

DATELINE: PORTLAND, OREGON

A New Era for Masonry Heaters and Fireplaces

n October 24th and 25th, fifteen people, most of them MHA members, convened in Portland Oregon at OMNI Environmental. one of North America's most respected stove testing labs. They had each paid \$375 in order to take the "Short Course on Masonry Fireplace and Masonry Heater Emissions Testing Methods and Combustion Design", designed by OMNI for MHA.

Following you will find a slightly edited transcript of what my trusty Sony microcassette recorder picked up during the classroom part of the proceedings. As you will see, a wide range of issues of interest to heater masons, as well as other people in the industry, was covered.

We are devoting the first part of this issue of MHA News to this most significant event. You'll find regular association business at the end of the newsletter.

We are publishing these proceedings warts and all, so that you can make up your own mind as to its impact on our profession. Of particular interest is that ordinary stove masons, many of them long time MHA members, organized this event in response to issues that are confronting them on the West Coast. If you don't think that this is a bellweather for us in the rest of North America, you're dreaming. What got officially kicked off in Portland is nothing less than the cutting edge of environmentally appropriate woodburning technology.

A special thank you is extended to Professor Stockton (Skip) Barnett of OMINI for his great efforts in putting this course together. Skip Barnett is one of North America's most respected residential woodheating authorities, as you will shortly see. So, without further ado, sit back, relax, kick off your shoes and join us on a trip to Portland, Oregon: -NS.

Introduction

The proceedings were kicked off by Paul Tiegs, principal of OMNI, who asked Rick Crooks, engineer at Mutual Materials, to give a brief introduction and overview. Rick began by giving a brief history of the recent Western Clay Products sponsored in-field emissions study of masonry fireplaces and heaters conducted by OMNI.

Rick Crooks: Regulatory activities in Fresno got the Western Clay Products Association interested and kind of woke us up a little bit. Members of that association were not too interested initially, except that it was an intriguing problem and that we had a pretty good masonry fireplace business in the Northwest.

The masonry heater business was something we were familiar with - dabbled in a little bit. I think a year ago we really didn't have the respect for it that we do now.

Looking ahead at the woodstove business, we could see that there were going to be some regulations, so we thought we'd start now, and get ahead of the game a lttle bit- get some baseline data and see just how good masonry fireplaces are.

We're regulated in Fresno obviously, Colorado, and not just stoves but fireplaces. We also wanted to see where masonry heaters fit in.

We needed some baseline data. We had some EPA data - 14 grams per kilogram, and we wanted to see if that was accurate..

We added heaters as an afterthought - we thought they were promising so we wanted to check them out. We also wanted to look at some other designs look at the Rosins and the Rumfords and see where they fit in.

Good News/Bad News

The results we got were good news/bad news. The bad news was that we would have been real happy with 14 grams per kilogram. On the other hand, we learned some things about how fireplaces were burned - they're not burned like woodstoves, they're burned 3 1/2 to 4 hours a day instead of around the clock. The loads are different.

We developed a signature - I think Skip will talk about this later - of how a fireplace and how at least a couple of heaters are burned - what kind of burn patterns they have. allow us to burn extremely clean. There is a very good opportunity for us to expand our market and provide the public with a very clean burning, very safe, and very attractive appliance.

The Regulatory Front

Skip Barnett (henceforth called "Skip"): Thanks Rick. Now I'd like to bring John Crouch out here. The reason we

"We looked at the Rosin curved back design and found that we got a reduction of over 50%."

We developed an existing baseline, I think we did very well on that. We burned over 350 hours, so we had a significant base.

We examined some new technologies. We looked at the Rosin curved back design and found that we got a reduction of over 50%. The masonry heaters also showed some cleaner burning versus fireplaces, and they showed that they have the potential to burn as clean as if not cleaner than some of the pellet stoves. We got very good results out of the masonry heaters.

So, now what do we do? That's basically where we're at, and that's what this course is all about - we have this ongoing need for education. Not only within the industry, but for builders, contractors, masons who think that they know all about building fireplaces.

We also need to educate the regulators. I don't think that before this project even Skip Barnett had a very good understanding of the difference between a masonry fireplace and a masonry heater.

We also want to look at safety. We all know that brick chimneys, brick fireplaces have a tremendous safety record - very positive things that we want people who want to use our materials to know about.

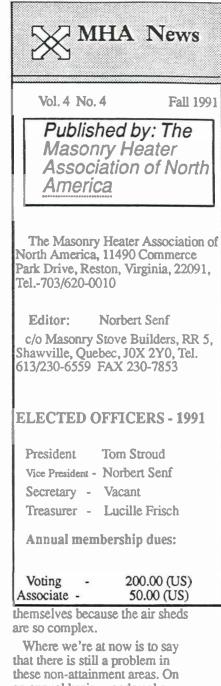
Because we have this dense ceramic product - clay brick, fireclay brick, etc., we can burn extremely hot and this will also asked him to come and speak with you today was to make you aware of what's going on right now on the regulatory front. I hope that you will buttonhole him this morning during the coffee break to get him to tell you what's going in your own area right now.

John Crouch (WHA Emission Specialist): By and large, what we do is indentify areas of the states that violate federal air quality standards, and we work with the local governments to come up with strategies and programs that will clean up the air. Help them achieve standards. They're called non-attainment areas.

There are a handful of them in this state for PM10 - Klamath Falls, Medford, Grant's Pass and Eugene-Springfield area.

We work on a wide front addressing a wide range of sources - industry, automobiles, slash and agricultural burning, road dust - and - wood heating.

Probably the most famous - or infamous, depending on your point of view - control strategy developed so far has been the certification process back in '84 (Oregon) that Skip talked about. It was new, it was innovative, it was groundbreaking, it was controversial, and it has come a long way since then. That has made significant strides in cleaning up the air in Oregon in non-attainment areas, although by and large it has not succeeded in cleaning up the air sheds



Where we're at now is to say that there is still a problem in these non-attainment areas. On an annual basis, woodsmoke plays a significant but not an overwhelming role. In a worst case situation in the wintertime the air quality problem is by and large woodsmoke dominated.

The certification program was not enough to fix that. In a lot of these areas we have gone into a curtailment program to deal with some of these worst case situations. We have local ordinances that curtail woodburning on certain days.

Green, Yellow, Red

On a green day, when there's lots of ventilation and none of these inversions are socked in, just about anything is allowed to burn. When it gets a little worse, most communities call it a out their old woodheating sources and upgrade to a variety of heating sources - gas, pellet stoves, Phase II stoves. It was also authorized to set up a state wide low interest loan program to help accomplish the same thing. days, but I cannot guarantee that at this point.

We have a lot to learn about them. We know about the technology generally, but we have not delved into it yet.

We could make the recommendation to local

"There could very well be electricity shortages in Washington state."

yellow day, and only EPA Phase 2 stoves are allowed to burn. On a red day, no woodburning is allowed.

What I've passed out to you gives you an indication of what we see as the relative contribution of woodstoves and fireplaces in the premier non-attainment area of the state, Klamath Falls. They mailed out 19,000 surveys in 91 to get woodburning trends and compared them with a similar, smaller survey in 1987.

Fireplace Use Declining

If you look at he chart you'll see that homes equipped with regular fireplaces dropped from 19 to 17% - the overall use of fireplaces is declining, appreciably.

We feel that the measures taken in Klamath Falls are necessary to get the air quality problem under control. However, we don't see them as the long term solutions.

You may be familiar with a piece of legislation introduced by the DEQ this summer - House Bill 2175. It basically says that the air shed is not a free dumping ground, and that if you're going to pollute then you are going to pay. It not only applies to industry as it has done traditionally, but applies to everybody, including residential woodheating.

There are proposed fees on sources, including woodstoves, to run the attainment programs. This is a fee per cord applied at the cut level to get a forestry permit for wood. The money will be used to help low income people in these areas to change There will be restrictions on sale of used woodstoves. There is a provison to require building code ammendments. After July 1995, local authorites may ban non certified units. There is an increased sales fee on new stoves to \$15 from \$5 for education and enforcement activities.

So, we are still hoping that the long term solution for the state of Oregon is to get the people into the latest designs - and not only get them into new stoves but to educate them - change the way they burn.

A point made by the industry and well taken by the DEQ is that a heating system is not just the woodstove, but relies on the flue system, a critical component, and operator practice - a critical component.

