Masonry Heater Association Of North America

MHA News

Volume 8 Number 1 Spring 1995

Sustainable Construction - Has it Reached Critical Mass?

FIRST INTERNATIONAL CONFERENCE

Introduction

The First International Conference on Sustainable Construction was held in Tampa, Florida, November 6 - 9, 1994. Sponsors included Environmental Building News (see MHA associate member list), Rocky Mountain Institute (home of soft energy paths advocate Amory Lovins), the University of Florida, and CIB - International Council for Building Research Studies.

An international group of researchers presented about 150 papers, and about 300 people participated in the conference. The Conference Proceedings are available from the University of Florida (885 pages, $100 US).(Continued on p. 3)

1995 MHA Annual Meeting
Las Vegas
March 22 - 24, 1995

This year's annual meeting will be held immediately prior to the Hearth & Home Expo sponsored by the Hearth Products Association (HPA).

There will be a new format this year, in order to attract more working stovemasons to the meetings.

The first full day (Thursday March 23) will be a Technical Session.

The morning session will be devoted to a discussion of bakeovens, and will feature noted baker and bakeoven builder Allan Scott, as well as longtime mason Dale Hisler. The afternoon will feature shop talk. Topics so far include: callback issues, heater design, fine tuning and combustion. Contact Pat Manley if you have suggestions for more topics.

Informal shop talk sessions after regular meetings have in the past been some of the most popular events. This year marks the first time that they have been moved front and centre on the agenda. Don't miss it! (see next page for more details)...

In This Issue

Masonry Heater Association Of North America MHA News

Volume 8 Number 1 ....Spring 1995

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The Masonry Heater Association of North America

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Membership Policy:

Membership is open to anyone with an interest in masonry heating .

Annual membership dues:

Voting	200.00 (US)
Associate	100.00 (US)

IMPORTANT NOTE: Please check the membership list in the current issue and notify us immediately of any errors in your address, phone numbers, or dues status. Voting members are entitled to a set of in print back issues of MHA News.

Contact the Editor if you haven't received your back issues or if the information published in this issue's membership list needs correction.

1995 MHA Meeting

Agenda

Wed. , March 22, 1995 6:00 to 8:00 pm	Welcoming Reception at the Stardust Resort & Casino
Thurs. , March 23, 1995 8:00 am to 5:00 pm	MHA Annual Meeting at the Convention Center

A Heater Builder's "Bricks & Mud" Technical Session

8:00 am	Coffee and Welcome Hour
9:00 am	Bake Oven Construction and Operation by Allan Scott; additional comments from Dale Hisler
12:00 noon	Lunch on your own
1:30 pm	Shop Talk - • heater design • building for longevity and avoiding callbacks • fine tuning combustion • other topics
Fri. March 24 8:00 am to 5:00 pm	MHA Annual Meeting at the Convention Centre

Annual Business Session

8:00 am	Greetings and Introductions Minutes and Treasurer's Report
8:30 am	BIA Report Slide Program Update Colorado Review PR Program Update ASTM Update and other topics
12:00 noon	Lunch on your own
1:30 pm	Test Results from Lopez Labs Training Update Testing/Certification
7:00 pm	MHA Banquet
9:00 am to 5:00 pm	Expo Open
Sat. March 25 9:00 am to 12 noon	MHA Annual Meeting at the Convention Center Planning Session for Training Program
9:00 am to 12 noon	Expo Open

For hotel and additonal details, see back page of this newsletter

Keynote speaker Paul Hawken stated that in the year since the publication of The Ecology of Commerce, his most recent book, he has become convinced that the sustainability movement has reached critical mass.

See the separate report on Hawken's ideas elsewhere in this issue.

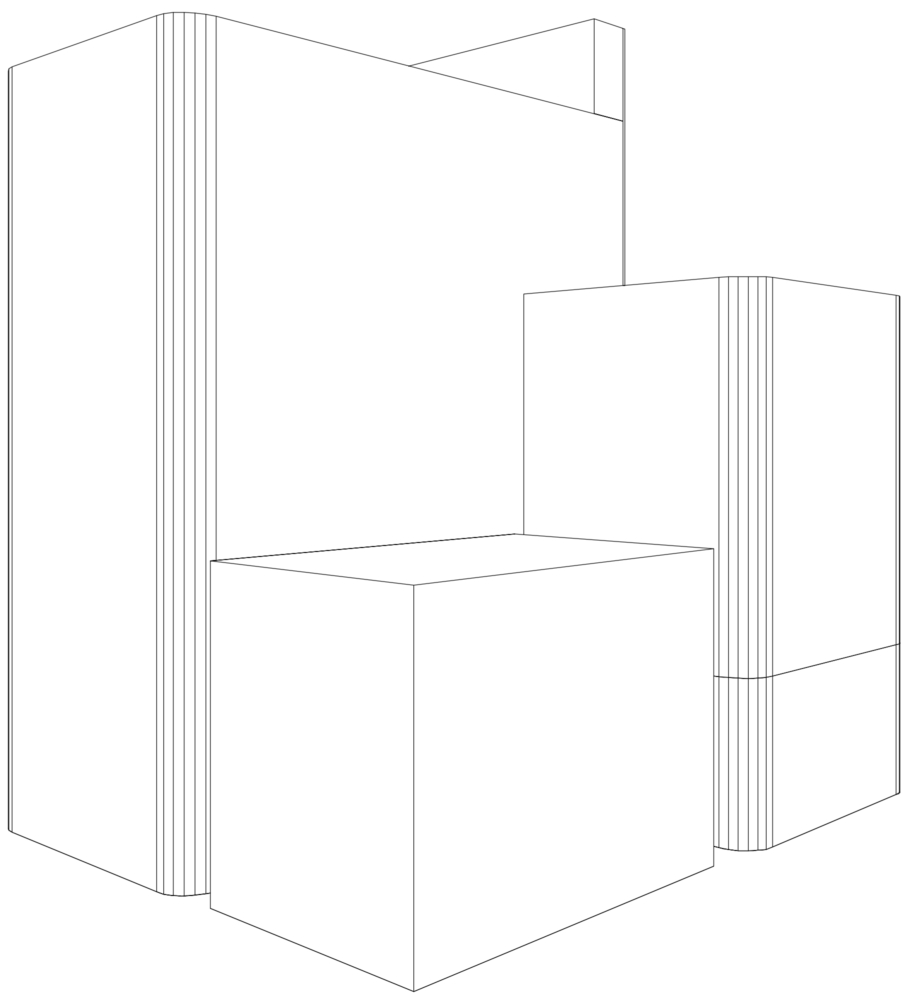
Keen Interest in Masonry Heaters at Trade Show

The conference included a small trade show with 30 booths. Masonry heaters were present with an MHA booth hosted by my wife Leila and myself. We had the generic photo display put together by Lou Frisch (contact Lou if you're a voting member and aren't yet represented). We had also sent a letter to MHA member manufacturers with details of the show and an offer to distribute their literature. Interest in masonry heaters was the highest of any show that we've seen. The attendees were well qualified and included a high proportion of architects, architecture professors and builders who were specifically looking for "green" products. We soon ran out of MHA brochures and newsletters. We brought plenty of MHA (voting) membership lists, and no doubt members can expect some calls. What seemed like a large supply of Biofire brochures that we brought from home lasted only thirty minutes.

Masonry heaters were in excellent company at the show. Our booth neighbour to one side was Collins Pine Company, owners of the first forest in the United States to be independently certified for its impact on the environment. Since sustainable forestry practice can yield large volumes of firewood, it is a perfect complement to environmentally responsible woodburning. Certified sustainably grown firewood is available in Germany, pushed by demand from educated consumers. Our neighbour to the other side, from Germany, was Hebel aerated concrete, "both environmentally and structurally sound", and now manufactured in the United States. We felt very much at home at this show - there were no fossil-fuelled fireplaces to be seen.

It is important for masonry heaters to become more visible in the sustainability arena. Very clean (as opposed to merely "EPA clean") biomass technology, such as ours, has an important contribution to make. Sustainable construction is only now approaching critical mass, and consensus is only starting to be approached on many of the concepts. Energy efficiency certainly is the key. Embodied energy is an idea just beginning to gain widespread popularity (see below). On the heating side, we don't really see much offered

> WE LIVE THE LIFESTYLE OF ADDICTS. RIDICULOUSLY CHEAP ENERGY IS OUR DRUG.



yet. This is probably because the recent cheap oil era has given us a sort of collective amnesia about heating. Heating is now automatically associated with fans, pumps and controllers - it has become the domain of the mechanical engineer. It is our job to start challenging some of those unconscious assumptions - we've got some good cards to play.

Defining Sustainability

The conference was split up into 13 sessions. Sessions 1 and 2 addressed "defining sustainability".

What does sustainability mean? The idea of trying to live a sustainable lifestyle and designing a sustainable economy means that we need to start behaving as if we would like to have great-grandchildren and beyond. To North Americans in particular, it is a wakeup call. It is becoming quite clear to increasing numbers of people, including a lot of masonry heater builders, that we are living in a fool's paradise if our only guiding principle is "business as usual", with perhaps the hope of a techno-fix or two. We need to redesign our economy and our businesses and figure out how to make a good, enjoyable living off annual solar income, instead spending our principal and compromising not just our own future, but also that of the global ecosystem. Viewed from the international perspective of a conference such as this, it soon becomes obvious that a majority of North America is asleep at the wheel. We live the lifestyle of addicts. Ridiculously cheap energy is our drug.

Conference organizer Charles Kibbert kicked off the discussion of defining sustainability at the conference and presented the following comparison:

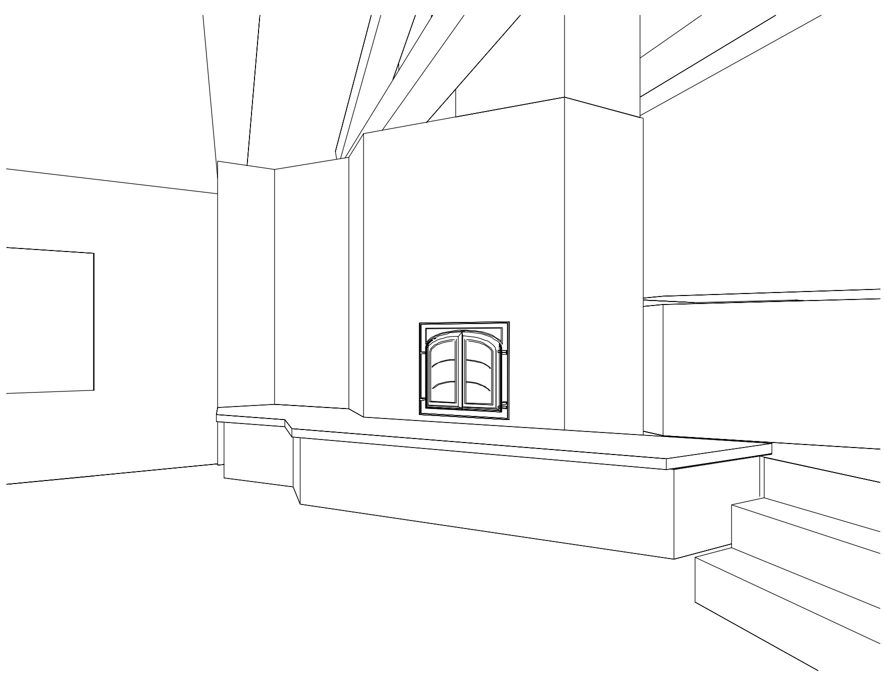
Traditonal Criteria	Sustainability Criteria
Performance	Resource depletion
Quality	Environmental degradation
Cost	Healthy environment

AN AUSTRIAN PAPER REPORTED THAT, IN SOME BUILDINGS STUDIED, THE EMBODIED ENERGY IN THE BUILDING WAS EQUIVALENT TO ABOUT 40 YEARS WORTH OF ANNUAL ENERGY CONSUMPTION.

Embodied Energy

One of the main threads to emerge at the conference was the concept of *embodied energy content*. Embodied energy includes the amount of energy used in the manufacture of the materials. For wood, it also includes the energy content of the wood itself, which is classed as renewable. An Austrian paper reported that, in some buildings studied, the embodied energy in the building was equivalent to about 40 years worth of annual energy consumption.

Embodied energy analysis is a new field. The flavour of some of the current research can perhaps best be illustrated by an example from a paper presented by Tarja Häkkinen, chief research scientist at VTT, the Finnish Building Technology Technical Research Centre. The paper is titled "Environmental Aspects of Building Materials"[1] and gives the following detailed analysis for some timber products:



[11] Häkkinen, T., Environmental Assessm Building Materials, VTT, P.O. Box 1805 (Kemistintie 3), FIN-02151 ESPOO, 1994.

EMBODIED ENERGY CONTENT ANALYSIS FOR THREE CONSTRUCTION MATERIALS			
Material or Energy	**Emissions or use of raw material per kg product (dry material)**		
	Structural timber	Roof truss	Cladding boards
EMISSIONS			
CO_2	95.7 g	98.4 g	94.1 g
CO	5.91 g	8.33 g	5.83 g
NO_x	3.39 g	4.02 g	3.34 g
SO_2	0.112 g	0.121 g	0.110 g
VOC total	1.16 g	1.56 g	1.14 g
CH_4	0.415 g	0.552 g	0.409 g
PAH	0.00123 g	0.00175 g	0.00121 g
Benzene	0.0341 g	0.0474 g	0.0336 g
Other VOCs	0.700 g	0.915 g	0.690 g
Heavy metals	0.000478 g	0.000679 g	0.000471 g
Dust into air (particulates)	0.773 g	1.06 g	0.761 g
BOUND CARBON (CO_2)	792 g	792 g	792 g
RAW MATERIALS			
Wooden raw material (wet/dry)	4900/2660 g	5400/2940 g	4830/2750 g
Phosphate fertilizers	0.300 g	0.331 g	0.295 g
Nitrogen fertilizers	1.71 g	1.88 g	1.68 g
Potassium fertilizers	0.300 g	0.331 g	0.295 g
Pesticides	0.0173 g	0.0191 g	0.0170 g
Saw blade chain oil, biol.	0.0628 g	0.0691 g	0.0617 g
Saw blade chain oil, miner.	0.128 g	0.141 g	0.126 g
Lubricants, biol.	0.246 g	0.271 g	0.242 g
Lubricants, miner.	0.917 g	1.01 g	0.902 g
Steel bands	0.790 g	0.870 g	0.780 g
Wrapping	2.11 g	2.32 g	2.08 g
Stamping colours (latex)	0.0135 g	0.0380 g	0.0133 g
Blue stain prevention	0.320 g	0.350 g	0.310 g
Nail and nail sheets	6.22 g	42.2 g	7.22 g
Paints	-	-	201 g
ENERGY			
Renewable energy (Higher Heating Value of logs)	54.6 MJ (=15.2 kWh = 14410 BTU)	60.2 MJ	56.5 MJ
Fossil fuels	1.40 MJ	1.38 MJ	1.38 MJ
Electricity	0.0140 MJ	0.0100 MJ	0.00695 MJ
Utilization of waste heat	0.208 MJ	1.21 MJ	0.205 MJ
Potential energy of products	17.1 MJ	17.1 MJ	17.1 MJ
of loss at building site	2.61 MJ	-	4.95 MJ

I asked Ms. Häkkinen whether a similar analysis has been done for masonry materials. She replied that it hasn't. The masonry industry in Finland is considering it, but hasn't yet decided to do it.

Other Factors:

Dr. Kibbert went on to suggest the following scheme as a starting point for assessing the sustainability aspects of the building process:

1. Embodied energy content
2. Greenhouse warming gases
3. Toxics generated/content

He warned that translating this from an academic discussion into the real world is fraught with complications. A repeated comment that I heard many times on this topic was that our current database is inadequate - the real homework is only starting to be done in this area, but research is growing rapidly. I learned, for example, that US-EPA is planning to put an online database on the Internet within two years that will give access to such things as embodied energy information for building materials and processes.

