North American made refractory materials (firebricks, refractory concrete, soapstone) which are ruled out by EN15544 which stipulates conductivity < 0.90 W/mK
- allow larger sized glass firebox doors (EN15544 limits glass door surface area to 1/6 of firebox surface area). Recent Austrian testing has shown the heat loss through a 11”x15” single pane glass door to be only in the 5% range. Prior to this testing, losses were assumed to be in the 20% to 30% range*
- allow the use of a prefabricated or partly prefabricated core (covered by standard 15250 in Europe)
- make the burn rate variable. This will allow the simulation of firing with large firewood pieces (EN15544 sets firing duration to 77 minutes, whatever the fuel load,

meaning that the larger the load, the smaller the pieces have to be, which is not how masonry heaters are typically operated in North America)
- base the dimensioning of the firebox on burn rate instead of on fuel load (EN15544)
- make the air factor variable (set to 2.95 in EN15544)
- make the air speed and gas speed variable (set at 4mN3/kg and 4.8 mN3/kg, respectively in EN15544)
- make the temperature at the top of the firebox and at the entrance of the heat exchanger variable (set to 700°C and 550°C, respectively in EN15544)
- allow the coefficient of heat transfer to vary with the cross section area of each channel
- allow the coefficient of heat transfer to vary with the orientation of the gas flow (horizontal, upward, downward) in each channel
- allow the coefficient of heat transfer to vary with the gas flow velocity in each channel

These last three changes are instrumental in making the standard accurately calculate thermal transfer in units where most transfer happens when the gas flow is descending (Contraflow and Bell heaters) and in units where the gas flow is very slow (Bell heaters).

EN15544 isn't designed for these situations because in Austrian style heaters gasses mostly flow horizontally or upward and through channels where the ratio between height and width is no more than one in three.

These developments are very important to our members because Finnish Contraflow heaters have been the most popular type of masonry heaters in North America in the last 25 years and Russian Bell heaters have become increasingly popular in the last 5 years.

*See:
Appendix A(5)

MHA would like to submit the following additional information:

STATUS REPORT, July 29, 2014:

Damien Lehmann is a French engineer who joined the MHA technical committee in January, 2014. His engineering background is in civil, computer software development, and industrial control systems. Since 2008 he has been actively working with masonry heaters.

Mr. Lehmann has developed a masonry heater dimensioning calculator based on EN 18834 and EN 15544 that addresses most if not all of the limitations of the existing EN 15544 standard, as enumerated above. The software is open source and in the public domain.

Lopez Labs Co-operative is composed of 6 members of the MHA Technical Committee, who have all established the capability to do independent laboratory and field testing of masonry heaters, using the Condar method to obtain PM emissions data that has been demonstrated to be compatible with EPA M5G data for research and development purposes.

To date MHA has instrumented 4 masonry heaters with internal pressure and temperature sensors to compare flow conditions predicted by EN15544 calculation with measured values. Initial testing indicates that the model predicts values well for the narrow range of heaters that is included in EN15544. These are channelled, Austrian style heaters with an assumed fixed burn rate where the interior channels fall within a narrow range of parameters.

Initial tests on Contraflow and Double Bell heater types indicates discrepancy between calculated and actual values, caused by the lack of buoyancy (Bernouilli's principle) effects being accounted for in large downdrafting channels at low speeds. We are conducting testing to verify the addition of a buoyancy coefficient to the pressure terms, to yield calculated results that more closely match measured results.

We have established the following timeline to establish a viable software simulation based approach that may be used to certify masonry heaters to a guaranteed level of emissions and efficiency performance:

	Work Item	**Date**
1	Goals definition	31/08/2014
2	Contextual analysis and perspectives	21/09/2014
3	Summary of theoretical knowledge in relation to the context	15/10/2014
4	Definition of measured quantities and units	30/10/2014
5	Defining objectives of the experiment	15/11/2014
6	Definition of measuring instrument and man-machine interface	15/12/2014
7	Definition of a test protocol	31/12/2014
8	Measurement on simplified cases	Winter testing season
9	Check presuppositions	01/03/2015
10	Challenging technical choices and theoretical approaches	15/03/2015
11	Establishment of a definitive protocol	01/09/2015
12	Campaign measures on real stoves	01/03/2016
13	Adjusting the theoretical parameters of the method and property safety margins	01/08/2016
14	Publication of the worksheet	01/10/2016

The second phase of this project is to identify a third party certifying authority, and develop a certification system that will meet EPA requirements. Since this will likely involve additional testing by an EPA accredited laboratory to verify the work done by MHA, we estimate that this may take an additional 24 months. Note that our May 5, 2014 submission, 7B, provides a European example of vetting a masonry heater dimensioning software model for certification purposes.

Calculator discussion:

The operating principle of the EN15544 calculation is that it insures proper drafting performance for an appliance under worst case conditions. These conditions are: half load, warm ambient temperature, low barometric pressure, high humidity. A failure of the venting system would result in sub-optimal combustion, which would lead to higher emissions.

The calculator is not used to predict emissions numbers for the heater. Rather it has been certified to guarantee that the numbers are below a set standard. It differs from current EPA certification testing in that it models the performance of a site-specific heater and chimney system, rather than testing at a standard 16' chimney height. It does not predict the emissions, but instead guarantees that fluid dynamic and heat transfer considerations to guarantee good combustion are met.

In September 2011, the Austrian Kachelofen Association issued a specification for a masonry heater combustion air system, known as the "Eco-labelled Combustion Chamber". A copy of the specification may be found here:
http://mha-net.org/docs/codes/austria/MB_10_eco-friendly%20combustion%20chamber_20120424Version2.pdf

In the spring of 2014, an MHA technical committee member built and tested a large North American style masonry heater with this firebox air specification. The PM and CO numbers were quite low, about 50% lower than the average obtained in previous Lopez Labs testing in several heaters over approximately 150 burns.

Subsequently, two other Lopez Labs Co-Operative members tested two additional heaters, of different design and at different sites. Both sets of tests confirmed the initial results. Details are located here:
http://www.heatkit.com/research/lopez-2014-03-01.html

As of 2015, Austrian emissions regulations require that this firebox air specification be used in certified heaters, in addition to the EN 15544 calculator. It should be noted that the new Tulikivi whirlbox firebox design follows this specification.