Oregon DEQ

Next on the agenda was David Collier from the Oregon DEQ (Deparment of Environmental Quality) to talk about Oregon's Air Quality Regulations.

(Question by Tom Stroud to David Collier regarding the exemption of masonry heaters):

David Collier I believe that the curtailment programs have been locally adopted and the locals are free to exempt what they want. I'm not sure, but I think that masonry heaters right now are regarded as fireplaces and required to stop burning probably on yellow days and for sure on red days.

Unlike Washington state, we have not dealt with masonry heaters. If we were to design a state wide program, I think that masonry heaters would probably be allowed to burn on yellow govenments, if they asked us whether they should be exempt on yellow days, I think that our answer would likely be yes.

(Question and discussion of slash burning, and whether it is not more significant that wood heating, and what basis there is for making the claims)

David Collier: We have looked at this in a number of different ways, where we document how many homes, how many cords, when they burn, which gives us an estimate of the total number of tons used by residential woodburning. We compare this with other surveys, other pollution inventory data which gives you tons from industry, tons from automobiles and you can compare it that way. There has been chemical mass balance modelling done where we have confidence that you can isolate the chemical fingerprint of various sources. When you say 30% of PM10s come from woodburning, you're obviously not saying 30.0, but the relative contributions are very close.

I'm also saying that in every area, the impacts are different. In the Willamette Valley there are impacts from slash burning, field burning. In some areas there are significant impacts from dust.

Washington DEQ

The next speaker was Fred Greef from the Washington Department of Environmental Quality

Fred Greef: I'm going to talk a little bit about our first Clean Air Act and the 1990 ammendment to it and finally the 1991 ammendment to it, which takes on the question of fireplaces.

Wood is probably one part of the necessary energy mix to meet all of our needs at this time, and it is renewable which fossil fuels are not. There could very well be electricity shortages in Washington state, and we have taken several approaches to some interpretation in there as to what the law actually means.

When we write the new regulation on that, there's going to be some controversy. An emmission test may have to be developed for them, and it will have to be comparable in some way. It may have to be a different fuelling mechanism and may Further, we encourage municipalities within our jurisdiction to adopt their own woodstove regulations if they feel that ours are not strong enough. This has included enhanced education efforts, where towns felt that our measures were not doing the job adequately. We also encourage them to adopt enforcement

John Crouch: "Anybody here from California? Nobody? That is so sad. That is so typical. Those people are going to be hit by a freight train."

dealing with the wood smoke problem.

We've followed Oregon's lead in requiring certification, and we've also looked at burning bans and opacity. We've looked at several things at once to try and push the woodstove technology to cleaner burning models, but we're not looking to outlaw wood heat use. It is a necessary part of the energy mix today.

A Lot of Smoke

Originally, Mother Earth News told everyone to buy an airtight stove, load it full of wood, and turn the air down, this was how you were supposed to burn them. Everbody started making wood stoves in their garage, and there were a lot of problems with these stoves. Many of them made a lot of smoke.

We did an extensive survey in the state and started finding out about health effects. We found we were in violation of federal particulate standards in several parts of the state and we had to do something about it.

In 1987 the Washington Clean Air Act was passed and there was a lot of support for it in the legislature. Then in 1990 and 91 ammendments were made with fireplaces being included in 1991.

The non-masonry standard actually requires fireplaces to meet the current 7.5 grams per hour woodstove standard. For the new masonry design standard, it calls for something comparable or equivalent, so it does leave have to be something other than brands. You're always going from a completely cold start and then burning for three or four hours, so its going to have to be something a little bit different.

Naydene Maykut

Next on the Agenda was Naydene Maykut, who is Senior Scientist for the Puget Sound Air Pollution Control Authority (PSAPCA)

Naydene Maykut: PSAPCA takes into account four counties, and these are at the core of the populated region around Puget Sound - about half of the population of the state of Washington

Our (local) woodstove regulation is called Article 13 and is part of Regulation 1. It is part of the solid fuel device regulation standard. This includes fireplaces as well.

Its policy and purpose is

-to control and reduce air pollution cause by woodstove emmissions

-to educate the public on the effects of emmissions, particularly the health effects

-to educate the public about other heating alternatives such as gas, oil, electricity

-for those people committed to using wood heat, about better performance through using certified stoves..

This year we added something to our policy and purpose. It was to encourage the replacement of uncertified stoves. programs or to join in with our own enforcement programs.

Definition

First, I'll go over these definitions real quickly:

Adequate source of heat 70F three ft above floor

First stage of impaired air quality

- 75 micrograms per cubic meter of PM10 on a 24 hour average. Can also be invoked if CO reaches 8 parts per million, although this provision has never been used

Second stage - PM10's greater than 105 mcg/cu.m.

In regard to the fines, we are telling people that if they come in and show us that they got a phase II stove, we'll waive the fine. We're trying to change people's behaviour.

The WHA Perspective

Next on the agenda was John Crouch, Wood Heating Alliance (WHA) Emissions Specialist to talk about the industry (WHA) perspective:

John Crouch: From an industry standpoint, the problem is not in the Northwest. The Northwest continues to have a problem that is woodstove dominated and that has to get cleaned up. The focus is pretty much in the sunbelt and in California - largely from a growth standpoint.

You look at where new homes are getting constructed, and you will see where fireplaces have become, or are going to become, an issue - Las Vegas, Fresno, San Obispo county, Sonoma county. You look at the growing perimeter of metropolitan areas in the sunbelt and that is where fireplaces are being talked about or thought about or draft regulations are in effect or being kicked around.

California Freight Train

The other issue - who here is from California?

Nobody here from California?

That's so typical. That is so sad. Those people are going to be hit by a freight train.

Forty nine states of the country deal with the federal standard for ambient air and particulates, which is 150 micrograms per cubic meter average over 24 hours. California's standard is 50. Their legislature blithely did this a couple of years ago, and I haven't found anybody who understood what the impact of that was going to be at the time the bill was passed. The immediate impact is that the entire state, with the exception of Murdock county, is non-attainment for particulates at the state level

Now, if you're non-attainment at the federal level at 250 micrograms, you're not going to say anything publicly, but privately you're going to laugh. The net effect is that its going to allow a growing area with county supervisors who are going to say "My God! We're non-attainment! We've got to do something!" And they may be talking about 60 or 70 micrograms as their worst case day.

Well, as Naydene states, in the Seattle area, when it gets to 75 micrograms, there's a first stage burn ban. When it gets to 105 we go to a second stage burn ban.

Second stage bans are called at different levels all over the states, and you should never assume that what you heard in one area applies to another area. The meteorology and the local politics create huge differences across the West.

The other key area is definitions. That creates a lot of problems for fireplaces and pellet stoves - Jerry can tell you about masonry heaters.

EPA

Originally, EPA decided they were not going to regulate woodstoves. It was getting dealt with in the West on a local level in places like Oregon and Colorado. The National Resources Defense Council sued the EPA on the premise that woodstoves were too large a polluter and that the EPA could not fail to regulate them.

A federal judge in New York state agreed, and that forced federal woodstove regulation. That's of importance to fireplaces, because the suit dealt only with woodstoves so that what EPA did was create a box that contained only woodstoves and left everything else out fireplaces, masonry heaters, coal stoves, about two thirds of the pellet stoves, the cookstoves.

It didn't matter if any of them were cleaner or dirtier. The court order was over woodstoves. There is much, much confusion afoot across the land because of what happened here.

So a lot of this confusion revolves around this term "EPA exempt", which in itself is actually a misnomer. Only cookstoves are EPA exempt. The correct term is "non-affected facility".

A pellet stove with a fuel to air ratio greater than 35:1 is a non-affected facility. You get a letter from EPA that says " Congratulations, you don't have to deal with us."

And if people have wanted to get certified, that is a very disappointing letter to get. Because there are regions where you can do things if you have the certificate that you can't if you are a non-affected facility and can't get one.

Besides this definitional problem, there are a couple of other things that set a woodstove apart from a fireplace. First is the more limited use that a fireplace gets. Study after study shows that a certain percentage in any community fails to light a fire in their fireplace at all. Another large percentage will burn one or two fires a year. At the other end of the continuum, for reasons unknown to me, are people who try to heat their house with a fireplace. They go through a lot of wood.

By and large, every study you see in the midwest, fireplace people use a lot less wood than woodstove people both on a per season and often on a per night basis. As Skip and others are pointing out here today, its not on a seasonal but rather on a per-night basis that this whole issue is premised. I'm not saying a fireplace is better, I'm saying its different.