> ANOTHER MAJOR SHIFT FOR EPA WILL BE A CHANGE IN THEIR MANDATE TO FOCUS ON POLLUTION AVOIDANCE RATHER THAN AN "END-OF-PIPE" APPROACH TO TOXICS AS IS NOW THE CASE.
> HEATER BUILDERS SHOULD TAKE NOTE, BECAUSE POLLUTION AVOIDANCE IS SOMETHING WE ARE VERY GOOD AT

Masonry Heater Builders Take Note:

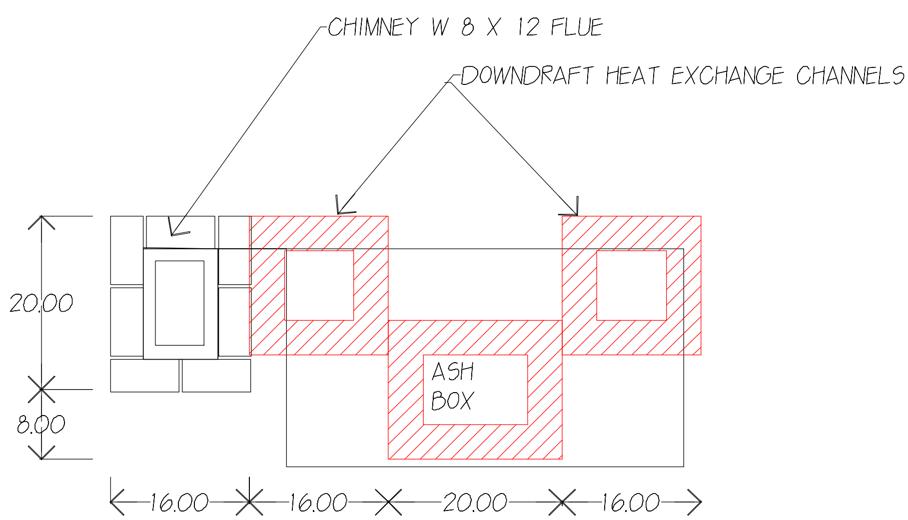
North American heater builders who can offer an analysis of their product will thus have an automatic edge on the Infobahn. Another major shift for EPA will be a change in their mandate to focus on pollution avoidance rather than an "end-of-pipe" approach to toxics as is now the case.

Heater builders should take note, because pollution avoidance is something we are very good at. So far, we've been getting smacked with the same stick as the woodsmoke culprits. We've been forced into a position of defending ourselves (reactive) rather than getting the credit for cleanburning that most of us can rightfully lay claim to (proactive). This hasn't been entirely bad, since it forced our industry to take a hard look at emissions issues and has in fact resulted in cleaner masonry heaters and in ongoing improvements.

If we want to be serious players in this arena, however, we've got to move beyond merely making claims that often are unsubstantiated and make a long-term commitment to educating ourselves in this field. Our clients are using more sophisticated criteria all the time in making their choices. Most of them are well educated and research their heater choice extensively. One manufacturer recently told me that purchasers are often more informed about heater issues than some of the dealers. The heater builder who builds up the most expertise will have a head start. This means education and training. It also means engaging in and supporting research. And it also includes networking with fellow builders and building our collective knowledge base.

> EPA IS PLANNING TO PUT AN ONLINE DATABASE ON THE INTERNET WITHIN TWO YEARS THAT WILL GIVE ACCESS TO EMBODIED ENERGY INFORMATION FOR BUILDING MATERIALS AND PROCESSES

When the EPA database and others come online on the Internet, where will masonry heaters be? Will manufacturers and builders be ready to make their case to the public? Can you formulate an environmental impact statement for your product and your business? We have an excellent product in many cases and can make a good



First Floor Heater with Downdraft Channels to Lower Level case, and the playing field right now is fairly level inside the wood heating industry itself (although far from level when it comes to fossil fuel). More and more people are just beginning to consider these things in depth. The analogy with sports should probably stop here, because the winners will be co-operating with the other players, rather than trying to beat them into the ground. In many cases this will be a bottom-up process with smaller companies leading the way. A sizeable chunk of MHA members are doing this already, and have been for years - there are interesting, fun times ahead.

Other Events:

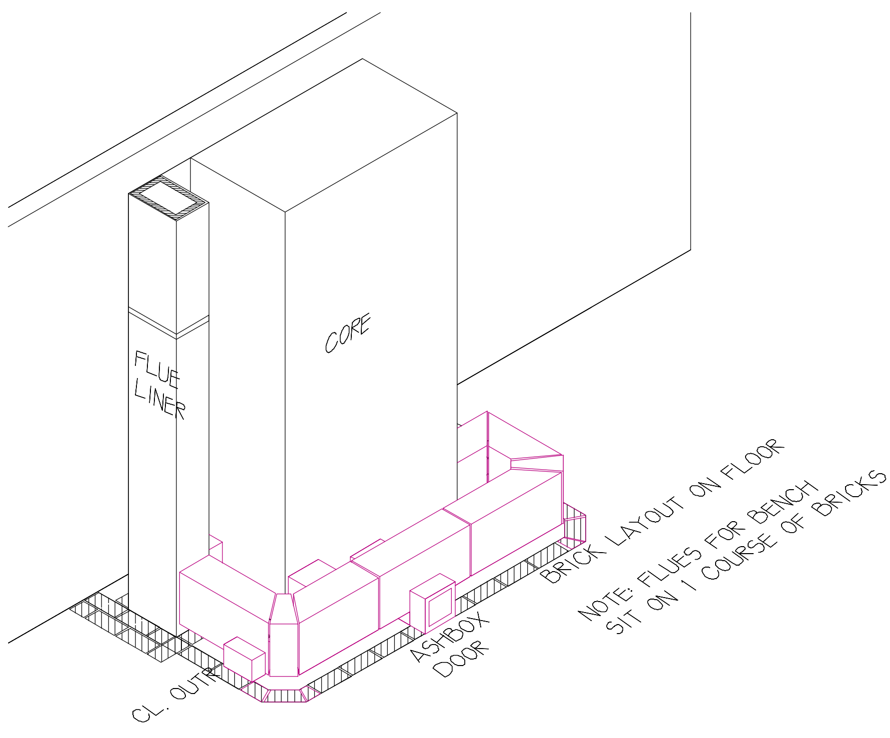
The list of papers presented at the conference was large, almost overwhelming. I'm still trying to digest much of it, but earning a living keeps interrupting. A presentation by Paul Hawken had the most impact on me, and is described in more detail below. Here's sampling of other presentations:

> IN MANY CASES THIS WILL BE A BOTTOM-UP PROCESS WITH SMALLER COMPANIES LEADING THE WAY. A SIZEABLE CHUNK OF MHA MEMBERS ARE DOING THIS ALREADY

Environmental Building News: This 20 page bi-monthly newsletter seems to be one of the most influential publications in the field. MHA members will recognize the name from our Associate member list. Managing Editor Nadav Malin led a workshop on the pros and cons of various building materials that was extremely well received. Low key and articulate, he picked the audience's brains on their knowledge of various building materials with the help of a simple slide show. It was a fast education for everyone, and the knowledge of many of the audience members was astonishing. A number were leading edge builders who have to deal with toxicity of building materials and liability issues on a daily basis. Many of them are pioneering the use of new materials in the workaday construction world (a lot of parallels with heater builders here) and have to be on their toes continously. For example, one discussion centered on a new type of insulation consisting of batts made from cotton instead of glass fibre. Many people had had experience with it, knew particular details about manufacturer, availability and supply problems, as well as performance details. One builder had a house ignited by a plumber's torch because a faulty lot of the insulation didn't have adequate flame retardant chemicals. Others knew what the current status of the product was. This type of spontaneous networking and sharing of information was typical of much of the conference.

What became obvious here is that many of us in the "construction industry" are making the move into an information economy. Spending money to attend a conference is a good example. As Steward Brand has stated, the paradox of information is that it both wants to be expensive and free at the same time. Most of us have some expensive lessons under our belts, yet it is a thrill to share and swap them with colleagues. Information about the lesson, duplicated and given away, gains in value. In addition, we also have a new market out there of enlightened clients looking for efficient, non-toxic, low-environmental impact buildings. Often these buildings can be lower in cost, because it may involve leaving things out, such as carpeting and other surface finishes. Viewed from the right perspective, even a masonry heating system is low cost - perhaps even compellingly so. Price and cost are two different things. So are talking and doing.

Environmental Building News was one of the



Layout For Heated Bench - Contraflow Heater sponsors of the conference. The publication is respected, often by parties on both sides of an issue, because of the thoroughness of its research and the even-handedness of its reporting. It is considered essential reading by many members of the sustainable building communinty in North America and elsewhere. They know about masonry heaters, for example. By the same token, we all need to know more about how masonry heaters fit into the larger picture of appropriate construction. Subscriptions are $60.00, available from EBN at RR 1, Box 161, Brattleboro, VT 05301; 802/257-7300; FAX 802/7304. They need your support so that they can continue and expand their valuable work.

Finland:

"**Design Method and Tools For Sustainable**

> SUSTAINABLE DEVELOPMENT HAS A LONG TRADITION IN FINLAND

Construction", presented by Pekka Huovila, VTT Building Technology:

"Sustainable development has a long tradition in Finland. Our national epic poem, the Lakevala, published in its final form in 1849, based on material that goes back to the first millenium of our era, describes the felling of trees for growing of barley and oats as follows:

He cut down all the fine trees
but he left one birch
to the birds' resting place
and the cuckoo's calling tree

So were set the first written design guidelines for sustainable development 150 years ago. The challenge of sustainable development has also been taken as a starting point in the Finnish Building Law:

"An area to be planned or its use must be planned in such a way that the planning will support the sustainable development of the natural resources and of the environment".

Mr. Huovila described several projects at VTT, including a 5 yr, $20,000,000 program to develop new design tools. For one such tool, known as ECO-CAD,

"the objective of the project is to apply existing knowledge rapidly in use through developing a simple tool that gathers basic information of building parts from building designs, their corresponding environmental information for material, component and production databases, calculates their cumulative environmental impact and gives the ecological profile as output".

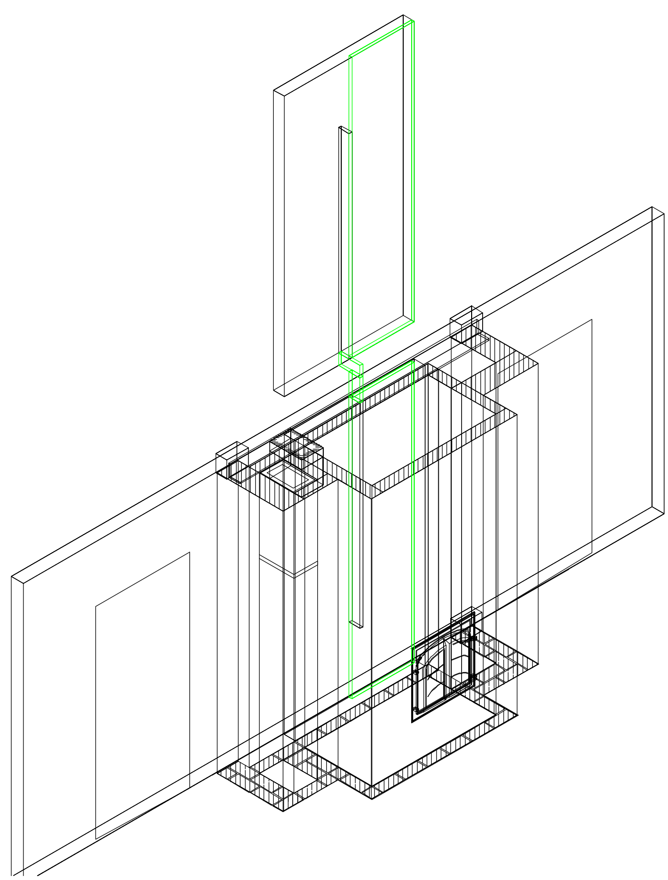
Also described is Design For Environment (DFE) in product development:

"Following the Dutch National Environmental Policy Plan, which is based on sustainable development (van der Horst et al, 1994) to obtain environmentally improved products one has to choose for higher quality and innovation first. Next, the least input of resources can be attained by closing the material cycle; reduction and selectivity of material use; preference for renewable and recyclable material; saving of energy as much as possible. Finally, minimization of hazardous waste, especially toxic emissions, has to be striven for."

Some of the other papers:

Ancient solutions for future sustainability: building with adobe, rammed earth, and mud - Michael Moquin (USA)

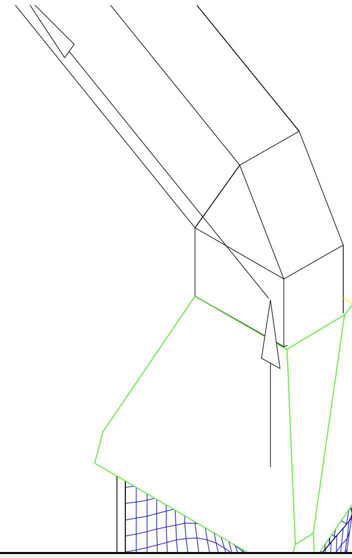
Site design and planning for sustainable construction -



Closed Air Loop Radiant Panel Driven by Lower Level Contraflow Heater

Kim Schaefer (USA)

Pressed soil-cement block: an alternative building material for masonry - B.V. Venhakatarama Reddy (India)



OFTEN THESE BUILDINGS CAN BE LOWER IN COST, BECAUSE IT MAY INVOLVE LEAVING THINGS OUT, SUCH AS CARPETING AND OTHER SURFACE FINISHES. VIEWED FROM THE RIGHT PERSPECTIVE, EVEN A MASONRY HEATING SYSTEM IS LOW COST - PERHAPS EVEN COMPELLINGLY SO.

Construction and demolition wood waste used in wood cement composites - Robert Frank (USA)

Plastered straw bale construction : A re-discovered vernacular building system - Maire E. O'Neill (USA)

An appraisal of the deciduous roof - J.S.C. Evans et al (UK)

The use of recycled high density polyethylene fibers as secondary reinforcement in Portland cement concrete - Flynn L. Auchey (USA)

Construction waste and a new design methodology - Richard C. Hill, et al (Australia)

Ekotecture: an integrated approach to sustainable construction - Lee P. Butler (USA)

Understanding ecological changes in the Danish building tradition - Kim H. Hansen (Denmark)

Quantification of construction and demolition waste - Robert L. Christensen (Canada)

The green material index - development of an environmental auditing system for building materials - David E. Shiers et al (UK)

Possibilities of reusing construction waste: a feasibility study for the city of Vienna 1993 - Peter Maydl (Austria)

Geonomics: fostering a market for sustainable building by reforming taxes and subsidies - Jeffrey J. Smith (USA)

Developments of new type of reinforced concrete composite using high flexural strength surface forming materials for solving environmental problems - Takaaki Ohkubo et al (Japan)

Using waste materials as an aggregate in low thermal conductivity mortars - John A. Tinker et al (UK)

Suggestive concepts and new developments of earth conscious methods for constructing reinforced concrete structures - Akio Baba et al (Japan)

Newly developed reinforced masonry structures suitable for global environmental requirements - Miho Makatayama et al (Japan)

PAUL HAWKEN AND THE ECOLOGY OF COMMERCE

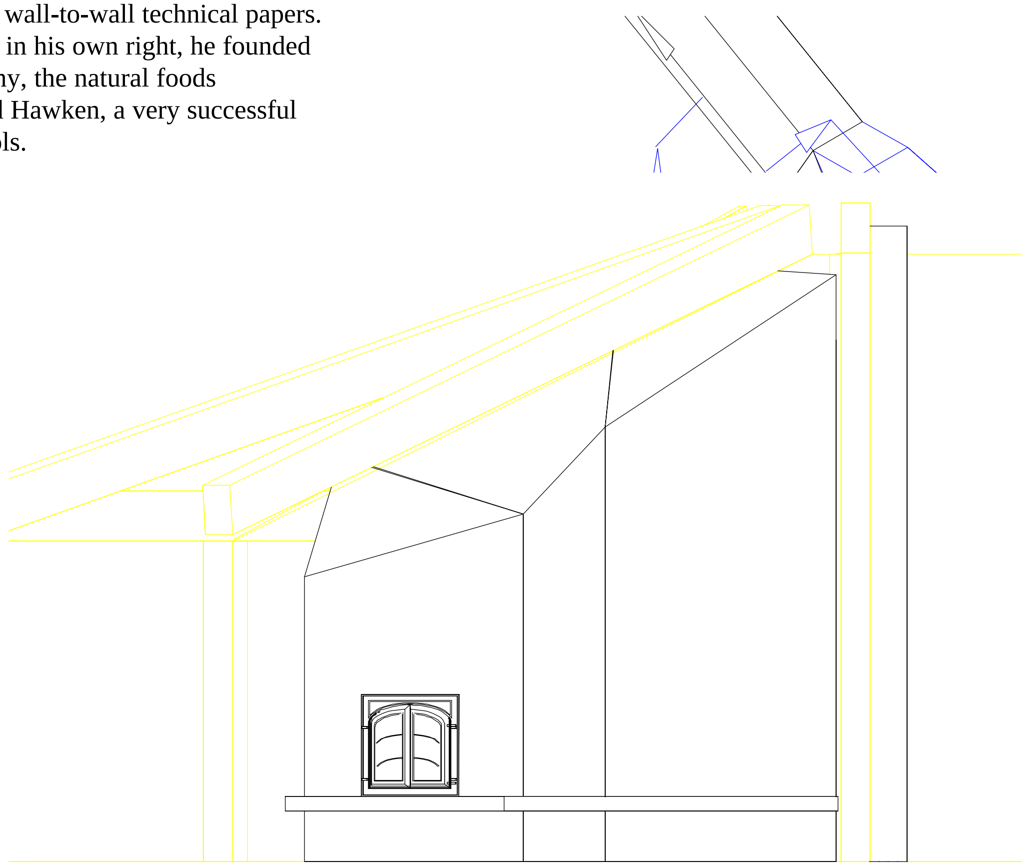
Day two of the conference concluded with a dinner that featured speaker Paul Hawken. It was easily the highlight of the conference, and recharged everyone's batteries after two days of wall-to-wall technical papers. A successful entrepreneur in his own right, he founded Erewhon Trading Company, the natural foods wholesaler, and Smith and Hawken, a very successful retailer of high quality tools.