The other major difference between the two types of appliance, as you all well know, is that fireplace combustion is essentially non-controlled. And, in recognition of the fact that the consumer can tinker with the woodstove combustion, woodstoves have to demonstrate their emmissions at four different burn rates.

Fireplace Definition

For your reference, the difference between EPA 90 and the previous standard is that woodstoves now have to demonstrate that they burn clean on all four burn rates. In the past they were allowed to average the results. That has been extremely difficult for the industry, and it has been a watershed event. Some companies were not able to make the final cut into the 1990 standard.

However, that's not germane to fireplaces because in fireplaces consumers cannot control the air. I think that will turn out to be the primary definitional difference.

The EPA definition of this difference between a fireplace and a woodstove was an air to fuel ration of 35:1 or a burn rate greater than 5 kilograms per hour. A couple of small companies over the years have opted out of the woodstove definition using one or the other of these criteria. Pellet stoves turn out to be right on the cusp. They can be tuned to be on either side of the fuel to air ratio.

A third difference which I failed to mention is the 800 kilogram weight limit, or 1780 fireplaces burn wood, so they're a woodburning appliance, so they have to be certified."

If I were a masonry fireplace person, I would see that as very destructive since it totally confuses the distinction between these two appliances.

Now, I'm going to pass out

Well, I need to wind up here. I want to add the caution that these are draft ordinances.

Virginia Tech Tests

Three years ago we convened our people in August to begin working on a study that we did the initial stage of with the Brick

"One of the problems that Colorado has is that it doesn't have a good constituency for masonry heaters. In fact, where you have the best constituency for masonry heaters, Washington, that's where they're the most recognized. "

lbs. EPA did not want to get into the business of regulating masonry fireplaces.

The point of all this, folks, is that if you want to design an appliance to burn clean, you have to avoid becoming a woodstove in the process, and this narrows your parameters dramatically or, meet woodstove standards.

The existing method of regulating fireplaces is very simple, and I run into this consistently in California, where regulators are very sophisticated about regulating carbon monoxide and ozone, but not yet very sophisticated when it comes to particulates. To them, you put wood into both appliances and smoke comes out of both appliances, so they're the same thing, right? This is very funny to people who may have been building fireplaces all their lives but may never have put in a woodstove - and its also funny to the woodstove folks.

The main forms of control on fireplaces are episodic controls and bans on new construction. Episodic controls tend to work real well because fireplace users are not that committed to using their appliances and tend to want to be good citizens.

Fireplace Bans

In some areas there is a de facto effort to ban the installation of fireplaces in new construction by simply saying that all woodburning appliances have to be certified. "Fireplaces can't get certification". "Well, I don't care, some draft ordinances. I've written "draft" on them, because I have seen draft ordinances that turn up as legislation in other parts of the country years later. In fact I was quoted something in the Bay area two weeks ago off the King county draft ordinance that was in fact never passed.

What you're going to see is a proposed ordinance for the city of Aurora Colorado. Aurora is a suburb of Denver which has had an episodic control program and a real heavy history of woodburning issues. Vail similar, although dissimilar in many respects - recently changed their ordinance. Their old ordinance said no woodburning in new construction - this got picked up on the AP wire, in fact I got clippings from all over the country. What didn't get picked up on the wire was that in August they ammended it to allow certified stoves or pellet stoves.

One of the problems that Colorado has is that it doesn't have a good constituency for masonry heaters. In fact, where you have the best constituency for masonry heaters, Washington, that's where they're the most recognized. In California I think you could do a lot more if there was more of a constituency for masonry heaters.

I'm kind of setting up what you are going to be dealing with tomorrow. That is why you need to get busy and get a strategy for masonry fireplaces that hits the streets pretty quickly with a lot of data behind it. Institute and the Masonry Heater Association at Virginia Polytechnic Institute. Our primary concern is that if you test a fireplace with the wood load that you use to test a woodstove, it will drive you towards defining and designing things that work and look like stoves.

What you are dealing with here is critical. How you load the appliance determines what you end up with in terms of clean burning appliances later on.

So the WHA has created what it considers to be a reasonable fuel crib - and Skip has his opinions on that that you will hear later - reasonable fuel crib for fireplaces.

Masonry Heater Paper at PM10 <u>Conference</u>

And we will essentially over the next couple of years be engaging the air quality community - beginning with the conference on PM10 in Phoenix that Tom (Stroud) is going to be presenting a poster paper on masonry heaters at. The head of the WHA's fireplace technical committee, Frank Broom, will be presenting a paper on the development of a clean burning fireplace relative to that emmissions crib.

I'll just wind up by saying that withing the last thirty days, on of the larger manufacturers of factory built fireplaces has put an appliance on the street that will reduce pollution by approximately two thirds over the baseline data that they have seen on their own appliances. So, the factory built industry is moving. We'll see three or four more of those in the next year. I think it goes without saying that the masonry fireplace industry needs to keep moving if they want to not fall too far behing.

I'm dealing with regulatory people all the time who don't want to create <u>any</u> niche for fireplaces. So, if there's going to be a niche for a third way, a new generation fireplace, the industry 2.Chemical Composition of Wood and Air 3.Chemical Composition of Air

Emissions

4.Products of Incomplete Combustion

5.POMs and Related Compounds

6.Acidity

7.Size Distribution of Particles

8.RWC Particulate Impacts

9.Air Toxics

0.1% level. You won't see that in any regulation.

So what's important is that there are potentially a lot of similar compounds that nobody has keyed on yet that could be quite toxic.

What's a PM10?

One thing about combustion particles produced by combustion processes tend to be small compared to particles

"One of them is retene...The pulp and paper industry is very concerned about it. We've measured it in woodsmoke at the 0.1% level. You won't see that in any regulation"

has to respond, and it has to respond quickly.

The Chemistry of Woodsmoke

Skip: The next person I'd like to introduce is Dr. James Houck. He is an environmental chemist at OMNI. He is a PhD in chemistry who has done extensive work with the physical and chemical characteristics of woodsmoke and biomass burning in general. So, he's had a wide variety of experience in this field for a long time, at least a decade.

Dr. Houck is going to talk to us about the chemical and physical characteristics of woodsmoke. He's also going to talk a little bit about the early question of just exactly what is the impact of woodsmoke in some airsheds and he has some data that he will share with us on that.

Dr. Houck: I want to talk a little bit about what really comes out of a woodstove and a fireplace. There's a lot of chemistry involved, so you can nod off if you wish.

(Picture of smoke in a valley) The bottom line is, you see this stuff in an airshed and you say "What is that stuff?" That's what I want to talk about.

Outline of Dr. Houck's presentation:

1.Mass Balance

10.RWC CO Impacts 11 Light Extinction 12.Water Vapor/Liquid Partitioning

O.K., we've talked about the major constituents. Now we're going to talk about the minor constituents that people are really concerned about. These are the POM'S - Polycyclic Organic Molecules. PAH's, Polycyclic Aromatic Hydrocarbons - same stuff.

These things are the benzene rings that are joined together. These compounds are considered carcinogenic. Also, regulators estimate that something like 40% of these compounds nationwide come from woodsmoke, so this is some of what is driving the regulations.

I'm not going to bore you with all the chemistry of these things. I just want to point out that trace levels of these substances can't be ignored.

(slide) This is what I talked about a little earlier. People analyze woodsmoke for POM compounds, but there are lots of similar compounds that no-one has ever looked at. They are not in your cookbook EPA methods.

One of them is retene...The pulp and paper industry is very concerned about it. We've measured it in woodsmoke at the produced by mechanical processes such as dust. Just to visualize it - hot gases come out of the stack, they condense, so they form lots of little particles.

(slide) This shows the particle size distribution of of dust compared with woodsmoke. In the soil dust, about half the particles are larger than 10 microns. This is the PM10 level that we have all been talking about. So, fifty percent of agricultural dust is too big to worry about. In the less that 1 micron range, there is only 4%. Compare this with woodsmoke, where virtually all of the particles are less than one micron.

To give you an idea of what it's all about, this is an electron micrograph of a red blood cell. This is one micron right here (points). The red blood cell has a diameter of about seven microns.

The reason this is important, why regulators have set standards, why they're concerned about particles produced by combustion more so that particles produced by dust, in fact why they've come up with a PM10 standard is - this right here

(another slide) This curve shows the particle size versus the deposition fraction in your nose. For particles around 2.5 to 10 microns most of them get taken out by your nose. Particles that are smaller than that get right into your lungs.