Paul Hawken is also emerging as one of the leading philosophers of the sustainability movement. His third book, "The Ecology of Commerce" has been in print for about a year. It is a must-read. His previous books include "The Next Economy" and "Growing a Business." Our own business philosophy started to be influenced about ten years ago by articles of his that first appeared in CoEvolution Quarterly, and his insight has served us well.

Before undertaking the writing of his most recent book, Hawken's research included reading 200 books and 1000 papers, more than 20,000,000 words in all. He said that the more he read, the more depressed he became about the actual state of the world today. It is in a lot worse state than he had imagined.

Every natural system in the world today is in decline. The loss of habitat and of biodiversity is not only continuining, but is in fact accelerating.

Multinational corporations have become so large and so successful at exploiting the earth's natural resources that we are witnessing the physical limits being reached.



Custom Heater for YMCA Earth Residence, Kitchener, Ontario
Design output is 15 kW incl 5 kW hot water (2000 litres/day)

channels are 8x8 Refratco flue liners.

A large array of toxic waste products are being released into the environment where they will never be broken down - chemical compounds such as chlorinated hydrocarbons have no counterparts in nature, and therefore there are no natural processes to assimilate them. They include the CFC's that are depleting the ozone layer, as well as the millions of gallons of herbicides that are applied annually to North American lawns.

The current method of increasing profits for corporations and their shareholders is to eliminate employees. In California, PacBell has told its telephone operators that they can no longer use the word "please". This will save enough time to allow them to lay off enough operators to save 5 million dollars per year. California is also currently building the world's largest penal colony and calling it "economic development".

SEVERAL YEARS AGO HE CALCULATED THAT IN ORDER TO REVERSE THE CURRENT TREND AND LIVE ON CURRENT SOLAR INCOME INSTEAD OF SPENDING OUR CAPITAL, WE NEED TO REDUCE THE THROUGHPUT OF ENERGY AND RESOURCES PER PERSON BY 80 PERCENT

Since the publication of his book a year ago, Hawken has given more than 120 talks worldwide. From what he has seen in the last year, he is convinced that the sustainability movement has reached critical mass. It will probably take another 50 or 60 years of hard work to get there however, so we need to be of good cheer and prepared to roll up our sleeves.

At the turn of the century, the total number of human beings that inhabited the planet was 1.5 billion. Today, when Hawken speaks to a university audience, he points out that 1.5 billion is the population increase since today's freshman was born. In the preface to his book, he states: "The problems to be faced are vast and complex, but come down to this: 5.5 billion people are breeding exponentially. The process of fulfilling their wants and needs is stripping the earth of its biotic capacity to produce life; a climactic bust of consumption by a single species is overwhelming the skies, earth, waters and fauna...Making matter worse, we are in the middle of a once-in-a-billion-year blowout sale of hydrocarbons. They are being combusted at a rate that will effectively double-glaze the planet within the next fifty years..."

Several years ago he calculated that in order to reverse the current trend and live on current solar income instead of spending our capital, we need to reduce the throughput of energy and resources per person by 80

SINCE THE PUBLICATION OF HIS BOOK A YEAR AGO, HAWKEN HAS GIVEN MORE THAN 120 TALKS ALL OVER THE WORLD. FROM WHAT HE HAS SEEN IN THE LAST YEAR, HE IS CONVINCED THAT THE SUSTAINABILITY MOVEMENT HAS REACHED CRITICAL MASS. IT WILL PROBABLY TAKE ANOTHER 50 OR 60 YEARS OF HARD WORK TO GET THERE HOWEVER, SO WE NEED TO BE OF GOOD CHEER AND PREPARED TO ROLL UP OUR SLEEVES.

percent. This was considered a radical idea at the time, but recently a Swiss research group has come up with a figure that is closer to 90 per cent. We are all stressed out, in debt, and working long hours. This is it. This is as fast as it gets. We've reached the limit.

Despite the recent right wing shift in politics, Hawken believes that the growing movement towards sustainability is beyong right-left politics. The political right has appropriated the moral high ground when in fact they have no solutions to offer. The only solution offered by the right is to bring everyone in the world up to North American consumption levels through trickle down economics. Rather than reducing throughput by 80%, this would require a global increase of 20,000%, a clear physical impossibility. We have to stop being such political wimps. It is for the sustainability movement to reclaim the moral high ground.

This rings true for many heater masons that I've talked with over the years. As Paul Hawken told Leila: "Your products are beautiful. They are the right thing." He also told the audience: "You are real the low cost leaders". Many of us have believed for years that we are not a high-end product, but in fact the very opposite. Gas fireplaces and plastic patio furniture are the high cost products - it is time to stop pretending otherwise. On the way home, at a gas bar in Florida, we got a good illustration of the difference between cost and price: we paid 90 cents a gallon for diesel fuel, and 2.59 for a quart bottle of water. What's wrong with this picture?

Hawken feels that we essentially have a design problem. Businesses can buy all the recycled paper and recycle all the toner cartridges they want, but that won't make a sufficient difference. If every business in the world emulated environmental leaders such as 3M and Ben & Jerry's, it still will not be enough to reverse the environmental decline.

In order to solve the problem, we must first define it in real terms. The first half of Hawken's book does this with an in-depth look at today's envronmental problems - they must be understood before solutions can be designed. He states: "Although I think the problems are actually more severe than we realize, embedded in each one of them is a realizable and crucial design solution."

He then proposes a set of eight design objectives. In his opinion, business is the only entity with the resources and skills to implement such a large undertaking. Briefly, the design solutions will:

1. Reduce absolute consumption of energy and natural resources in the North by 80 percent within the next half century.
2. Provide secure, stable, and meaningful employment for people everywhere.
3. Be self-actuating as opposed to regulated or morally mandated.
4. Honor market principles.
5. Lead to a way of life that is more rewarding than our present one.
6. Exceed sustainability be restoring degraded habitats and ecosystems to their fullest biological capacity.
7. Rely on current income.
8. Be fun and engaging, and strive for an aesthetic outcome.

Some examples of action towards these goals are already evident in several European countries, including Germany and Sweden. In Germany, there is now cradle-to-grave accountability in several industries, including the auto industry. When BMW sells you a car, their responsibility for its environmental impact doesn't stop when you drive it off the lot. When you are done with it, they have to take it back. Federal law puts all manufacturers on a level playing field, and strong economic signals encourage them to design for recyclability. The Japanese challenged this as an unfair trade practice. They lost. When you wrap your Toyota around a tree in Germany, Toyota either has to recycle it in Germany or ship it back to Japan.

An even more radical change is currently being discussed in Sweden, and is in fact agreed on by all political parties. It is known as the "tax shift". Hawken believes that this will eventually become the economic model here in North America. It involves a complete restructuring of the tax system. Taxes will be taken off of income and profits, and placed instead on emissions, energy, resources and pollution.

AN EVEN MORE RADICAL CHANGE IS CURRENTLY BEING DISCUSSED IN SWEDEN, AND IS IN FACT AGREED ON BY ALL POLITICAL PARTIES. IT IS KNOWN AS THE "TAX SHIFT". HAWKEN BELIEVES THAT THIS WILL EVENTUALLY BECOME THE ECONOMIC MODEL HERE IN NORTH AMERICA. IT INVOLVES A COMPLETE RESTRUCTURING OF THE TAX SYSTEM. TAXES WILL BE TAKEN OFF OF INCOME AND PROFITS, AND PLACED INSTEAD ON EMISSIONS, ENERGY, RESOURCES AND POLLUTION.

An example of how this would work in the United States is as follows: to minimize economic dislocation, the tax change is phased in over 20 years. This allows companies to write off existing investments in plant and equipment. The tax is made revenue neutral for low and middle income earners. So, for example, a 3 dollar per gallon carbon tax is added to gasoline to more accurately reflect the true costs associated with consuming it. This would mean an increase of 2,400 dollars per year in the gasoline bill for the average American. To make it revenue neutral, the average income tax is reduced by a corresponding 2,400 dollars. Therefore, it doesn't cost you one penny extra to run your car. However, you are now living in an economy that is giving you more accurate information about the impact of your actions on the environment. You have a lot more incentive to buy an energy efficient car, and the auto industry has more incentive to design and build one. Right now, the tax on gasoline is about 2.50 per gallon in Germany. In the United States it is 38 cents, the lowest in the industrialized world. Which signal do you think places you in a better position to thrive in a future economy?

With a cost structure that is more in line with environmental costs, businesses will be able to lower their costs by lowering their environmental impacts, instead of achieving low prices by externalizing costs such as toxic waste production onto the public at large. Why should a coal fired power plant in the Ohio Valley be able to discharge sulphur into atmosphere that reduces the growth rate in my 60 acres of Québec hardwood forest? Am I not entitled to damages, and should these damages not be assessed against the electricity consumers of Ohio? If they are not getting this signal, then it needs to be designed into the economic system. 200,000 people in Bhopal, India, had their health seriously and permanently damaged by the Union Carbide Company. They haven't been paid. Why are corporate lawyers the only winners in this scenario?

A design-based economic restructuring as envisioned by Hawken and others could be a boon for the masonry heater industry. A truly level playing field would make biomass extremely competitive with non-renewable energy. Dirtier methods of woodburning could be directly penalized with taxes on their emissions, again a potential boost to our industry. And among masonry heaters, the cleanest systems would achieve a price advantage. This would stimulate clean-burn research. The marketplace would be restructured and would now deliver accurate information that includes the enviroment in the bottom line.

Reducing resource and energy consumption may sound to many people like a pipedream, but isn't really that difficult to achieve, according to Hawken: " In material terms, it amounts to making things last twice as long with about half the resources. We already have the technology to do this in most areas, including energy usage."

Here's a sampling of other quotes from "The Ecology of Commerce":

"Because the restorative economy inverts ingrained beliefs about how business functions, it may precipitate unusual changes in the economy...the restorative economy will be one in which some businesses get smaller but hire more people, where money can be made by selling the absence of a product or sevice, as is the case where public utilities sell efficiency rather than additional power, and where profits increase when productivity is lowered. Corporations can compete to conserve and increase resources rather than deplete them. <u>Complex and onerous regulations will be replaced by motivating standards</u>." *(This is exactly the situation where we are now at with R2000 and masonry heaters. We have the option of adopting an enlightened approach to change, favouring collaborative efforts to redesign*

> "ONE STATISTIC MAKES CLEAR THE DEMAND PLACED ON THE EARTH BY OUR ECONOMIC SYSTEM: EVERY DAY THE WORLDWIDE ECONOMY BURNS AN AMOUNT OF ENERGY THE PLANET REQUIRED 10,000 DAYS (27 YEARS) TO CREATE."

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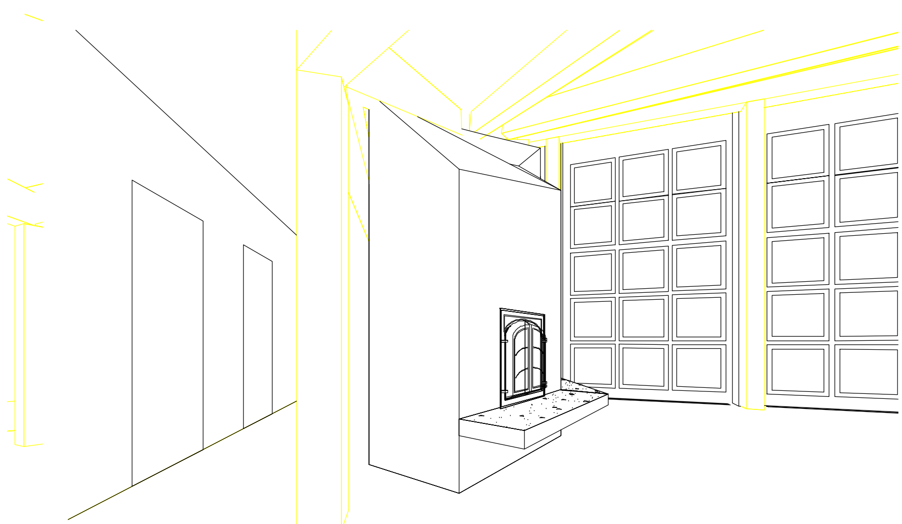


codes and standards for everyone's benefit).

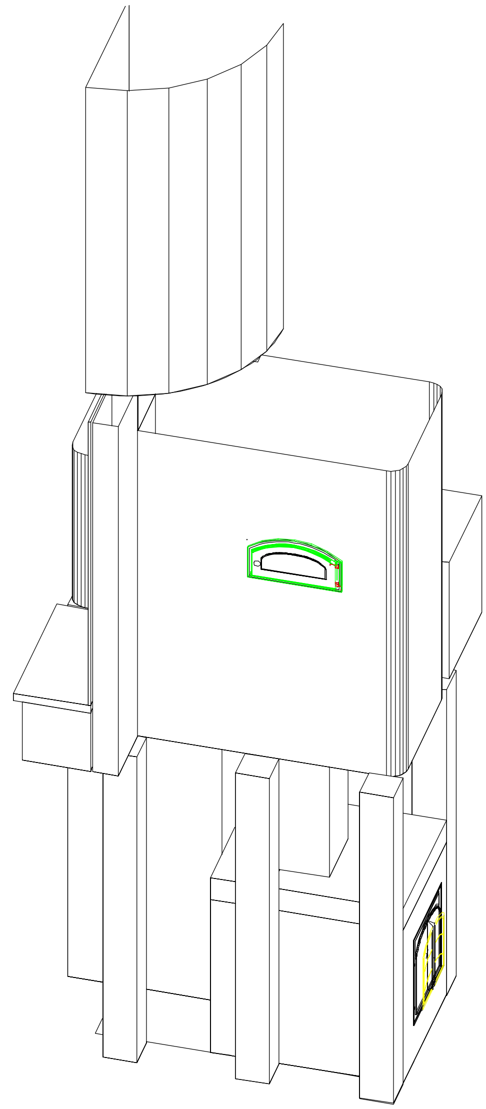
"One statistic makes clear the demand placed on the earth by our economic system: every day the worldwide economy burns an amount of energy the planet required 10,000 days (27 years) to create."

"Biologic diversity, in the end, is the source of all wealth, and with a developed and practiced knowledge of nature, it could be even more so."

"...Germany, formerly the most wasteful nation in Europe, now (is) the leader in recycling. (But they still have a ways to go, still averaging yearly 824 pounds of waste per household. At 1900 pounds per household, we Americans have even farther to go; we're the world's worst wasters. With just 5 percent of the world's population, we produce 50 percent of its solid waste.)"

..."Markets are superb at setting prices, but incapable of recognizing costs...

NONE OF THE PRODUCERS (OF COAL) ARE HELD ACCOUNTABLE FOR THE EFFECT COAL IS HAVING ON THE ATMOSPHERE--THE PROSPECT OF GLOBAL WARMING. THE RESULT? PLANET EARTH IS HAVING A ONCE-IN-A-BILLION-YEAR CARBON BLOW-OUT SALE, ALL FOSSIL FUELS PRICED TO MOVE, NO REASONABLE OFFER REFUSED. AND WHEN THIS EON'S HYDROCARBONS ARE SOLD, THEY'RE GONE, NEVER TO BE SEEN AGAIN



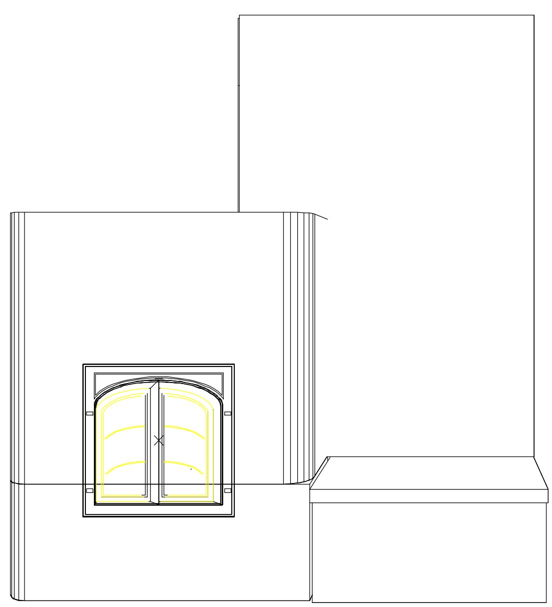
The answer cuts right through abstract political philosophy: We cannot return to the era of local markets, but we can regain control of the larger markets by enforcing the payment of costs--total costs...The incentive to lower costs is the same as the one that presently operates in all businesses, but in this case the producer's most efficient means to lower them is not externalizing these costs onto society, but implementing better design.

...none of the producers (of coal) are held accountable for the effect coal is having on the atmosphere--the prospect of global warming. The result? Planet Earth is having a once-in-a-billion-year carbon blow-out sale, all fossil fuels priced to move, no reasonable offer refused. And when this eon's hydrocarbons are sold, they're gone, never to be seen again.

Another way of imagining the scale of the carbon dioxide problem is by removing its two oxygen molecules. Looked at that way, every time you fill up... you are depositing into the atmosphere the equivalent of a 100-pound sack of pure carbon.

It stands to reason that coal should be the most expensive form of energy, not the least expensive. The only reason that it is now the cheapest is that the newer technologies (solar, biomass, etc), ...more accurately internalize their costs to the environment and future generations."

Custom Heater: lower level firebox drives first floor heat battery, bakeoven and second floor bathroom heater. Design output: 10kW
Built by: Foyers Radiants DeBriel (Québec)



TOWARDS A SUSTAINABLE MASONRY HEATER

We can ask some interesting questions if we decide to take a look at masonry heaters from the standpoint of sustainabililty. There are many things that we are obviously already doing right - let's list some:

Sustainability Features of Masonry Heaters

- Use renewable energy (biomass) - zero net carbon impact if fuel is grown using sustainable practices
- Minimum processing of fuel (cordwood),

fuel obtainable locally

- Low emissions under all operating conditions - excellent ability to target low average energy demand of efficient housing
- Contributes to good indoor climate (longwave radiant heating)
- Long lifecyle (therefore sustainable by definition)
- Low maintenance (requires good design, built properly, operated properly)
- Made from reusable/recyclable materials

(Brick could be the ultimate reusable building material if appropriate mortars are used. Instead of carting them off to the landfill site after demolition as is done now, they could be reused basically forever. How Buildings Learn, Stewart Brand's recent book, has an eloquent section on the inherent "rightness" of brick as a building material)

That's a pretty good start. A good excercise would be to expand the list, and to start analyzing some of the points. The goal is to get ourselves up on the learning curve.

A slightly more radical approach would be to ask the question "How can I increase the sustainability of the heaters that I build?" This list will be more personal, and more tailored to your own situation and locale. Here's a more or less random list of items, by no means exhaustive and hopefully getting longer as time goes by:

Making Masonry Heaters More Sustainable

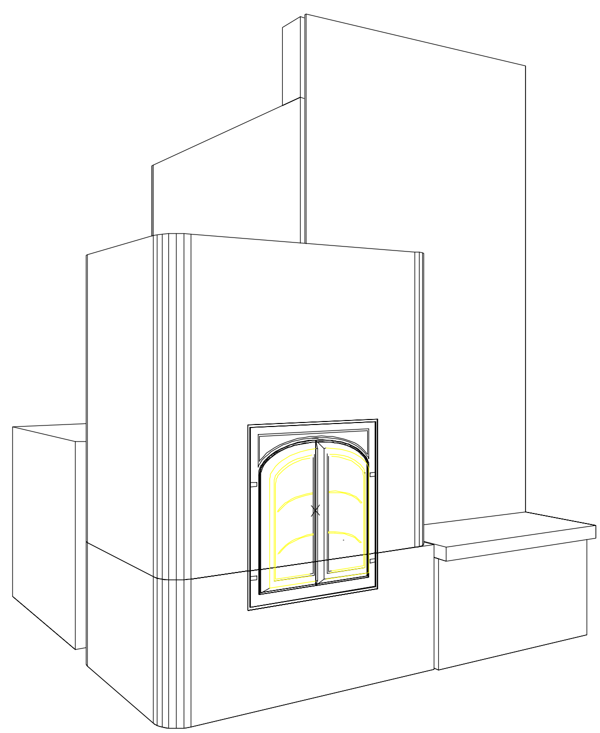
•*Maximize lifecycle of heater* - improve design, invest in professional development, get feedback from previous clients, keep up with current developments in the field, network with other builders.

•*Maximize efficiency and clean-burning aspects of heater* - learn about and apply current research, educate clients in proper use

•*Maximize reusability/recyclability* - use clay mortar instead of cement; use modular units and a modular design (minimize cutting) - we test heaters at home, and are on the fourth one from the same reused firebricks and channel castings.

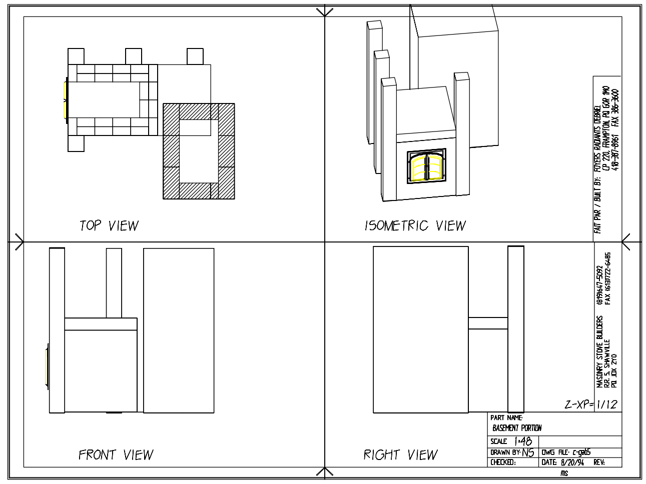
•*Reduce the embodied energy of the heater*
- demand environmental impact information from manufacturers
- use local materials (stone, unfired clay)
- use soft bricks instead of hard bricks
- get more organized (drive less)
- get a diesel truck

•*Add Sustainability Features* - a bakeoven operates for zero dollars. In the province of Ontario, a hot water coil can displace half of the 200,000 lethal doses of



plutonium currently generated annually by an electric hot water heater, which is 60% nuclear fuelled[2].

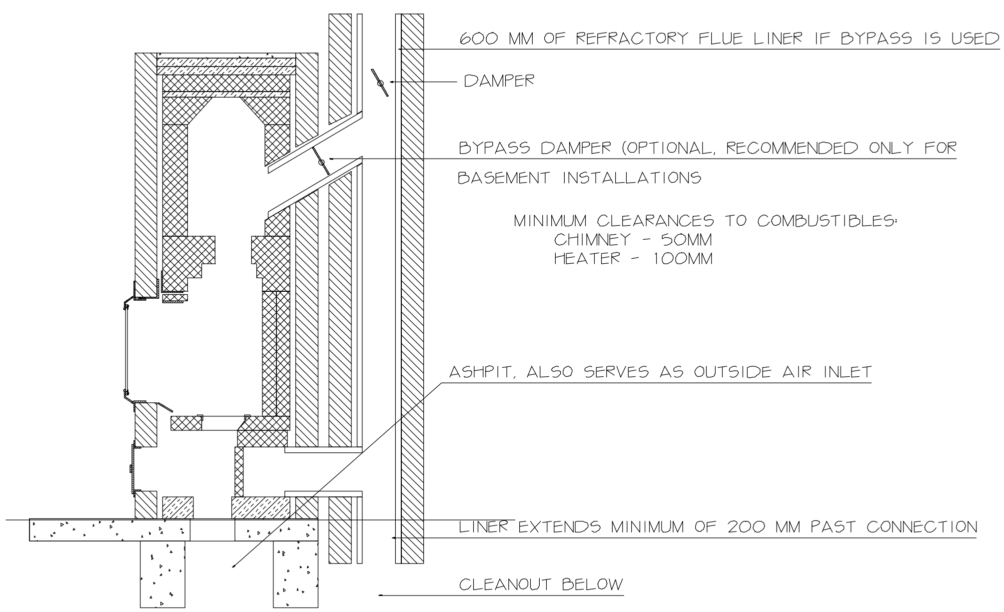
The next step might be to start an environmental impact study/analysis of your business and the products and services that you sell and that you use. You are building the heater anyway, using a certain amount of natural resources and energy. When you implement better design, you are adding information with no increase in resource or energy use. This is the definition of value added. Eventually, if you can't provide an environmental impact assessment for your product or service, your competitor will. The demographic slice of aware consumers is growing daily.



North American drivers have, probably, the single largest environmental impact on the planet. Masons drive pickup trucks. Your pickup truck puts its own weight of carbon dioxide into the atmosphere every

> A SLIGHTLY MORE RADICAL APPROACH WOULD BE TO ASK THE QUESTION "HOW CAN I INCREASE THE SUSTAINABILITY OF THE HEATERS THAT I BUILD?"

year. Drive less. Get better organized and make checklists for repetitive jobs (like heater core installations) so you don't forget something and have to make an extra trip - you'll boost profits at the same time. When the time comes to buy a new truck, consider a diesel. Many MHA masons are driving one already - the favorite seems to be the turbocharged Cummins from Dodge. It uses about 25% less fuel and has plenty of power. Invest in rustproofing and be scrupulous about maintenance so that you don't have to buy one as often - again, you'll reap more profits by being more organized. And it'll look good on your environmental impact statement.



[2] Source: William Shore, EnergyFutures, (1)3 p.1, Energy Probe, Toronto, 1990

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THE USE OF MASONRY HEATERS AND OVENS IN BELARUS TODAY

By Marcus Flynn

The following observations were recorded during a brief visite to the village of Bolshiu Sliva in the Republic of Belarus

In Belarus all dwellings were traditionally heated by a large Masonry Oven “Pichka” located in the kitchen and a small to medium sized masonry heater “Grupka” usually situated in the living area. Today almost every rural home has a Pichka, but only about 40% still have and use their Grubka.

Though less efficient than the Grubka, it is the Pichka that are still built, probably due to the traditional sentimental attachment of the local population, and the multifunctional use as a heater, bed, and oven. Modern homes are now built in brick, and it is said that Grubka give out

Figure 1. Front view of a Pichka built in 1976

Figure 2. Front view of Pichka built in 1978. Note the wooden step and opening to the hollow foundation behind it. The second opening to the foundation is directly below the opening in the smoke hood. The second damper is for a briquette burning central heating furnace seen at lower right. Damage to the tiled finish (middle right) was done when the furnace was planned into the Pichka.

only enough heat to heat the old wooden houses. Consequently, even in some of the old wooden homes, briquette fired central heating systems have replaced the Grubka.

Pichka consist of a 5 foot long arched brick oven built on top of a hollow rectangular masonry foundation. The oven has no door, just a tin shield which is placed over the firebox opening once the fire is out. A broad smoke hood covers the oven entrance (Figure 2), gradually tapering as it reaches the chimney connection just above the ceiling. On top of the oven (Figure 1) is a flat masonry sleeping platform about the size of a small double bed. This “Root” used to be reserved for the oldest female member of the family.

The fire is built directly in the oven, its smoke and gases leaving by the only opening, which is the firebox entrance. The smoke is then drawn up into the smoke hood, where it enters the chimney.

Pichka are built with clay bricks laid in clay mortar, the only other material being the iron lintels used over the oven and smoke hood openings, and 6” by 6” wooden beams used to span the hollow foundation.

Traditionally finished in white, lime based stucco, many Pichka are now given a more “up market” tile finish (Figure 3). The foundation is often divided into two sections, one used to store wood, and the other to keep piglets and chickens on cold nights.

The foundation is slightly larger on one side than the oven that it supports. This recess acts as a high step, which is often supplemented by a narrow wooden step closer to the floor.

Below the sleeping platform are two square

Figure 3. Rear view of the same Pichka as figure 1. A sheet of pressed wood mounted on the end of the sleeping platform acts as a headboard for its 92 year old operator.

Figure 4. Grubka photographed in the same dwelling as the pichka in figure 1.

openings horizontally as far as the oven’s inner wall. These drying niches are often fitted with cast iron doors.

(Figure 7) The two floor level openings in the foundation and the opening in the smoke hood are closed off with simple curtains when the Pichka is not in use.

Due to the compact layout of rural dwellings, Pichka were always built against an interior wall or into an interior corner.

Traditionally in winter all cooking was done on the Pichka, though now most houses have a calor-gas stove in which “fast” cooking is done.

Pichka have a specific kind of cast iron cooking pot which have evolved with them. (Figure 5) These pots are placed in the oven using a long wooden pole with two wrought iron semi-circular prongs at one end. A small pile of sand, permanently kept in the oven, is raked around the pots to speed up cooking. A long-handled L-shaped rake is used to position the sand and remove the ashes.

Inside the smoke hood at either side of its opening, just above the path that the smoke takes as it leaves the oven are two cast iron shelf-like grills, used to smoke meat and keep a constantly warm pot of water.

Grubka are medium sized single skin Russian style masonry heaters. In rural areas they were usually built in brick with a whitewashed stucco finish. In cities, many were built with real stove tiles (Figure 4), as opposed to modern Pichka which are finished in regular flat bathrooom tiles.

Figure 5. Three of the tools used to operate the Pichka. From left to right: long handled “ouchvat” used for removing the round cast iron cooking pots, right angled rake used to arrange the sand in the oven and remove ashes. Short handled ouchvat. Not shown here is a fourth pole-like tool used to open and close the dampers which are too high to reach.

Grubka are usually freestanding and located centrally in the living area. Today Grubka are rarely built.

Birch is by necessity the preferred fuel for both types of heater, with pine used as kindling. The local population is extremely conservative with their wood supply and still practice pollarding (coppicing). Fires are laid with great care and precision and damper adjustments during firing are frequent.

Many heaters of both types have suffered severe cracking, which their operators eagerly told me results from over firing, or firing too soon after construction.

Each village or group of villages have their own stove builder, or pichnik. The stovebuilders work completely from memory using no plans and having no formal training, their knowledge being passed down from father to son or from master to apprentice.

Officially these pichnik are employees of the local collective farm and it is only at night or on days off that they can practice their alternative occupation. Traditionally it has been the local population themselves who have had to take care of their heating needs and with the central government being unable to offer a viable alternative, the individualistic behaviour of the pichnic has been reluctantly tolerated. Not only is this remarkable in such an authoritarian Marxist state, but it has meant that design and building techniques have remained virtually unchanged for the last 80 years. This is in stark comparison to the Northwest European democracies where design and development have advanced enormously in recent years with the aid of govenment and privately sponsored research and the advent of high-tech refractory materials.