This is why we have PM10 standards, and this is why woodsmoke is particularly nasty, because you get it right into your lungs.

(slide comparing emisson factors with coal fired powerplant) ... So, woodstoves are dirty. I hate to say it. So are fireplaces. - compared to fireplaces. I jump up and kown and get on my bandwagon about this.

If you're legislating against PM10 particles, you can forget about carbon monoxide. (*slide*) This table here is a ratio between carbon monoxide and fine particles. In all the studies the ratio is between 6:1 and 10:1.

If you take the worst case ever measured, in Klamath Falls in Norbert Senf: But the other thing that we're saying is that if you restrict this to masonry heaters, you're eliminating all the slow burn situations. You've got one particular situation - fast burn, high heat, lots of oxygen.

Skip Barnett: It's certainly cheaper to measure CO.

Norbert Senf: That's really the reason we're here. It costs us a lot of money to go to a lab to

"I cannot see why anyone is concerned about carbon monoxide in woodstoves and fireplaces. I jump up and down and get on my bandwagon about this."

industrial sources. EPA has forced industry to clean up its act.

Walter Moberg: How do the emissions from a coal fired power plant compare to woosmoke?

Dr. Houck: My opinion is that woodsmoke is more toxic. The impact is real. It's been quantified 16 different ways.

Can of Worms

Now I'm really going to open up a can of worms - the Clean Air Act. (slide) Its got 189 compounds listed here. The key thing is - you look down this list and a lot of the compounds in woodsmoke are listed here. They have been identified in the new Clean Air Act, and thery're going to do something about them.

I don't know how this is all going to fall out for woodstoves. Washington has passed a new law - you've got California, you've got Oregon legislating against toxics, and they're jumping all over industry. It won't be long before you're affected by it too - woodstoves and fireplaces.

Good News - Carbon Monoxide

The last thing I want to talk about, and perhaps this is good news, is carbon monoxide. I cannot see why anyone is concerned about carbon monoxide in woodstoves and 1988, you get 792 micrograms of PM10 (per cu. m. of air) over 24 hours. About 80% of that is from woodsmoke. Using the ratio of 7:1 gives you 4000 micrograms of carbon monoxide from woodsmoke. On the worst day in history, you're still below the carbon monoxide standard.

A Question

Norbert Senf: A question. As masonry heater builders, one of the things we need to do, because there is so little information, is to build a database on how these units perform in the field. Can you reverse that logic and tune the units for minimum CO and assume that you're tuning them for minimum PM's as well?

Dr. Houck: I think Skip is going to talk about that. There are different kind of combustion conditions. I think in general you can, yes, better combustion conditions will reduce CO. I don't think this always holds, though, and Skip will talk more about that later.

Skip Barnett: If you go back to your previous slide, I think it confirms that. The certified woodstoves have a much higher ratio of CO. You're basic contention still is true, however. But as you can see, if you're at 150 micrograms of PM and you go down from there, the ratio changes. And it may change as well for masonry heaters. find out stuff that maybe we could be finding out a lot cheaper.

Skip Barnett: You're going to have to determine what that ratio is.

Dr. Houck: There's a couple of things. For a given unit, as combustion efficiency gets better, the amount of particulates are going to go down. But for different units, you've got a lot of parameters that are not the same. You've got different amounts of excess air, - it's hard to find an across the board correlation.

Norbert Senf: But if our goal is to provide data to heater and fireplace builders that will allow them to build a cleaner unit - here's what you do and this will reduce CO to an absolute minimum - then you're also going to get lower PM's, are you not?

Skip Barnett: We've compiled data from 105 different tests on different stoves, and the relationship is just too loose to allow us to draw that kind of conclusion.

Dr. Houck: Again, if you do one, its going to improve the other. It's certainly a reasonable thing to do, but its not a one to one relationship.

O.K., let's have a look at this chart (slide). These are CO measurements taken in seven different towns across the West. The readings are broken down

^{...}

into several categories: all days, cold days, Sundays and holidays, and Sundays and holidays that were also cold days.

The reason we included the Sundays and holidays is because it allows you to separate out the effect of automobile emissions. We've got the total CO values, and we've got the nephelometer values, which allows us to she is going to speak about the health effects of woodsmoke.

Naydene Maykut: You need to know why we have to make these regulations. Maybe you don't believe it, but the regulators really don't like to make regulations. However, when we see a problem that is seriously affecting people's health, we have to do something one of our most serious problems that is causing health effects that doctors can relate to right now.

We've done a study in Seattle that shows a very high correlation between emergency visits to the hospital and the air pollution index.

Walter Moberg: I think that people here accept that. That there are all sorts of serious

"Well, I have to say, that wood is a dirty fuel." - Naydene Maykut, senior scientist, PSA.PCA

separate out the CO that's due to residential wood combustion.

The residential contribution goes from 13% all the way to 67%, but in most cases 20 to 30% at max. of the CO in that airshed is from residential wood combustion.

(slide) Here's a graph taken during a CO violation episode in Portland Oregon. You have to work real hard to find a violation day. When you find one, then you look at it and determine what fraction of the CO was due to residential wood combustion. As you can see, its a small piece of the pie.

So, carbon monoxide from woodsmoke is not a serious concern. It's not something that requires regulation, because if you control the particles, you're automatically controlling CO.

Again, like with PM's where we've looked at 16 different ways of assessing the woodburning contribution, we've done the same thing with CO. There is no question as to what percentage of the total is contributed by woodburning.

Health Effects of Woodsmoke

Skip Barnett: Thank you Dr. Houck.

The next speaker that we've asked to give a presentation is Naydene Maycut, who spoke earlier about Puget Sound Air Pollution Control Authority Regulations. Naydene is the senior scientist at PSAPCA, and about it.

So, why is there such a fuss about woodstoves? It's a problem that's caused locally, but its a problem all over the United States, all over the West from Reno clear to Alaska.

The problem is that woodstoves put out very fine particles like the ones we've been talking about that cause all kinds of problems. They get breathed down into the lungs, and they carry with them these toxic substances that cause respiratory problems, that cause a lot of damage.

We also have carbon monoxide, which is a deadly gas as you all know. Its not a high percentage, but even a small amount can cause a problem.

And also, complex organic compounds that are very unhealthful.

(Question from the audience)

Naydene Maykut: Well, I have to say, that wood is a dirty fuel.

Norbert Senf: But the ranges that we see between bad stoves and good stoves are on the order of a hundred to one.

Naydene Maykut: Let me show you a slide I have here. I mean, we can have a good fight here if we want to, but what I am trying to show you is why we have to control woodsmoke why you have to be here looking for a more responsible way of woodburning, and what message I have to try and take to the public and take to my board of directors. And that is that this is problems here in the Northwest. But, the point is that our industry and the people who have careers in this industry produce responsible, clean burning, energy producing equipment, which is part of why we're here.

We believe that we can provide an alternative that is a relatively safe alternative for providing heat in the Northwest.

Tom Stroud: You have to understand that the majority of people here were producing radiant units running at one or two grams an hour, ten or fifteen years ago. We were doing this long before it ever came to the forefront on the health issues. The majority of our stoves are burning at that rate, and we haven't even tried tuning them yet.

Walter Moberg: If you had 600,000 people in the Northwest burning masonry heaters, instead of what they're burning now, we wouldn't be here talking about this.

The Bottom Line

Skip Barnett: O.K., we've kind of been skirting around the issue all day, so let's find out what some of the numbers were that we actually got last year.

Last winter, OMNI was commissioned by Western States Clay Products to conduct an investigation into fireplaces and masonry heaters as they operate in the home.

All this work was done in the Portland area, within 50 miles of where we are right now. I must also mention that kind of a seed project was conducted to try and instill some interest in Western States. This was conducted by Mutual Materials, with Rick (Crooks) spearheading that particular project.

Rosin Retrofit

I'll incorporate all of the results into one here, but it appears that Rick got as interesting an the most interesting and important.

A Baseline

First of all, we wanted to establish a baseline emission factor for conventional fireplaces. There have been NO fireplaces studies in homes in which there's been burning conducted or sampling conducted anything like the way percentage, then you can start chipping away at the emissions as you see them to be in this futuristic scenario.