In Belarus as in the rest of the cold areas of the former Soviet Union a heating system has evolved as a direct result of trial and error on the part of the local population over many generations.

Figure 6. View from the inside of a Pichka oven showing cast iron cooking pots surrounded by hot sand.

Figure 7. Side view of the same Pichka as figure 1 showing narrow step and drying niches.

HOW DO YOU SIZE A MASONRY HEATER?

Heat output for a masonry heater is calculated as follows:

Total Heat Output = Surface Area (number of sq. m) X Heat Output per sq m

Heat output per square metre is a function of the following variables:

- Overall Efficiency
- Weight of fuel charge (assuming constant moisture)
- Firing cycle (number of hours between firings)
- Construction (wall thickness, total surface area)

Construction

The thickness of the heater walls determines the outside surface temperature. With thin walls, the heater will heat up rapidly and reach a higher surface temperature. It will also cool down faster, because there is less thermal mass available for storage. With thicker walls, surface temperature drops and storage time increases. A heater of heavy construction therefore has to be physically larger in order to achieve the same output as one with lighter construction.

The following classification scheme is used in the German system of masonry heater sizing, which includes specifications for wall thicknesses for the different construction types:

Construction Type	Heat Ouput, W/m^2 (watts per sq. m. of surface)
light	1280 - 1100
medium-heavy	1100 - 850
heavy	850 - 700
over-heavy	< 700

For example, a contraflow heater with 7” thick sidewalls (2.5” firebrick liner plus 4” face) is classed as “over-heavy”, and one with 5” sidewalls (1 inch liner plus 4” face) is “heavy”.

Output can be calculated from surface temperature as follows:

Surface Temperature, C	Heat Output, W/m^2
58	465
65	580
85	930
90	1045

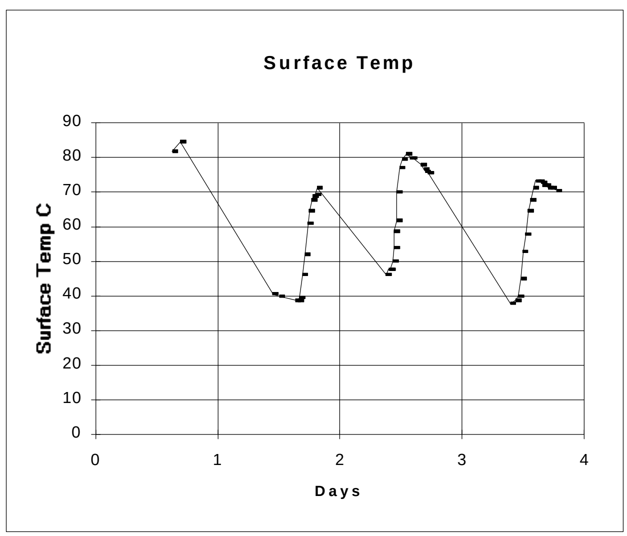
Thicker walls mean lower surface temperature and more heat storage and more thermal lag. Therefore a larger heater is required for a given output, but is fired less often. Cycles longer than 24 hours are impractical, and for very heavy heaters it is more usual to supply a base load and then use backup heat to fill in as needed.

Once the construction style is chosen, an appropriate formula is used to derive the firebox size from the surface area. A larger surface requires a larger firebox.

Below is data from some recent testing at Lopez Labs on an 18” contraflow heater with a surface area of 6.5 m^2 and a 1.5” granite face. The lab was unheated (10 C overnight).

This heater was fired from a warm start on a 24 hour cycle, and the fuel loads were as follows (in kg, 17% moisture Douglas Fir): 19.5, 15.2, 14.2 and 16.8. Overall efficiencies (combustion effic. x heat trans. effic., Condar stack loss method) were 75.7, 75.5, 70.9 and 76.1.

If you were to fire this heater on a 12 hour cycle, your average surface temps would be up in the 80 - 90 degree range required for a 1000 W/m^2 output.



WHAT IS THE HEAT OUPUT OF A MASONRY HEATER?

Example 1: Generic Calculation:

Calculations are based on Net Efficiency figures as measured by OMNI Environmental in EPA-audited in-home tests[3,4,5]

Efficiency is calculated using the Condar Method (Oregon Method M-41)[6]

Average Net Efficiency for all OMNI tests is as follows:

Underfire air masonry heaters (combustion air grate in firebox floor):	56.5%
Overfire air masonry heaters (no grate):	60.4%

For wood fuel at 20% moisture, the higher heating value (HHV) is (8600 x .8) BTU/lb

For a contraflow masonry heater with a standard 18" wide firebox, the average fuel load from 53 test runs at Lopez Labs with Douglas Fir was 39.8 lbs[7].

Therefore, for an average overfire contraflow heater, heat output is calculated as follows:

Output = Efficiency x Fuel Weight x HHV / Heating cycle (hours)

Maximum output is achieved with the shortest heating cycle, which is 8 hours (ie., 3 firings per day):

Maximum Output = 60.4% x 39.8 x (8600 x .8) / 8 = **20,673 BTU/hr (= 6.05 kW)**

Example 2: Prototype contraflow heater - (27" Firebox w. bakeoven)

Calculations are based on Net Efficiency figures as measured at Lopez Labs[8].

Efficiency is calculated using the Condar Method (Oregon Method M-41)

Average Efficiency for 15 Lopez tests on this heater is as follows:

Combustion Efficiency:	96.7%
Heat Transfer Efficiency:	68.7%
Overall (Net) Efficiency = Comb. Effic. X Heat Transfer Effic.	66.5%

For wood fuel at 20% moisture, the higher heating value (HHV) is (8600 x .8) BTU/lb

For a prototype contraflow masonry heater with a 27" wide firebox, the average fuel load from 15 test runs at Lopez Labs with Douglas Fir was 42.4 lbs.

Heat output is calculated as follows:

Output = Efficiency x Fuel Weight x HHV / Heating cycle (hours)

Maximum output is achieved with the shortest heating cycle, which is 8 hours (ie., 3 firings per day):

Maximum Output = 66.5% x 42.4 x (8600 x .8) / 8 = **24,250 BTU/hr (= 7.11 kW)**

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[8] N. Senf, "Very Low Emissions Cordwood Combustion in High Burn Rate Appliances - Early Results with Possible Implications", to be presented at the 88th Annual Meeting of the Air and Waste Management Association, San Antonio, June 19-24, 1995

MHA Membership List as of 1/11/95

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Dale Hisler	Lightning Arrow Stove Works	Box 25	Pray	MT 59065	(406)333-4383	]	94
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David Johnstone	Barclay, Tarr, Walters & Co.	P.O. Box 198	Errington	BC V0R 1V0	(604)248-6535		94
Stig Karlberg	Royal Crown	333 E. State - Suite 206	Rockford	IL 61104	(815)968-2022	968-0739	94
John LaGamba	Temp-Cast Enviroheat Ltd.	33320 Yonge St. P.O. Box 94059	Toronto	ON M4M 3R1	(416)322-6084	486-3624	94
David Lyle	Heating Research Co.	Box 300	Acworth	NH 03601	(603)835-6109	]	94
J. Patrick Manley	Brick Stove Works	374 Nelson Ridge Rd.	Washington	ME 04574	(207)845-2440	same	94
David McGee	Masonry Concepts	P.O. Box 2557	Evergreen	CO 80439	(800)305-9244		94
Mark McKusick	Hearth Warmers	RR 1 Box 27	Colrain	MA 01340-9705	(413)624-3363	624-3367	94
Joe McLaughlin	J. McLaughlin Agency	PO Box 14249	East Providence	RI 02914-4249	(800)472-3780	434-5521	94
Walter Moberg	W. Moberg Design/ FireSpaces	921 SW Morrison St. Suite 439-440	Portland	OR 97205	(503)227-0547	227-0548	94
David R. Moore	MTC Construction	11817 Vail Rd. S.E.	Yelm	WA 98597	(206)458-4866	]	94
Erik Nilsen	Thermal Mass Inc.	RR 1 Box 367	Littleton	NH 03561	(603)444-6474	]	94
Brian/Marcia Olenych	Olenych Masonry Inc.	HC 65 Box 3	Bovina Centre	NY 13740	(607)832-4373	832-4561	94
Arthur Olson/Jim Donaldson	European Masonry Heaters Co.	706 California Blvd.	Napa	CA 94559	(707)259-0208	252-1782	94
Jamie Paiken	Jamie Paiken Masonry	600 Cove Rd.	Ashland	OR 97520	(503)482-4379		94
Steve Patzer	Patzer & Co. Masonry	3N 743 RTE 32	St. Charles	IL 60174	(708)584-1081	]	94
Martin Pearson	Pearson Masonry	40 Rhodes St.	Cumberland	RI 02864	(401)333-6583		94

Ron Pihl	Cornerstone Masonry	Box 83	Pray	MT 59065	(406)333-4383	]	94
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Stanley Sackett	Sackett Brick Co.	1303 Fulford Street	Kalamazoo	MI 49001	(616)381-4757/(800)848-9440	381-2684	94
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Don & Gary Wilkening	Wilkening Fireplace Co.	HCR 73 Box 625	Walker	MN 56484	(218)547-1988/(800)367-7976	547-3393	94
Ron Williams	Kentuckiana Chimney Inc.	9216 Cornflower Ave.	Louisville	KY 40272	(502)935-0752		94
Rod Zander	Artisan's Workshop	127 North Street	Goshen	CT 06756	(203)491-3091	same	94

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Customer Information Series:

MASONRY HEATERS AND THE ENVIRONMENT

WOODSMOKE EMISSIONS

Woodsmoke emissions are an increasing environmental concern.

Smoke consists of very small tar droplets, known technically as particulate matter smaller than 10 microns (thousandths of a millimetre), or PM10. Woodsmoke is similar to cigarette smoke from a public health standpoint. The main culprit is the small size of the tar droplets. A blood corpuscle is about 6 microns, so that both wood and cigarette smoke particles are small enough to enter the bloodstream directly through the lung walls.

Woodsmoke emissions are of most concern in areas with high concentrations of woodburning appliances and with unfavourable local weather patterns. The main culprit is appliances that permit “smoldering” combustion. This happens when your heat requirements are moderate and you need to turn your stove down by reducing its supply of combustion air. In most modern houses heat requirements are low most of the time.

In addition to producing smoke, the tar droplets will condense inside the chimney as creosote and require routine inspection and cleaning in order to avoid becoming a serious safety hazard.

There is some good news, however. In the United States, the Environmental Protection Agency (EPA) has made it mandatory for all new conventional woodstoves sold to pass a laboratory emissions test. These EPA-certified stoves generate much less creosote than in the past.

For masonry heater owners, there is even better news. Through the Masonry Heater Association (MHA), both laboratory and in-home emissions tests have been done on a wide variety of masonry heater types. Laboratory testing was conducted by Virginia Polytechnic Institute. The MHA field tests were conducted by OMNI Environmental (Beaverton, Oregon) and included audits of the test method by EPA.The Association, in collaboration with Lopez Labs (Seattle), also has developed a large in-house database of heater testing with almost 200 simulated field test runs to date.

The data in Table1 is taken from an EPA summary of all field testing to date, and from the 1993 and 1994 Lopez Labs tests. Results are expressed in grams of tar (PM-10) produced per kilogram of wood burned.

Based on actual in-home results, it is evident that masonry heaters provide, by a wide margin, the cleanest way to burn cordwood. Emissions are comparable to those of the cleanest pellet stoves. It is also well worth noting that the difference in emissions between the cleanest technology and

Woodsmoke Emissions, grams of tar per kilogram of wood burned

		EPA (AP-42)	**Lopez, 1993** (Contraflow)	**Lopez, 1994** (Prototype Contraflow 16 runs)	**Lopez, 1994** (Prototype Contraflow last 4 runs)
Masonry Heaters	**All**	**2.8**	1.8	1.5	0.52
	Underfire air (heater has a grate)	5.5	3.9		
Woodstoves (Non-Catalytic)	Conventional	15.3			
	EPA-Certified	**7.3**			
Pellet Stoves	Non EPA	4.4			
	EPA	2.1			
Standard Open Masonry Fireplaces		17.3			

that of pre-EPA stoves, is around 10:1. Masonry heater owners never have to worry about creosote deposits.

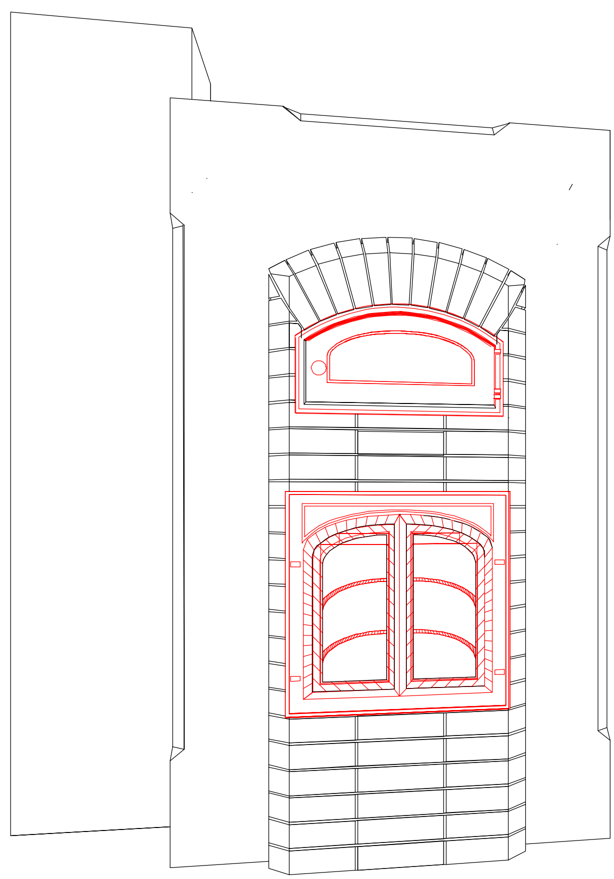
Why do masonry heaters burn so cleanly? The answer is simple: wood is inherently a clean burning fuel (except when you force it to smolder by depriving it of combustion air.) Masonry heaters can store heat, and therefore can burn cordwood at its optimum burn rate and not overheat your house in the process.

Environmental Benefits

Provided that you burn it cleanly, using wood to heat your house has many benefits for the environment. Like fossil fuels, wood releases the greenhouse gas carbon dioxide when it burns. However, if your firewood comes from a sustained-yield forestry operation, then the carbon dioxide is reabsorbed by the forest. With wood, you are not contributing to global warming.

A common misconception is that, if everybody heated with wood, there eventually wouldn't be any forests left. On the contrary, if forestry is practiced on a true sustained yield

THE BEST INVESTMENT YOU CAN MAKE, BOTH FROM A FINANCIAL AND FROM AN ENVIRONMENTAL POINT OF VIEW, IS AN ENERGY EFFICIENT HOUSE WITH A



basis, large amounts of firewood are the inevitable byproduct of thinning, culling damaged trees, limbing, etc. Left to rot on the forest floor, these thinnings produce exactly as much carbon dioxide as if you were to burn them. The only outflow is in the minerals that are left as ash - you could easily return these to the forest floor.

It makes sense to conserve precious fossil fuels for necessary activities such as transportation. The best investment you can make, both from a financial and from an environmental point of view, is an energy efficient house with a masonry heater.

REPORT ON THE 1994 LOPEZ LABS TESTS

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INTRODUCTION

Jerry Frisch and I conducted 16 days of testing last spring at Jerry's lab. MHA News published a preliminary report in the last issue. This article presents our findings in more detail, and is adapted from a paper prepared for presentation at the AWMA (Air and Waste Management Association) meeting this coming June in San Antonio, TX. For those of you interested in learning more about the testing, there will be a question and answer session during the technical program of day 1 (March 23) at this year's annual MHA meeting in Las Vegas.

For this year's tests, Jerry had made changes to the laboratory chimney setup that allowed us to conduct tests on five appliances per day. We had three contraflow masonry heaters, one fireplace, and a hybrid heater/fireplace. There were two stock contraflow heaters. One was the same HeatKit that we tested in 1992 and 1993 and that was been tested at VPI and by OMNI (in underfire mode). The second one was a Tulikivi TU-800 tested in 1993 and converted into a TU-1200 for 1994. This is a small, prefabricated soapstone contraflow heater. In addition, Jerry (Frisch) and Jerry Haupt had built a new prototype contraflow heater with a larger firebox, a straight firebox backwall, and a white bakeoven with floor heat. The assembly drawings for this heater are presented in the article following this one.

About halfway through the testing we invited Paul Tiegs from OMNI, who drove up from Portland, to inspect the lab and give us an evaluation and make comments. MHA had agreed to pay Paul's expenses for the trip. As reported in the last issue, one of our most unexpected findings this year was that a stock masonry fireplace can be made to burn quite cleanly. Paul witnessed one of these burns, which initially were done with a hot start. We all stood outside looking at the chimney, waiting for smoke that didn't come, scratching our heads and trying to figure out what was going on. More on that later. Later Paul sent us a letter stating that he was quite impressed with the setup at Lopez, and provided some very useful advice on several of the technical issues surrounding our test procedures and emissions calculations.

REPORT

This report deals with with testing that we conducted on three of the five appliances - a standard Rosin masonry fireplace with an airtight door, a standard 18" contraflow heater, and a prototype 27" contraflow heater with white bakeoven.

We looked at fueling and combustion parameters affecting particulate matter (PM), carbon monoxide (CO) emissions, and efficiency. The goal is to define a minimum emissions appliance/operator system. Preliminary indications are that both cordwood fueled heaters are able to operate with emissions similar to the cleanest pellet stoves. An unexpected result was that the standard masonry fireplace could apparently be modified to achieve similar PM emissions performance.

Fuelwood is a renewable energy source. It is our belief that domestic scale biomass combustion is likely to be a key component in most scenarios for achieving sustainability. For example, some current atmospheric carbon reduction models[1] require an eventual per capita reduction of fossil fuel use of 80% to 90% for the average North American. In such a scenario, the continued widespread use of petroleum for low grade applications, such as home heating, is clearly a physical impossibility. Emissions then becomes a critical national issue for cordwood fueled appliances. The presence of smoldering combustion can increase the particulate emissions from wood fuel by a factor of up to 50 times, which would be intolerable in densely populated areas. Will this require conversion to processed fuels, such as wood pellets and briquettes, or can we develop techniques for cordwood combustion that are ten times cleaner than current United States Environmental Protection Agency (US-EPA) requirements?

Masonry Heaters

Masonry heaters are high burn rate domestic appliances that use a thermal mass to store heat. They are native to the colder regions of Europe, with the exception of Britain and France. Typical systems being built in North America today often resemble traditional masonry fireplaces in outside appearance. In contrast with a fireplace, all of the fuel charge is loaded and combusted at once. Internal flue gas heat exchange channels transfer energy to the masonry. Typical external surface temperatures of 140 F. provide the additional benefit of a true radiant heating system, i.e., the energy is in the longwave range of the infrared spectrum.

The ability to store thermal energy allows the burn rate to be decoupled from the heat output. This scheme avoids smoldering combustion, which is the main technical challenge in conventional stove design. This problem is most intractable in high efficiency houses, where heat demand can be very low (less than 2 kilowatts) for prolonged periods.

Masonry Fireplaces

These appliances are typically site-built by fireplace masons. The system studied at Lopez Labs consists of a precast refractory firebox embedded in insulating refractory castable. It is connected to an 8” diameter insulated metal chimney and fitted with an airtight ceramic glass door. Conventional masonry fireplaces usually are built under the locally applicable building code. Codes typically assume that masonry fireplaces will not be fitted with doors and do not address the issue of additional clearances to combustibles that may then become necessary because of higher firebox temperatures.

Canadian studies[23] have shown that a positive feedback loop can result from a direct coupling of the combustion air supply, and potentially the burn rate, to chimney draft. A runaway fire may result. Our testing indicates that the air inlet may also be configured so that the coupling yields a controlled, clean burn.

TEST METHOD

The Condar Dilution Tunnel Method

The Condar Method is used at Lopez Labs to measure particulate emissions. Developed by the late Dr. Stockton (Skip) Barnett, the Condar is a very simple piece of equipment. It is a dilution tunnel, but of an interesting type. A sample probe extends about 1/2 inch into the stack, from which the gases immediately enter a 6 inch diameter cylinder which is attached to a pump. In front of the pump is a filter. The dilution is provided by a series of 24 holes drilled into the face, providing a dilution ratio of approximately 20:1. The orifice is calibrated, and the pump is regulated to provide a constant pressure at the dilution chamber, insuring a constant sample flow. As the filters load with particulate, a Variac control on the motor provides pressure compensation to maintain constant flow. The temperature after dilution is under 90 degrees F., assuring condensation of atmospheric particulates prior to filtering. The Condar design allows real-time monitoring of emissions simply by pulling the filters at anytime and weighing them.

The Condar Method is not an official EPA method, i.e., a Method 5. However, it was approved by Oregon and is known as Oregon Method 41. The Condar has been used to develop, interestingly, the very cleanest burning woodstoves.

Quality Control Procedres

A quality control manual has been written for the Lopez test method and is used for all tests. It includes a checklist that is followed for the complete test process. Included are calibration histories for the gas analyzer and the analytical balance, and a detailed fueling protocol, described later.

A separate section of the manual deals with the handling of the particulate filters. Handling and weighing the filters is the most sensitive part of the test procedure. The fiberglass filters used are moderately sensitive to ambient humidity. Filters are held in the drying cabinet for 24 hours and then conditioned in ambient air for 30 minutes prior to their final weighings. A control filter is kept alongside the other filters. A running record of the control filter, as well as a reference mass, serves as a double check of the weighing procedure. A spreadsheet routine adjusts filter weights in accordance with small moisture induced changes in the control filter while filters are out of the drying cabinet. Filters are 150 mm diameter with a typical weight of 1000 mg. A front and rear filter is used, and filters are changed in the Condar after the first 15 minutes, for a total of 4 filters per run. Typical filter catches are 50 mg for the front and 2 mg for the rear filter. An analytical balance with a resolution of 0.1 milligram is used. As a double check, filters are batch weighed after being weighed individually. A spreadsheet routine flags any discrepancies.

A statistical snapshot of all Lopez test runs to date for which filter controls were in effect is provided by the histograms in Figures 1 and 2.

Figure 1 shows the distribution of the discrepancies between individual and batch filter weighings. A resolution of 0.1 g/kg in the PM emissions factor would represent about 2.5 mg of filter catch. The average moisture adjustment is 6.7 mg, or approximately 0.3 g/kg. The asymmetric distribution of these adjustments adds about 0.1 g/kg PM factor to the average test run.

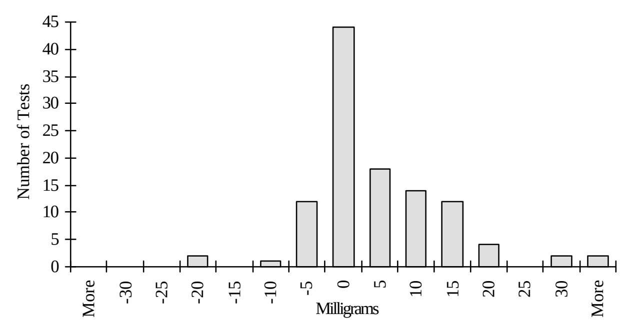

Figure 1. Distribution of moisture adjustments.

Flue Gas Analysis

A Sun Model SGA-9000 automotive emissions analyzer is used for the flue gas analysis. A problem with the accuracy of the O_2 cell used in this type of instrument resulted in a decision to calculate the flue gas O_2 from CO and CO_2. After consulting with Paul Tiegs from OMNI, we developed the following formula, based on test results for Douglas fir: $O_2 = 20.4 - CO_2 - 2CO$. The CO_2 and CO accuracy of the gas analyzer is very good. Previously reported results for 1993 were corrected and are reported in Table 1.

The Lopez Fueling Protocol

A rule of thumb from past experience is that, for masonry heaters, fireplaces and woodstoves alike, field test emissions factors tend to be about twice that of laboratory results. This may stem from the fact that most laboratory protocols so far have used fuel that consists of carefully spaced pieces of dimensioned lumber[456].

Since we felt that fueling protocol was likely to be one of the main variables affecting emissions, particular attention was paid in this area. A goal of the Lopez protocol is to duplicate in-home conditions as much as possible. This is because in-home testing has become the only recognized method of establishing performance figures for appliances that are not covered by the EPA woodstove regulations.

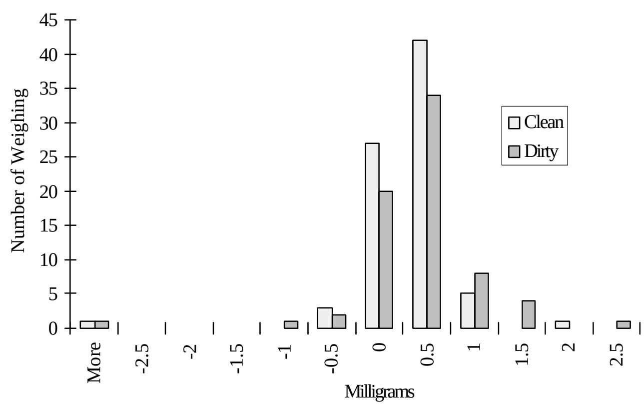

Figure 2. Distribution of discrepancies between individual and batch filter weights

The Lopez Labs fueling protocol for masonry heaters includes the following items:

- heaters are fired on a 24 hour cycle, which is typical of in-home use
- fuel is old growth Douglas Fir cordwood with no bark
- each piece of fuel is:
    - measured for moisture content
    - weighed
    - measured for length and circumference
    - numbered
- fuel load is spread out on floor of lab in sequence and photographed
- fuel is stacked in sequence
- fuel load in firebox is photographed
- the weight of kindling is held constant

Test data is entered into a spreadsheet that is programmed to perform the necessary calculations. It is programmed in Excel 5.0 for Windows. A graph of stack temperature and the CO_2, CO and HC readings is drawn dynamically on the screen as the data is entered. The time cell includes an underlying note field, allowing text or sound notes to be attached to the readings. Notes are printed out as part of the test documentation. Current plans for 1995 tests are to add a video clip to each 5 minute reading, since this technology has recently become affordable.

TEST RESULTS

Masonry Heaters

Results from 1992 and 1993 tests were reported in last year's AWMA paper (reprinted in MHA News, Vol. 7 No. 1). For 1994, we used the same contraflow heater as before. We also added a new prototype heater, thus allowing two contraflow heater tests per day (in addition to the testing for Tulikivi). The main difference from the stock heater was an enlargement of the firebox in width from 18" (4570 mm) to 27" (6860 mm). The sloped back wall of the firebox was changed to a straight wall to allow the inclusion of a bakeoven above the firebox. Table 1 summarizes the results from 49 test runs on masonry heaters. Run names are coded by prefix as follows: CF: 18" firebox; HK: 27" firebox; A: 1993; B: 1994.

Table 1. Summary of (Corrected) Test Results from 1993 and 1994

RUN No.	**AVE.**	CF-A02	CF-A03	CF-A04	CF-A05	CF-A06	CF-A07	CF-A08	CF-A09	CF-A10	CF-A11	CF-A12	CF-A13	CF-A14	CF-A15	CF-A16	CF-A17
g/kg PM (Condar)	**1.8**	1.26	1.09	3.87	3.53	2.02	1.58	0.71	1.31	1.09	1.13	1.04	0.87	0.93	2.83	2.68	0.63
g/kg CO	**27.9**	45.0	29.8	86.5	52.4	27.5	19.9	21.5	15.9	18.2	26.6	25.6	36.2	20.5	30.3	21.0	17.0
Overall Efficiency, %	**68.9**	76.8	74.8	69.8	68.8	70.5	57.3	56.0	63.2	62.0	61.5	60.7	66.9	69.7	66.4	59.3	63.1
Total Weight, lb	18.9	28.0	28.0	28.0	28.0	33.3	28.0	28.0	45.0	44.0	45.5	45.5	30.0	41.0	43.5	51.0	39.5
Wood Moisture, %	39.2	19.4	15.9	18.8	19.2	22.0	18.5	19.8	19.9	25.3	24.9	24.5	20.0	20.0	20.6	21.4	20.3
Number of Pieces	8.7	5	5	10	10	10	8	7	13	10	11	11	11	7	16	16	11
Surface/Volume, in^{-1}	4.4	4.2	4.3			5.0	5.5		4.4	4.2	4.3				4.9	5.0	4.6
Av. Stack Temp, F	293	178	199	192	246	237	335	318	378	364	315	341	243	293	334	348	301
Stack Dilution Factor	4.1	3.7	4.6	4.2	4.2	4.8	6.2	5.5	4.3	4.8	5.7	5.3	6.1	4.3	4.0	5.2	5.6
Burn Rate dry kg/hr	7.3	5.1	5.4	5.2	5.1	5.9	6.9	6.8	9.8	8.1	7.5	6.9	5.5	6.6	9.0	9.1	6.8

RUN No.	CF-A18	CF-A19	CF-A20	CF-A21	CF-A22	CF-A23	CF-B01	CF-B02	CF-B03	CF-B04	CF-B05	CF-B06	CF-B07	CF-B08	CF-B09	CF-B10
g/kg PM (Condar)	3.9	0.8	1.0	1.6	2.5	2.6	3.2	2.7	1.9	3.8	2.2	2.0	1.8	2.1	1.6	1.6
g/kg CO	35.9	10.2	18.9	22.9	22.5	20.1	27.5	14.6	33.6	63.3	28.0	27.6	41.8	38.4	17.8	16.5
Overall Efficiency, %	47.9	75.2	72.7	68.7	70.4	65.0	72.6	73.5	74.2	69.0	75.7	75.5	70.9	76.1	75.6	72.0
Total Weight, lb	43.0	49.5	47.0	46.5	55.3	51.0	37.0	33.0	43.8	38.8	43.0	33.5	31.3	37.0	36.5	32.0
Wood Moisture, %	19.6	19.9	20.9	20.4	20.0	20.2	19.5	18.7	18.0	17.5	17.3	16.7	16.7	20.0	16.4	16.7
Number of Pieces	9	7	8	8	8	7	6	6	8	8	8	8	8	8	8	8
Surface/Volume, in^{-1}			3.6			3.3	3.7	4.2	4.3		4.2	4.4	4.9	4.5	4.5	5.0
Av. Stack Temp, F	368	225	279	265	268	265	222	245	281	305	267	262	299	253	286	343
Stack Dilution Factor	6.8	4.1	3.5	4.8	4.2	5.9	4.8	4.2	2.9	3.1	2.8	2.9	3.3	2.6	2.8	3.0
Burn Rate dry kg/hr	11.8	6.6	6.3	7.5	7.5	6.7	6.6	6.8	8.4	7.5	8.1	6.8	5.9	6.4	6.5	8.8

RUN No.	CF-B11	CF-B12	CF-B13	CF-B14	CF-B15	CF-B16	HK-B02	HK-B03	HK-B04	HK-B05	HK-B06	HK-B07	HK-B08	HK-B09	HK-B10	HK-B11	HK-B12
g/kg PM (Condar)	0.9	1.1	1.1	0.7	1.0	2.2	1.7	1.4	3.1	2.8	2.4	0.8	1.2	1.2	1.4	1.7	1.8
g/kg CO	21.5	35.3	41.9	14.2	13.5	36.9	19.7	18.9	23.9	36.9	26.2	24.9	21.7	24.9	24.0	28.8	20.6
Overall Efficiency, %	74.8	71.9	75.5	72.5	73.9	71.4	72.4	75.4	68.3	73.0	66.9	66.0	68.2	68.4	66.3	63.5	64.6
Total Weight, lb	40.5	31.0	40.5	44.0	43.3	39.3	37.0	40.8	42.0	45.5	38.0	37.5	42.5	39.5	33.8	41.9	40.0
Wood Moisture, %	16.9	19.7	19.7	16.8	16.8	19.7	17.6	18.5	18.3	16.8	16.7	16.9	17.6	17.1	16.9	16.8	14.6
Number of Pieces	8	10	7	8	8	8	7	7	8	9	8	8	8	8	9	8	11
Surface/Volume, in^{-1}	4.3	5.4	4.0	3.9	4.0	4.1		3.8	4.3	4.1	4.4	4.5	4.1	4.3	4.8	4.1	5.0
Av. Stack Temp, F	320	264	264	319	346	309	249	291	300	284.8	317	348	335	342	341	352	327
Stack Dilution Factor	2.6	3.9	2.6	3.3	2.6	3.1	4.5	2.8	4.3	3.0	4.3	4.1	3.8	3.6	4.1	4.5	4.8
Burn Rate dry kg/hr	7.5	7.4	7.2	7.2	8.1	7.1	7.1	9.5	7.7	8.2	8.4	6.9	7.6	7.3	8.4	7.3	9.0

Of particular interest from the 1994 series were the last 4 runs on the 27” heater, which are reported separately in Table 2.