Rumford Backfires

Secondly, what we wanted to look at is what the emissions would be from some higher tech kind of fireplaces. We had a couple of candidates - the Rosin, which we talked about, and the

"There have been NO fireplaces studies in homes in which there's been burning conducted or sampling conducted anything like the way homeowners burn - technicians chuck the logs in."

outcome from his project, than perhaps from the rest of the data.

He was trying to see what would happen if you put a Rosin fireplace strictly as a retrofit insert, with no more whistles and bells - just slap it in. A one thousand and twenty fieve dollar special, right Jerry?

For a thousand dollars, what can you get? I think you'll find it very intriguing. I think it is very important, the effect that it can have on airshed, and I hope that the regulators will pick up on this.

The Meat

Nonetheless, we'll go ahead with the study. At the outset, we tried to design this project so that we could benefit from all that's been learned from the woodstoves - bantering back and forth with regulations since mid 1983. The good and the bad. To get right down to the meat of the issue here.

This is what came out of it. Generally, we wanted to come up with information that would be most beneficial in the regulatory arena so that regulations could be developed so that all stakeholders could be most fairly treated.

This research, indeed was not concocted to portray an industry point of view, as Rick can tell you from experience. I want you to remember that as we go through this. And then we have to, under that, determine what kinds of information we felt were homeowners burn - technicians chuck the logs in. There's only been a couple of studies in houses anyway, and the sampling systems have been different than what is now used. What I'm saying is that the literature is empty in this regard. There have been no studies, including to this day, of fireplaces, let alone masonry fireplaces.

So right now, there is data on masonry fireplaces in the field, but none has been obtained in the field on the zero clearance fireplaces.

So, we wanted to establish a baseline. The State Implementation Plans (SIPs) are the rage right now, trying to attain certain levels of emissions in areas of the United States that are out of attainment, particularly in the Northwest - areas like Klamath Falls or Medford or some other areas. The SIPs start with a baseline of what are the emissions now, how many stoves you've got and what are the emission factors as it now stands. Then they try to project into the future an attainment scenario and what they do is they take the number of stoves and reduce them - that's the simplest way. But what I'm saying, in essence, is that the baseline is the foundation for this.

Futuristic Scenario

Then, if you locate technologies that reduce emissions by some certain Rumford. But the Rumford backfired on us. It turned out not to be a Rumford in the strict sense or even close. In fact, we're considering that Rumford to be a conventional because it is so close. So we looked at one type of fireplace, the Rosin, as an example of the kind of technology that is out there already. You folks in the room know that the Rosin is not new, Professor Rosin did his research in 1939. So, its not new, but it doesn't have to be new to be good as far as I'm concerned. And I think our results show that.

Masonry Heaters

We also wanted to look at the masonry heater situation and we looked around to find some masonry heaters. We weren't entirely happy with what we got, although there's significance in what we found.

We looked at one, it was a Russian type of fireplace, I understand it was one of the first that that mason had built and that it may be typical of Russian fireplaces that were built some years ago, indeed that were built by local masons and that didn't have any consideration for some of the higher tech designs - I call them kits, but I may not be referring to them correctly.

The second one was to look at a contraflow which I understand is a common kit form, reproduced from house to house pretty much. So if we look at one, we have a decent representation of what might be around.

From some earlier lab testing at VPI the suggestion was that the contraflow would not be the cleanest out there, but that it would be pretty clean and perhaps would be competitive with woodstoves. The methodology that we used is one of basically four methodologies that are used to measure the emissions from woodstoves. The method is called the AWES - Automated Woodstove Emissions Sampler that has been used now for at least six years. It is used primarily in the field. It was developed for the field for we've also done some very extensive work with pellet stoves and so all of this data is related to one sampling system. It is very similar, by the way, to the famous EPA method 5 type of system which is, and you'll see more later, the reference method that EPA uses for woodstoves, called EPA method 5H.

Enough on the sampler.

"There had been some lab work at VPI which showed some extreme sensitivity. So we did these tests actually after VPI had gotten those extremely different results, and we did not find much sensitivity."

Testing Methodology

With that introduction, let's take a look at some of the testing methodology and them at what we found.

(slide) This is a little bit of our methodology right here. It's a cord of wood. We did use Douglas Fir throughout. The theme here is that we would have as many variables as possible under control, but that we would still let the homeowner run the fireplace exactly as they had. Indeed, we gave them no instructions whatsoever on how to operate the fireplaces.

We did hold control on the wood. It all came through OMINI and every single piece was measured for moisture because we did believe that there would be a sensitivity to moisture. We did study that. The wood was all sized to a reasonable size range. in fact a lot of it even came from one original pile. There was a lot of control over the wood.

All of the work was done here in the area so that we had this type of a climate, representing the Pacific Northwest from Seattle all the way down to Medford. That was very important to us because our clients were very interested in how things looked in the West as opposed to Ohio. I can speak of Ohio because I spent at least fifteen years there.

AWESome

evaluating the performance, originally, of woodstoves in houses.

(slide) Here it is. Here's your sample box, sample line, a probe that in the case of a fireplace goes up like so, about eight feet up so you're getting good mixing. We'll give you more on the sampling system later, but basically we're filtering out and capturing all the particulates and later weighing them.

Rear End Samples

As the sample comes out the rear end it now goes into a Tedlar bag that becomes filled with the clean gas, since it does not have any more particulates in it. It still of course has Oxygen, CO2 and carbon monoxide. We're interested here in looking at the carbon monoxide as it relates to the particulate.

The control for the whole system is over here. It looks like a standard computer and in fact it is, but we have inserted a couple of boards into it that make it work as a data logger. We take readings of oxygen and temperatures every five minutes while the stove is on over a one week period.

This system has been used since 1985 on all but one of the major woodstove projects that have taken place since then. There is a huge amount of data for comparison. The woodstove /fireplace competition is getting heavier every day and we need to know what the comparative data is going to show. Most recently

Moisture and Altitude

We'll take a look at some of the houses. (slide) This is a conventional fireplace. It was also used to measure the effect of moisture. We passed three loads of wood to this fellow. One was 20% - that's what everybody else was held to - then we handed him some 15% and some 24%.

(other slides)This guy's on top of a mountain, we looked at him because we wanted to study the effects of altitude. The problem with this guy is that he only burns on weekends, because that's the only time he's there, and he burns for a long time, around 7 hours compared to 3 or 4 for the average guy. Also, he just poured in the wood, so his quantity of wood was very high too. You should have seen the wood he had stacked up there.

(slide) Here we have a Rosin. In another house, the Zagelow house, we retrofitted a Rosin from Jerry and we can compare it with an original equipment Rosin installation.

Fuelling

We did two tests on this particular original equipment unit, one in which they burned this way, which the homeowners just kind of took to on their own. We let him burn for a week that way. Then we let him burn for a week with the wood different. He was told by (manufacturer) to build it kind of like a rail fence in there. We wanted to look at the sensitivity of stacking the wood.

(Question) Did you find much?

Skip: Again, hold on to your seat. (Laughter) No, not great. There had been some lab work at VPI which showed some extreme sensitivity. So we did these tests actually after VPI had gotten those extremely different results, way. I'd rather see grams per day, for instance, than grams per hour. Woodstove history kind of forced us to refer to it.

Some of the results.

First of all, what have we learned about how people burn

to a 5H. Well, we've got an EPA contract to kind of do this. Fundamentally we're dealing with an AWES and then simultaneously sampling with an EPA 5G tunnel. That effectively will establish the relationship between the method 5 and the AWES.

"In the 14 tests that we have conducted, and most of them were this year, there is a highly correlated relationship ..."

and we did not find much sensitivity.

Emission Factors

Let me talk about some terminology for a minute.

Emission Factors are, as John pointed out earlier, are across the land, except for woodstoves, portrayed as grams per kilogram. Grams of emissions per kilogram of fuel that's burned. And this is a very easy way to track emissions in a community, if you know how many cords of wood were burned. And that's not very hard information to get hold of, by the way. Then you can determine on an annual basis what the emissions were in that community.

But, woodstoves are based on a grams per hour, a rate. Implicit there when the regulations were originally set up was that this rate is representative of a continuous operating appliance. So grams per hour would be quite appropriate.

Grams per hour for a car, sitting in your garage, is not very appropriate, is it? The car is discontinuously operated.

I'm going to discuss this a little bit. Well, now we come to a woodburning device that is kind of like a car, that is not burned very often - the fireplace and the masonry heater. Now we come to a new term, the average daily grams per hour. That would be if you burned your fireplace for three or four hours - what would that look like as a grams per hour over the entire day? The only reason I do that is to compare back to the woodstove situation. I'd much rather not look at it that their appliances? The burn rate doesn't have a lot of variation. It goes from the low 2's to about 4 (kg/hr) with an average of around 3.3. That 3.3 is a whole lot lower that a lot of the lab tests and the in-home tests with technicians operating them referred to in the literature. Certainly not close to 5.

The hours in the burn. With the one exception of our high altitude friend at around 7, everbody else was at around 3.5 to 4 hours.

The number of loads per cycle is shown in green, here. Some variation,but not a lot, quite frankly. It averages around 4 loads, or close to one per hour.

The one that varies the most is the wood weight per load. It goes all the way from our high altitude friend at 14 lbs down to about 5. So there's a lot of variation here.

But we haven't so far seen a lot of variation in the other factors as you might expect.

Emissions

Let's get into the emissions. Like I said, there are four methods generally used historically and there are different reasons for the different methods. Nonetheless, the numbers that we give you here are AWES numbers and they are directly comparable to all field data that you could bring up woodstoves, pellet stoves, etc.

If you want to try and compare that data and reduce it down to the standard method, EPA 5H, you've got to go through a two step process. First you've got to go through 5G, which is a dilution tunnel and then you've got to take a 5G equation down

In the 14 tests that we have conducted, and most of them were this year, there is a highly correlated relationship and there is indeed a well defined slope. We can take some of our numbers and bring them over to 5H. We can't bring them all. Why can't we do that? Because. our comparison testing here does not go up to the grams per hour level that we are finding with fireplaces. You'll notice that it stops actually below thirty here. So with a conventional fireplace I can't give you a method 5number.

I can with a Rosin because it is that much cleaner. Take your Rosin numbers and take 20% off. Discount them by 20% and that will be your method 5 number.

The Numbers

O.K., let's take a look at some numbers. (slide) This is the good news/bad news that Rick talked about all on one slide (laughter). On the left side are the conventional units and on the right side are the Rosins. The grams per kilogram are shown in green here. I want to stress that there wasn't that much variation in the results. The coefficient of variation was 25%. I went back and looked at some of the studies that we had done with higher tech woodstoves in which we ran five groups of woodstoves that each had five in each group. I found that the average coefficient of variation was the same. So, this cannot be attacked on the basis of wildly highly variable results, indeed it is a highly respectable coefficient of variation.

For carbon monoxide the coefficient of variation was lower at about 14%.

The significance of the coefficient of variation is that you are trying to determine what's the plus or minus here? what's the error here? - It's commonly referred to as the 95% confidence level. Well, what is baseline data. I'm going to say it is somewhere over 20 and under 25 grams per kilogram.

<u>Rosin Numbers</u>

The Rosins are shown over here on the right. Now we're going to have both Rosins on a gram per kilogram basis. This is the established base of fireplaces. This has been the big job, because its easier to support with woodstoves. Getting those old stoves out of there is a lot tougher than getting rid of an old car, which wears out and is replaced by a new one with a catalytic converter. Figures I have seen show 10-12% max.

"... we can safely say that the (Rosin) average is 8.4 (grams per kilogram) which is really not bad. In terms of percent reduction it's about 60%. Existing technology that's out there is pretty good. "

it? It's dependent on two things: One is the sample size, which in this case is small - five. The second is the inherent variation.

Now, with a small sample size and a small inherent variation your 95% confidence limit is not that great. You small sample has been adequate to portray what is going on in a reasonable fashion. Your 95% confidence limit is plus or minus 8 grams.

If a regulator wants to go out and get more samples its because he wants to decrease that 8 milligram band. You must recognize that that will not just shrink down in direct proportion to the size of you eventual sample. Rather, it is proportional to the square root of the sample size. That means that you have to go out and really grind out a lot more samples in order to get a lot more precision. That is the reason why there often is a lot of value to small samples.

25 grams per kilogram is the upper limit of anything that the literature will show. AP42 is saying 14 - I suspect that the 25 grams, being a field value, if we were to relate it to 5H would probable ratchet down 10 - 15%. So I'll have to say somewhere between 20 and 25 grams per kilogram on a 5H basis. Nonetheless, it is going to be higher that we thought.

The grams per hour, accordingly, is going to be higher - around 83 or 84. So, I submit that this is going to be a reasonable estimate for a masonry fireplace for the Jerry's over here and this is the other one. They're both going to be about the same - about 9 to 10 grams per kilogram. Now we can take the 20% discount and we can safely say that the average is 8.4, which is really not bad. In terms of percent reduction its about 60%. Existing technology that's out there is pretty good.

Also, if you take a fairly hard look at the field results of woodstoves (of course, this is a can of worms) and try and compare conventional woodstoves with a baseline of 21 to 24 grams per hour with the field results for 1990 certified stoves, you find that the percent reduction is very similar. In fact I took the EPA's figures, and the Rosin had a reduction percentage hat was better that the catalytic stoves and not so good as the non-catalytic stoves. But, its a real can of worms. I've now studied a bunch of 1990 certified stoves out here in Klamath Falls and we found that they did considerably better than 60%.

Nonetheless, you're at leat already in the ballpark, in my opinion, with the technology that exists. And to boot, this can do it in a retrofit fashion, apparently just about as well.

If you take a look at a community like Reno or Fresno and you ask "what's it going to take, what can you do, to reduce emissions from fireplaces?". Well, we can go out and sell new fireplaces, but everyone that we sell we're going to add to the level of emissions in the air. What's the key? It's getting rid of replacement so far. Not denting the air shed very much so far. Other things have to be done.

I submit to you that fireplaces are going to be a lot harder to get rid of. They're not going to move. You have an advantage that the woodstoves don't have. They tried to develop a retrofit with catalysts but for various reasons it just did not work. But you have the opportunity to go into an airshed, and I think this is a big bargaining chip, and say that for every Rosin we sell we can reduce that house's emissions by 50% right of the bat.

And you can come up with your own calculations in a myriad of scenerios and they're going to show that you're going to have a positive effect on the airshed.

Indeed you could show, if you wanted to go to war with the the woodstoves, that this would be beneficial for a long period of time. Eventually, probably in about thirty years or so, you would cross over with the woodstoves. Anyway, I really just want to put this on the floor, put it in front of your face, the potential for you to clean up airsheds and to sell product. There's also the potential to improve the performance of this product if certain jurisdictions can't live with an 8 g/kg value. I think there is a fair amount of improvement possible for the product, given the state of the technology. We'll get into that later when we get into the lab.

CO Patterns

The CO patterns were very similar.

Wood Moisture

I've been drumming this one on regulators like Fred everytime I talk to them, I've been driving them crazy, about the effects of wood moisture. I was just so elated to see what he was showing me this morning (mandatory 20% moisture content for fuelwood in Washington state). Very forward types of approaches to wood moisture. You can only sell it at 20% or less or it has to have a big sign on it. I think that's a great idea.

(slide) Here's that one conventional fireplace with three moisture contents, 15%, 20% and 24%. Look how the emissions patterns look. Between 15 and 20% percent moisture there wasn't much difference at all around 20 -25 g/kg. With the moister fuel they went up to over 40. They wood we're buying is regularly over 30% moisture - we like it that way, because we can then dry it down to any level we want.

CO - same effect, not quite as pronounced.

So, we've been very high on controls on moisture on sales of wood. Studies on non-catalytic woodstoves have shown the same dramatic effect. In fact we've shown over a reasonable range of moisture a 3:1 ratio in emissions.

(audience discussion on feasibility of drying wood to 20%)

Skip: What we are talking about is indoor storage of wood.

Number Games

Skip: If I may indulge you a little bit, let's take a look at what happens if you take the same results and you just present them differently. Believe me, these results can be used so that we can show this, and someone else can show that. In the process, we'll take a look at some of the masonry heater results.

(discussion on different ways of presenting emissions results. Compare the two different charts shown below.)

My conclusion would be that we're starting right now, if you accept the Contraflow as a starting point, at better than, I'm convinced, at better than, the average Phase II woodstove, right now.

Emission Averaging

(question)

Skip: I've taken it one step further with the contraflow. I'm saying "wait a minute!". The contraflow is used to heat the house. The woodstove is used to heat the house. I'm saying, now we know that the efficiency of the contraflow is about the same as the woodstove. Therefore to get the same amount of heat, we're going to burn the same amount of fuel, whether that woodstove is burned for a whole day or just a spot, or whatever. We can now take it right down to a pound for pound of fuel, so we're really looking at grams per kilogram.