On run HK-B13 we used a slightly different kindling method, kindling the fire from the bottom front of the pile, near the air inlet. One observation had been that a large amount of initial air significantly reduced the chances of a CO spike during startup. We hypothesized that flaming from the virgin wood surface is greater due to surface drying and the lack of a char layer. There is a tendency on startup towards rich (high CO) conditions that is aggravated by reduced reactivity with combustion air until the firebox is warmed up. We were therefore seeking ways of controlling the initial flaming sequence in the firebox. With the configuration of run HK-B13, there was a fast ignition of the kindling which then ignited only the front part of the pile. This maintained sufficiently fast flaming to ensure a good start without igniting the whole pile at once and causing rich conditions. The notes from this run are instructive:

Start: Initial stack temp: 120; Time to start from ignition: 1 minute. Wood stacked 30 min. before ignition. Large pieces. About 1" gap between front top of pile and angle iron (forms a throat).

5 minutes: Door open a crack (about 0.5"). Good flaming start.

15 minutes: At 17 minutes, flaming is drastically reduced due to larger pieces with less surface area. Fire is burning mainly above pile. Front of pile is char, not burning. Closed door at 17 minutes.

30 minutes: Short flames dancing off bottom wood surfaces. Good flaming above, not too brisk.

The average CO from this run was quite low at 18 g/kg. One advantage of the Condar Method is that it can provide a preliminary particulate number immediately. Filter weights on this run translated to 0.62 g/kg after 24 hr. drying, or about an order of magnitude lower that the US-EPA woodstove limit.

There were only 3 test slots left for the year, and they were used to do repeat runs of HK-B13. The result was a very consistent 4 run series with little apparent data scatter. Average particulate emission factor was 0.58 g/kg with a 95% confidence level of 0.09 g/kg. A statistical summary of other parameters is presented in Table 2. A good first order validation of these runs is provided by the fact that tests were conducted on 4 other systems during this interval, and there is no indication of unusual results in the other data sets.

Table 2 Summary of most recent test results - 4 repeat masonry heater runs and 2 repeat fireplace runs.

Masonry Heater (27" Firebox)

RUN No.	HK-B13	HK-B14	HK-B15	HK-B16	Mean	Stand. Dev.	95% Confidence
g/kg PM (Condar)	0.62	0.45	0.65	0.62	**0.58**	0.09	0.09
g/kg CO	17.9	21.2	17.5	22.1	**19.7**	2.31	2.26
Overall Efficiency, %	65.6	62.3	65.7	65.5	**64.8**	1.68	1.65
Total Weight, lb	55.0	45.3	47.3	42.8	47.6		
Wood Moisture, %	20.3	16.8	15.2	17.5	17.4		
Number of Pieces	8	8	9	8	8.3		
Surface/Volume, in^{-1}	3.6	4.0	3.9	4.0	3.9		
Av. Stack Temp, F	410	422	392	374	399		
Stack Dilution Factor	3.5	3.9	3.7	3.9	3.7		
Burn Rate dry kg/hr	10.0	8.5	9.1	8.0	8.9		

Masonry Fireplace (2 - 1" Air Tubes, Cold Start)

RUN No.	FC-B10	FC-B11	Mean
g/kg PM (Condar)	0.77	1.69	**1.23**
g/kg CO	36.8	47.0	**41.9**
Overall Efficiency, %	52.5	59.2	**55.9**
Total Weight, lb	23.8	23.0	23.4
Wood Moisture, %	17.0	18.0	17.5
Number of Pieces	6	6	6.0
Surface/Volume, in^{-1}			
Av. Stack Temp, F	483	461	472
Stack Dilution Factor	4.5	3.6	4.0
Burn Rate dry kg/hr	5.9	5.7	5.8

Fuel sizing

In our opinion, fueling parameters are the main variable that we see in masonry heater combustion, once basic errors relating to combustion air location and sizing are avoided. We have developed a detailed fueling protocol at Lopez that allows us to track the ratio of surface area to volume of fuel, which is used as an indicator of sizing. The statistical distribution of fuel sizing for 38 masonry heater tests for which this data is available is shown in Figure 3. Figure 4 shows a histogram of the distribution of particulate emissions factor against the fuel sizing ratio for 41 tests.

Masonry Fireplaces

For the 1994 test series, a decision was made to use the fireplace tests as a control for the overall test procedure and simply repeat the same burn every day. Two changes were made from 1993. The conventional "cowbell" combustion air inlet on either sidewall was replaced by a length of 1.5" i.d. steel tubing, aimed directly at the fire. In addition, a fast start was used. The fireplace was run as the last test of the day, and the day's accumulation of cold and hot charcoal was used as a starter.

Table 3 compares the results from the standard air supply in 1993 with the modified air supply. In addition to a large particulate emissions reduction, the most obvious change observed was in excess air, which was reduced from 1000% to 410%. Qualitatively, this was observed as a "blowtorch" effect with the new air supply. With an airtight door, all of the chimney pressure is available at the firebox combustion air inlet to maximize the velocity of combustion air at the inlet opening. Less air is able to bypass the combustion process, resulting in a higher burn rate and higher stack pressure. A conventional fireplace lacks a heat exchanger, and therefore a higher burn rate, assuming equivalent excess air, results immediately in higher stack temperature. Stack temperature and burn rate become coupled by the combustion air. The flow in the air tube is most likely still laminar, however. For a pressure difference of 40 pa across a circular orifice, calculated air velocity is around 1 ft/sec. For air in a 1" dia. pipe, the critical velocity (transition from laminar to turbulent flow) is approximately 3 ft./sec.

The blowtorch effect mentioned above has been flagged

Table 3 Comparison of masonry fireplace emission factors.

Data Source, by Appliance Type	Particulates, g/kg	Carbon Monoxide, g/kg	N E
Lopez Labs. (Douglas Fir cordwood):			
Fireplace (Rosin) w. airtight door - conventional air supply.(16 tests, cold start)	6.6	44	
Fireplace (Rosin) w. airtight door - high velocity air supply (8 tests, hot start)	2.5	35	
Fireplace (Rosin) w. airtight door - high velocity air supply (2 tests, cold start)	1.2	42	
OMNI (in-home tests, owner's fuel)			
Open fireplaces, conventional	24.9	107	
Open fireplaces, Rosin	10.4	53	
VPI (dimensioned D.F. lumber)			
Open fireplaces, all	11.5	92	
Comparison with US-EPA AP-42, average of all in-home test data:			
Masonry Heaters	2.8	75	5
Phase II Woodstove	7.3	70	6
Phase II Pellet Stoves	2.1	20	6

as a potential safety problem by CMHC (Canada Mortgage and Housing Corporation)[7]. We did not observe this effect, however, with the previous “cowbell” air setup. With the cowbell, air first hits a deflector and is bounced away from the fire. Much of the air bypasses the fire, as evidenced by the 250% increase in excess air. This illustrates the great influence of geometry-dependent parameters in fireplace combustion. We believe that they will prove to be the key variables once a larger testing database on fireplaces is developed. Accordingly, geometry dependent parameters should be carefully accounted for in test protocols.

There was an indication that the nozzle could be reduced to the point of creating a very “normal” looking fire without a significant PM penalty. The air tubes were changed from 1.5” to 1” starting with run FC-B09. Using a fast start as before, the 10 minute observation from this run reads as follows:

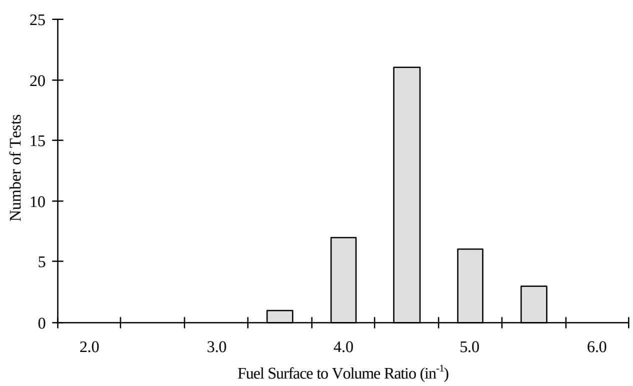

Figure 4. Distribution of average fuel sizing ratio for 38 masonry heater tests.

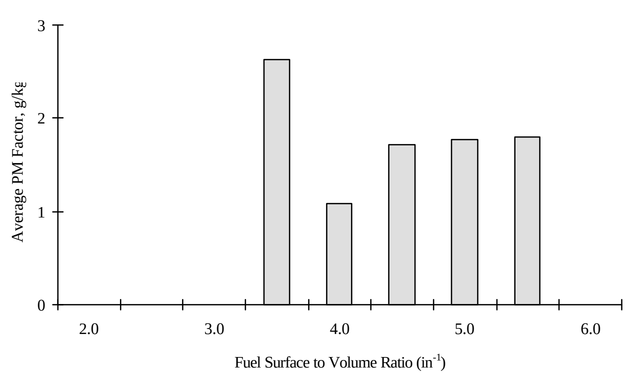

Figure 3. Distribution of PM emission factor by fuel sizing ratio for 41 masonry heater tests.

“10: Much slower start with the 1" air tubes. Much more controlled. More realistic, no runaway fire.”

PM remains low, although CO is up to 40 g/kg. Actual air consumption can be approximated as follows: stochiometric air for wood is 600 l/kg.[8], so our observed burn rate of 6 kg/h (dry) at 400% excess air would require a flow of 1.9 l/sec (4.0 cfm) per tube, assuming an (unrealistically low) door leakage of zero. If we use a ballpark value of -40 pa for stack pressure, a calculated flow[9] in each tube is about 1.0 l/sec.

Up to this point in the fireplace runs, we were assuming that the low PM factor was related to the hot start. While this was interesting, it is not typical of field conditions for fireplace use. For the next run, FC-B10, we decided to try a conventional cold start. To our surprise, we saw the lowest PM number of the two year series, at 0.77 g/kg. CO was still elevated at 37 g/kg. Next we did a repeat, FC-B11, which unfortunately was the last test in the series. Again, PM was low at 1.7 g/kg and CO was elevated at 47 g/kg. Results for the two cold start tests with the 1” air tubes are reported in Table 2 and compared with the last 4 masonry heater runs. Table 3 provides a summary of all Lopez fireplace tests, including a comparison with overall averages from field testing for other appliances, as compiled by US-EPA[10].

CONCLUSIONS

Masonry Heaters

North American testing to date of masonry heaters clearly establishes that as an appliance class they operate well below EPA Phase II limits for particulate emissions set for woodstoves. Testing conducted at Lopez Labs, though not conclusive, strongly suggests that sustained performance at a PM factor below 1 g/kg may be possible. This could qualify some masonry heaters for use in airsheds with some of the strictest RWC (Residential Wood Combustion) regulations, such as Reno-Sparks, Nevada[11].

Masonry Fireplaces

PM emissions performance equivalent to EPA Phase II pellet stoves has been demonstrated for a site-built masonry fireplace retrofitted with an airtight door and a simple high-velocity air supply. The lack of additional data points at this time limits further conclusions. However, it is significant that this is the first report in the literature of the potential for site-built, cordwood-fueled masonry fireplaces to be clean burning.

DISCUSSION

Repeatability

Although it is a limited data set, the repeatability demonstrated during the last four masonry heater runs is new, and has not been demonstrated before by other test protocols. Nothing in the Lopez fueling protocol or the Condar Method indicates any inherent lack of resolution or repeatability, vis-à-vis other methods.

The Need for Condar Calibration

The largest uncertainty in the Lopez Labs results is the lack of calibration, at low PM levels, of the Condar Method against the EPA-M5G dilution tunnel method, as well as against the other two field methods (the AWES (Automated Woodstove Emissions Sampler) and the VPI (Virginia Polytechnic Institute) Field Sampler)[12].

In our opinion, this lack of calibration is currently one of the main obstacles to developing very clean burning appliances and obtaining recognition and acceptance for such appliances from regulatory authorities. Cordwood burning appliances are more susceptible to operator influence than, for example, pellet stoves. The parameters relating to fuel size, stacking method, and ignition method need to be mapped before optimum real-world strategies can be developed.

The Need for Low Cost Tools

It is wasteful to use expensive and overly elaborate methods if a low cost method is likely to prove adequate, if not equivalent, in accuracy. All three recognized methods for obtaining M5H equivalency involve, among other things, a labor intensive (and environmentally questionable) acetone rinse of equipment, probes and hoses. This added overhead may prove redundant for sub-1 gram systems.

At a testing workshop in 1991[13], Dr. Barnett provided the following description of the Condar:

> "It is extremely fast and extremely reliable. All the other techniques, as used on location by manufacturers, have proved to be too slippery... they've been a problem, but this one has not. We used to take this one around to M5H locations and got the same relationship between it and M5H. You cannot do that with a dilution tunnel. You probably can't even do it with 5H and 5H."

The Condar has no sample hoses to rinse out, nor do we see any significant deposits in the dilution chamber after three years of testing. In addition, we can obtain real-time particulate data, which will be an asset in the study of operator influence.

It is interesting to note that the testing at Lopez Labs started as a grass roots effort by the small community of masonry heater builders. The original seed projects in this field[14] were triggered by regulatory changes imposed from above. However, the main driving force now seems to be individual heater masons recognizing both the lack of, and need for, tuning data to improve masonry heater emissions performance beyond that required by regulators. There appears to be little economic incentive to manufacturers, for example, to provide leadership for what in the end are brand-independent, generic results. Current economic models are not yet able to incorporate such factors as sustainability criteria. The work at Lopez Labs is a good example of a bottom-up effort.

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[5] D. R. Jaasma, J. W. Shelton and C. H. Stern, Final Report on Masonry Heater Emissions Test Method Development, Wood Heating Alliance, Washington, 1990.

[6] D. R. Jaasma, J. W. Shelton and C. H. Stern, Final Report on Fireplace Emissions Test Method Development, Wood Heating Alliance, Washington, 1990.

[7] Reference 3

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[9] R. Kent, Kent's Mechanical Engineer's Handbook II (Power), John Wiley & Sons, New York, 1936, p. I-11.

[10] ap42

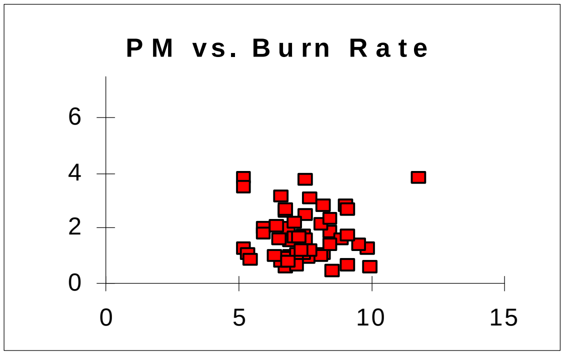
[11] Goodrich, A.C. and Jennison, B.L., "Residential Wood Combustion Controls in Washoe County, Nevada", presented at the 87th Annual Meeting of the Air and Waste Management Association, Cincinnati, June 19-24, 1994.

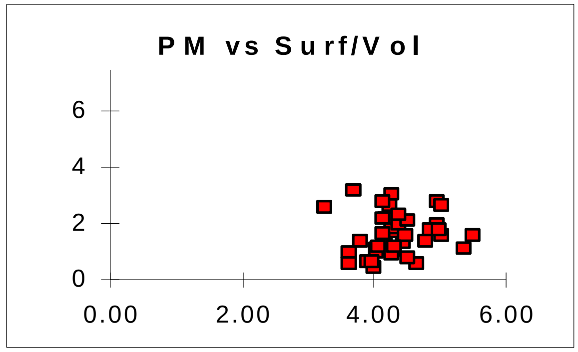
[12] Reference 4.