(question)

Skip: We only looked at one unit. However, we looked at it over a week. We had seven firings of it.

(question about variations in burn patterns)

Skip: Less than with woodstoves. Less than with fireplaces. The units that we're talking about here are loaded in this case with between 47 and 52 pounds of wood, every day, exactly the same. You're not dealing with a coal bed at various heights in the stove at varying temperatures. This is a pretty controlled kind of a situation. We're dealing with a pretty cold unit, same amount of wood, he lights off the wood, time temperature graphs show that he burns practically at the same time, he burns at the same peak temperature. Oxygen values are pretty much the same, as an indicator of combustion. So this is more controlled than any of the woodstoves. Its more approaching a pellet stove situation.

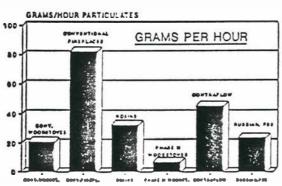
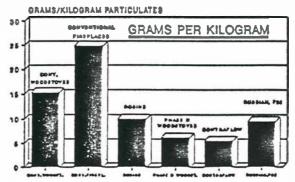


Figure 10

COMPARISON OF PARTICULATES; G/HR WOODSTOVES, FIREPLACES, MASONRY HEATERS

Conventional woodstows from EPA's AF-42 Phase & woodstows are finid average.

COMPARISON OF PARTICULATES; G/KG WOODSTOVES, FIREPLACES, MASONRY HEATERS



Conventional weadstows from EPA's AP-48 Phase N woodstoves are tipld average.

Figure 12

(question about if other units would compare)

Skip: I would say so, if they are built like this, and if the stack configuration is similar, and if we have probably the same instrument (laughter).

Tom Stroud: I just want to add that there is a bank of laboratory testing on basically will take care of some units. And if you can't do direct combustion air then we thought we had a test, a UL test, that would give us CO measurements that would give us some modicum of safety that turned out to be unworkable.

So. we're back to square one. We've got the health people telling us you have unacceptable that we're looking for is something less expensive.

I'm from the passive solar industry, and I'd like to see something completely passive. I'm not enamoured with putting mechanical devices into a house. But we need some options.

(comments from the audience)

"...we can't just stick our heads in the sand and pretend that there aren't any problems. Its kind of a neat opportunity, because Oregon isn't under the gun, but we need to take some steps."

the same unit so I'd say that this is pretty reliable stuff.

Norbert Senf: Plus, the contraflows that tend to get built I'd say were very very similar.

Indoor Air Quality

Skip: We've got some people here who are involved in Oregon's Building Codes. Peggy is going to talk about some of the recent changes and then Gary Curtis is going to talk about indoor air quality.

Gary Curtis: I'm Gary Curtis and I work with the Oregon Department of Energy. The reason that we're involved at all on this issue of indoor air quality is that we think there are very efficient ways of accomplishing ventilation. We'd like to reduce the random infilatration into buildings and then we'd like to have some kind of controllable ventilation system.

Some of the systems that are being proposed for use are negative pressure systems. They have passive slot vents in the walls or windows and then a central exhaust fan, so that the entire house is subjected to something like 7 pascals negative pressure. If we put a combustion appliance in that environment, there is a potential for backdrafting. Studies in Canada have shown that a 4 pascal negative pressure can backdraft some combustion equipment.

So, we're looking for help. We thought we had stumbled on an idea where we could say, OK, direct combustion air, and that levels of pollutants from combustion appliances in the living space, when you put negative pressure ventilation systems in, its going to get worse. You need to do something to make sure that the combustion byproducts don't get into the breathing air.

Well, the approach in Canada and the approach that the Bonneville Power Administration has used is to mandate sealed combustion - tight fitting dampers, tight fitting glass doors on fireplaces. We're looking for help. If there's something in between those, we'd really like some help on this. We haven't got an idea right now.

We have the health people coming and telling us you can't have these pollutants in your breathing air.

Norbert Senf: Why the hell would you want to depressurize the house?

Gary Curtis: It's an inexpensive ventilation system that gives you control of the fresh air rather than relying on random infiltration.

Norbert Senf: Why not go to air changers?

Gary Curtis: Dollars. I mean, I put an air-to-air heat exchangerinto my house, I think it is a very good option. It's what the Energy Department would like to push. Unfortunately, most builders aren't willing to cough up the dollars for it and its not something we're going to mandate in code. The options Gary Curtis: With forced air heated systems, that's exactly what they do. It ends up being slightly positive pressure or balanced ventilation. But with a zonal heated home, the expense of running ductwork to accomodate a distributed ventilation system - the general contractors are pretty resistant.

Walter Moberg: I do a lot of work with very large fireplaces where the makeup air requirements can be on the order of 1000 cfm. And generally speaking, the makeup air requirements for fireplaces in the code are not adequate. However it is possible to bring air into the room. Why not just provide a manually operated damper near the fireplace to bring in outside air?

Gary Curtis: The health professionals are telling us that it is unacceptable from their perspectve. The phrase they use is "aerodynamically decouple" the combustion equipment. That is, you don't want to be breathing the air that you are connecting to the combustion equipment.

Norbert Senf: And that's because you're depressurizing the house, right?

Gary Curtis: That's their general perspective and we're particularly concerned about it when we have a negative pressure inside the house. When we have a negative pressure it's going to be exacerbated.

Walter Moberg: That whole technology of specifying air into the firebox just because the Department of Energy says it has to be - that's still very much an infant technology. We're still working on specifying chimneys. We haven't really done our research yet on chimneys that go into fireplaces, and the codes are probably still pretty limited that way. They even had temperatures of 300 degrees in the intake air vents.

Gary Curtis: Can you get us some of that data? That would be

airtight glass doors will definitely cause a problem for masonry fireplaces that probably wouldn't meet a UL specification anyway. The code may even be inadequate now with two inch clearances behind it. On top that, imposing a lot of technology that is not thought through - glass doors, air intakes or whatever, changes it.

Gary Curtis: Right now we don't have tight glass doors

We're finding that with woodstoves that the new ones that are burning more cleanly are deteriorating a lot more rapidly than the old ones. Fundamentally, with a higher efficiency appliances you get higher combustion temperatures as well as longer flame paths and residence times in the stoves, so that you get all the fuel and all the air together at one time and get this effect laterally of sort of

"...the Good Sense program in Washington (requires tight glass doors on fireplaces). These things are premature. You're tinkering with a beast here without doing the research to make it all work." - Walter Moberg

really great to have.

Where we are is that we have the health people telling us there needs to be some change. We have the industry people like yourselves saying - that's not going to work, we think there's going to be some problems, and we even have some anecdotal evidence to show that there are problems with it. We're willing to look at some intermediate steps and then work at a longer term solution.

Like the lady from Puget Sound (Naydene Maykut) said, we can't just stick our heads in the sand and pretend that there aren't any problems. Its kind of a neat opportunity, because Oregon isn't under the gun, but we need to take some steps.

Walter Moberg: A lot of the systems that we use here are being used and have been for years in Scandinavia and other places where they do have negative pressure ventilation systems as well as heat exchange systems. They have learned ways to deal with it and for the most part it hasn't been direct combustion air solutions. Either diversion of the air, or makeup air, or a variety of other solutions.

The reason that we are avoiding direct combustion air in masonry fireplaces is that it bringing in cold outside air creates a problem in terms of combustion efficiency. Having proposed in our code.

Walter Moberg: Yeah, that's the Good Sense program in Washington. These things are premature. You're tinkering with a beast here without doing the research to make it all work.

Nobert Senf: I just got some information on the codes in Germany. Their requirement for the air supply in fireplaces is that the fireplace must be located in a room that has a window. (Laughter).

Skip: I kind of like that.

Tom Stroud: How about other forms of indoor air pollution, like formaldehyde? Are you dealing with that?

Gary Curtis: We're going to be dealing with that. Actually, ventilating the house is your last line of defense. The first thing you would do is source control, whether its radon or formaldehyde or whatever. Don't let it get into your building. But you're right, we need to take a more holistic approach. Ventilation is a last line of defence, and that is where we're starting.

Stressed Out

Skip: Something that's been ongoing and its going to continue is a stress test for woodstove. You might say "well, this doesn't mean anything to us." Well, I think it does. magnifying the actual temperature at that time.