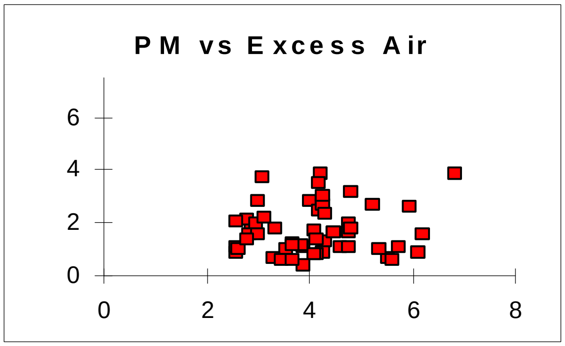
[13] S. G. Barnett, J. Houck, F. Greef, et al., Short Course on Masonry Fireplace and Masonry Heater Emissions Testing Methods and Design, OMNI Environmental Services, Beaverton, 1991.

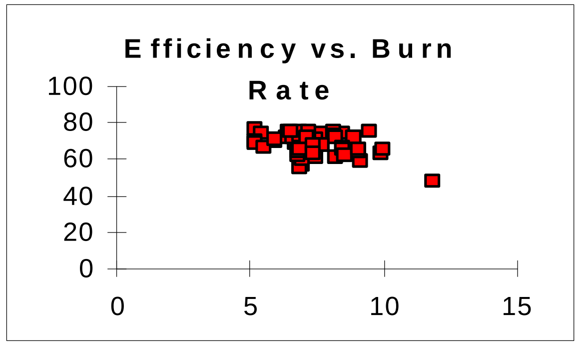
[14] References 6 and 7.

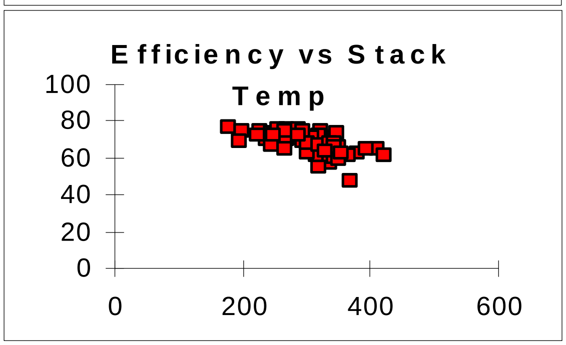
Additional Data Analysis- 1994 Contraflow Tests

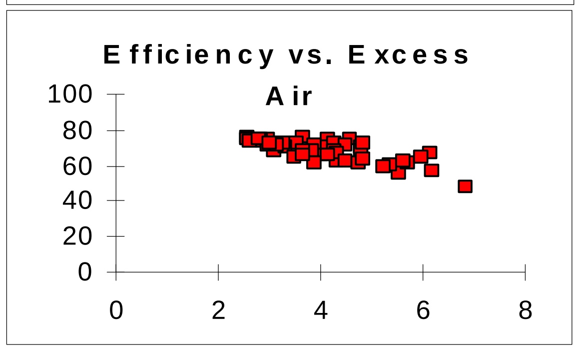


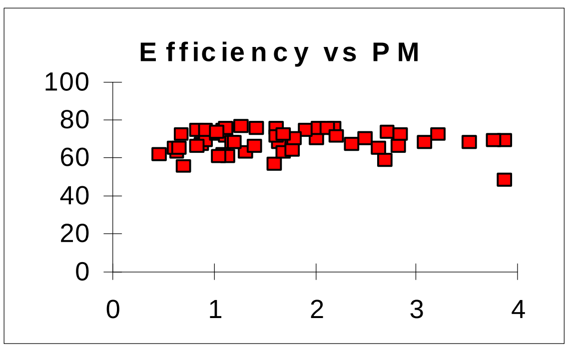


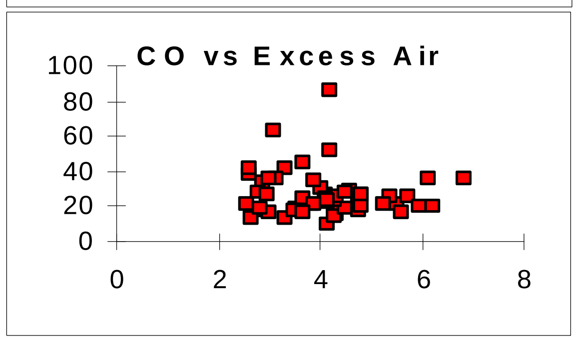


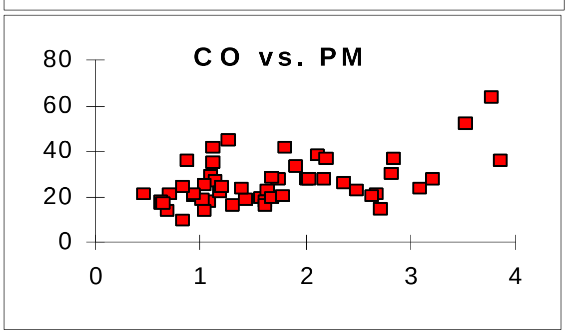


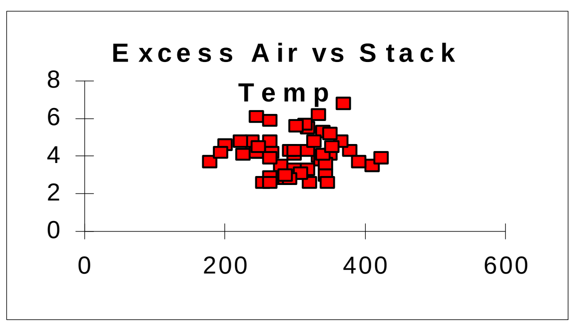






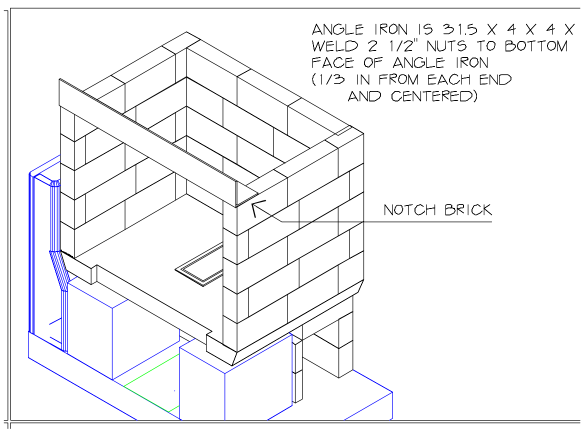




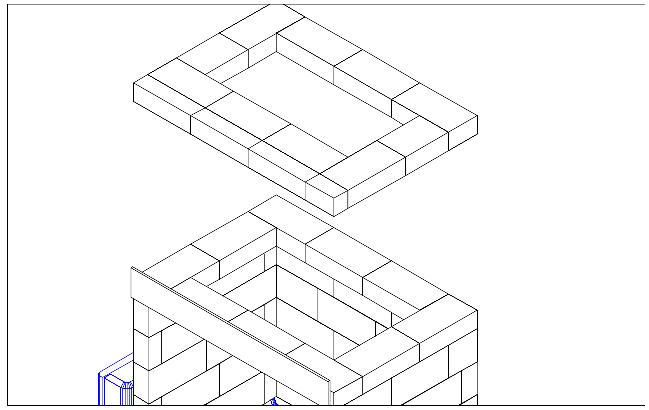


Lopez Prototype

Below are assembly drawings for the 27” prototype contraflow heater used for the 1994 Lopez tests. Bakeoven performance was also monitored and data was published in the last issue of MHA News.



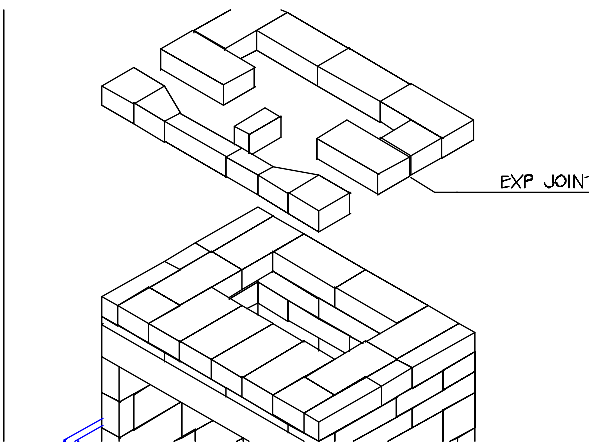
This firebox is designed to receive a 2.5” thick liner (firebrick shiners). The liner was not installed for the 1994 test, giving a 27” wide firebox. See revised detail on next page for angle iron lintel across firebox opening.



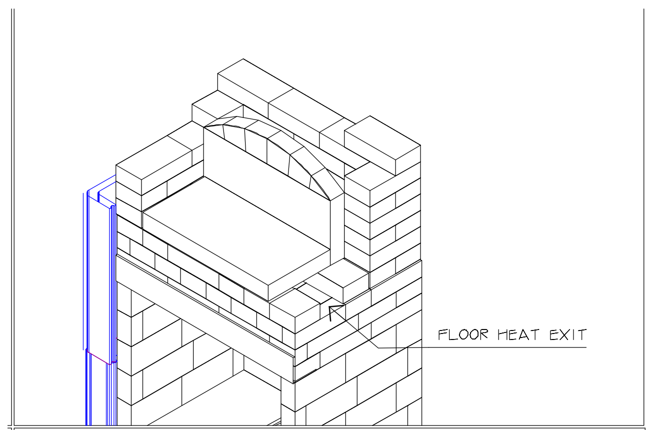
Layout is for standard 4.5 x 9 firebricks.

Not shown is a stainless steel strap used as a tension band around the first course of running bond. Outside corners on this course are filleted 0.5”.

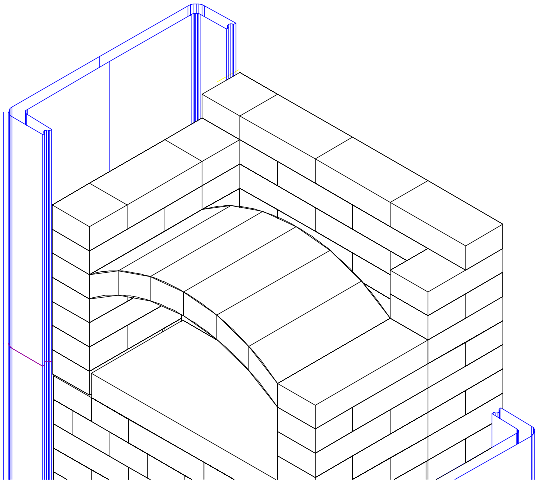
All sawcuts shown are soaps.



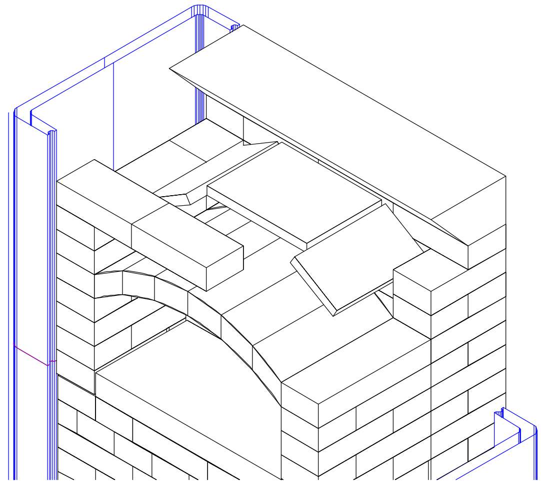
Openings shown are a bypass to provide oven floor heat. If a side chimney is used, one opening can be extended into a gasschlitz. With the Lopez chimney (approx. 24 ft of 8” round insulated + 6 ft. horizontal), there was too much floor heat bypass - - 25 - 50% smaller would be about right.



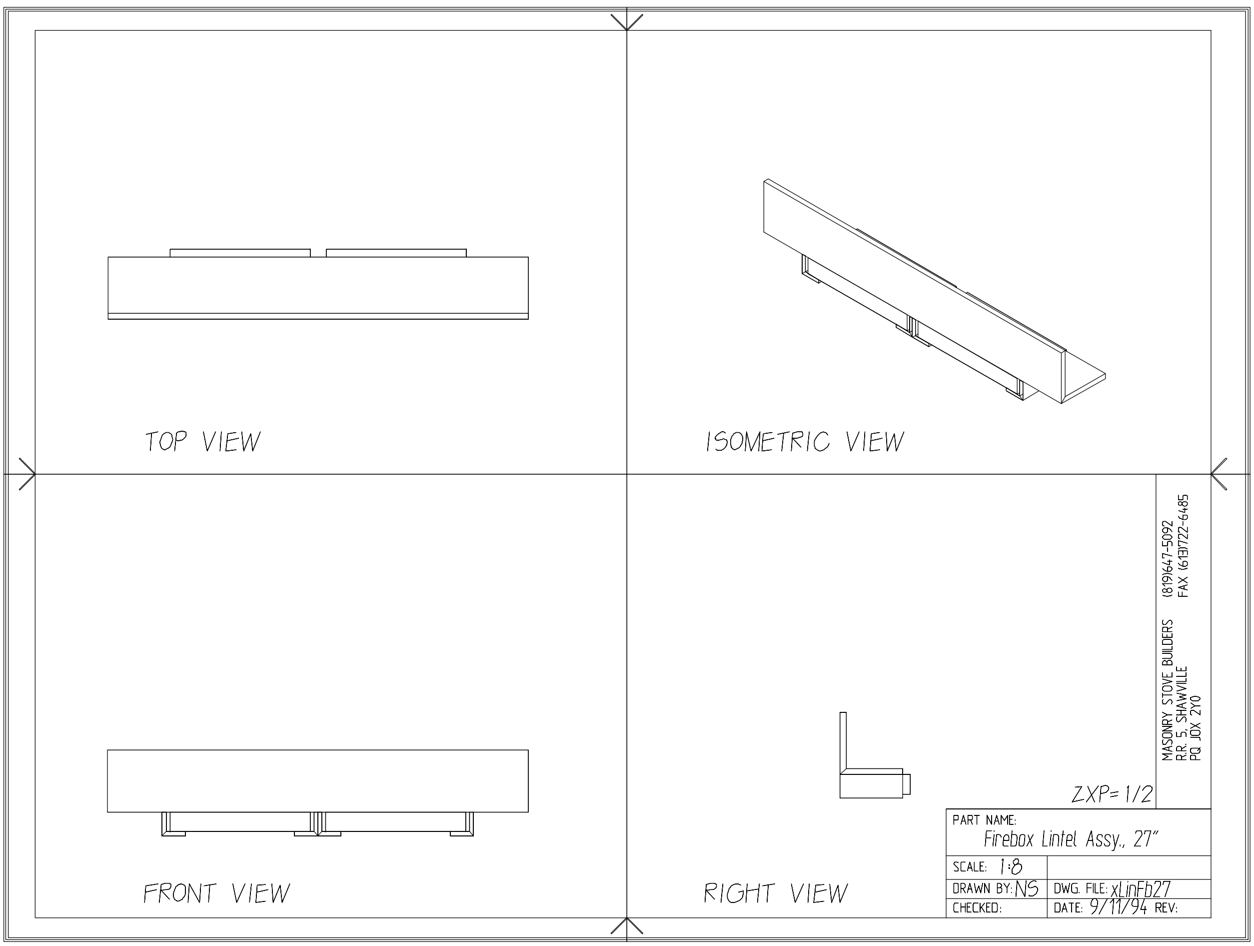
Bakeoven floor and back are precast. Ignore the lines on the back arch (computer artifact).



Oven top is precast. Ignore lines on arch.



Diverters above arch are made from millboard. Use your ingenuity when installing. Ceiling transition shown is precast.



Detail of heavier duty firebox opening lintel. Two replaceable heat shields have been added, supported on steel ledges as shown. Standard firebrick splits are used as heat shields.