The result of that is that you get stress on parts, and the result of that can be pretty significant. Tomorrow we're going to look at designing masonry heaters by transferring over the technology that we've learned in the woodstoves. We're going to look not only at the upside, but we're also going to have a look at a living example from our development of this stress testing procedure and what actually does happen. It can be pretty bad.

Its been going on for a long time with us. The idea is to give manufacturers a tool to pretest their units before they get out into the field so that they can develop a better product. Frankly, the sponsors are EPA and that type of group. If they find that the manufacturers don't embrace this and use it, then they're going to end up with a regulation and its just going to be the same thing as with cars. They go through a stressing period before the emission testing takes place.

OK that's the story on that one.

Stove Design

We all came down here to do emissions. We all figured that that's importand, and I'll have to agree with you.

There's really a two pronged attack here. One is to develop cleaner burning units. But, we have to have evaluations here of our iterations in design.

This is the problem that I went through for years trying to figure it out. About seven years, working with various manufacturers of woodstoves. When I worked for manufacturers as a consultant I was getting paid by the hour, so boy did they want fast turnaround time. In fact, we ended up with turnaround times of about an hour. That makes it

way or another to approximately room temperature and then they will all condense out and they will be what we call particulates. We understand that they are liquid droplet particulates by and large.

"You don't want to have to go down to a testing lab every time you want to test an iteration."

What do we really need?

Well, we needed some originality of design in the first place. But, frankly, it boils down to a very, I find, a very empirical situation. You're not randomly trying things, but you're coming closer to random than you would think.

Interactions

You are dealing with interactions of many variables, and when you change one you are affecting a lot of other variables. You are dealing almost fulltime with a multi-variable system. That's why it becomes really empirical - you just can't control the whole thing that well.

Since it's empirical, that means that you've got to do a lot of testing. You've got to be able to get an emissions number time after time after time.

If you're designing something, you've got to be able to get an emissions number kind of easy. You don't want to have to go down to a testing lab everytime you want to test an iteration.

Even on your own location you don't want to spend a lot of time and money to get a number. You're also not concerned with getting the exact precise number that a lab would anyway. So, we're going to allow some freedom here on the precision side, kind of back off that a little bit. And actually, you don't have to back off very much, apparently.

You need turnaround time. For instance, one method might take overnight because you have to dry a rinse of acetone out. That's unacceptable, unless you really like to work slow. kind of tough. It limits you in what you can do.

Window Shopping

OK, I'm going to talk about methods here. Because I think you're down here kind of window shopping methods. Hence I don't want to close out all the possibilities at the beginning, so its going to be kind of boring.

I've got four methods here, its kind of like four languages. I apologize up front, but I think you really have to dive in and take a look at them all and then choose one or two methods to take a closer look at.

I think we're in a position here at OMNI where we can make several methods availlable to you, even a complicated method, because we're very consistent in doing the required lab work (analyzing the samples).

So, without further ado, I'll launch into a discussion of the various methods.

What are we measuring?

We can measure particulates and CO. We went through this earlier, and I'm going to have to assume that we're going to measure particulates, because that's what the big boys require.

What are these particulates from our point of view? Fundamentally, the emissions that come from woodburning devices are at least 90 -95% condensible creosodic types of organics. Most of them have a condensation temperature above room temperature.

The idea in capturing them is to cool the stack gases down in one

They're not like dust, OK? If they were dust, they'd be easy to capture - just put a filter out there and suck the stack gases directly through the filter and we'd capture it all.

Not with this woodburning stuff - in order to catch it we have to cool it first.

Methods

Now we get into the methods. There are basically two methods. The easiest is to use a method of diluting the stack gases and cooling them as they are diluted. This process usually uses a 10 to 20 ratio of room air to stack gas by volume. This brings the temperature down pretty close to room air. The devices for doing this are called dilution tunnels.

Dilution Tunnels

They are actually tunnels of one form or another into which the smoke goes as well as makeup air from the room. You need at least 10 parts of air or the temperature stays too warm. The requirements, officially, for these methods are that the filter on which you are passing this diluted smoke must be below some certain temperature. Otherwise its too warm, you're cheating, and some portion of the smoke is passing through in the gaseous form. Its usually about 90 degrees to 130 degrees Fahrenheit.

Impingers

The other method, which I think is really an older approach, is to pass the gases through glassware which is sitting in an ice-bath and then bubble it through cold water. You basically get a water/organics mixture that has the color of apple juice and then later you will extract from that. These are called impingers, where the gases that are passing through are impinging on cold surfaces.

That's not exactly the way things happen in the atmosphere - the dilution tunnel is a lot closer to what actually happens.

The impingement method comes from EPA method 5, which is an older, standard method of analyzing stack gases.

The CO Question Again

Norbert Senf: Skip, could you expand on why we are ruling out CO?

Skip: CO does not have a very highly correlated relationship to particulates. The significance of that comes from the fact that particulates are the pollutants that are regulated for.

In order to bring CO up to the point where it violates the standard, you'd have to bring particulates up to around 2,000 micrograms per cubic meter. This, of course, has never been attained. There's probably only two or three days anywhere where you'd get over 500.

Norbert Senf: Perhaps I could rephrase that. Could you talk about using CO as a quick and dirty iteration tool to reduce your cycle of testing. I think what a lot of us are talking about is that there are basic things that we need to know and we can't really afford to get any fancier than is necessary to find these things out.

I know from following the German literature that that's what they do in Europe. They do a CO2/CO curve, and they think that's fine.

Skip: Over here they're regulating particulates.

Norbert Senf: But in terms of R&D - couldn't you use CO as a development tool?

Skip: Yeah, I've used it. Because it doesn't correlate that well. (Draws a chart of CO vs particulates) If you had data that fell very tightly together along a line we call that highly correlated. Then, you could use either CO to predict PM or PM to predict CO, if you had that very highly correlated relationship.

Walter Moberg: (Discussion about the differences in European appliances.)

Skip: If we had more data. We don't really have any data on masonry heaters.

Walter Moberg: Perhaps if we found that we had a good correlation then we could use CO?

Skip: That's right.

Norbert Senf: But you wouldn't expect one?

Skip: I wouldn't expect it because of all these different classes that we've looked at. The burden of proof would be to get data in order to demonstrate that.

But, I think that you could look at it in a couple of ways. (Draws on chart) The data is more like this, right? A looser relationship. Suppose you start with an appliance that up here is in PM and CO like that, and you make an improvement that, let's say, in reality is PM-wise only 50%. My statement was that you would not be able to see that level of improvement precisely and accurately with CO because there is just too much variation in the prior results.

But, if you have, in your design, developed something that is way over here in CO, then you could say that from the earlier work it could only mean that the PM is over here somewhere in this range.

If you can really improve the design of the appliance greatly, then your low CO values will have a prediction of a range where that whole range will itself be low in value. Maybe that's what you're getting at.

Norbert Senf: Yeah. And what I'm used to seeing there isn't even a CO number, but it's a CO chart, where you deduce things from the shape of the chart, the area under the curve, etc. - Compare one with the other and then you can say this one is better.

Skip: Actually, you can reduce CO data to grams per kilogram pretty easy, and I would recommend that you do that. If you got under ten grams per kilogram consistently, one would be hard pressed to argue with you that you had very high particulates, and I would say over 3 grams per kilogram.

An Example

Norbert Senf: I'll give you an example that pertains to masonry heaters. We feel that, particularly with the underfire air heaters such as the contraflow, that most of our emissions are happening during that five to seven minute start up phase. We need to know a lot more about what's going on in that particular area. When you look at the CO curve, its got a spike right there as well.

Rather than having a number at the end of a test, we could perhaps learn a lot of basic things by just looking at what happens during that firing cycle that the heater goes through consistently every time. And we need to know a lot about that cycle.

Skip: Yeah, I would agree that real time measurements are of value. Where you've got a cold start. By the time the thing gets going, its probable going to be <u>very</u> clean. Therefore you've got a real compression in your emissons here.

You have that with woodstoves too, but probably not quite to the degree that you guys do.

So I hope I've made it clear that for CO to be of value, you've got to have very low CO numbers before you could feel any comfort about the situation. But then, if you get to that point, and you subjected this heater to an official test, I think you would have a lot of comfort in that you could predict your particulate emissions to be correspondingly low.

So you've really got to drive it down. But I think there is value to CO for real time, too. Although, you can do particulates in real time as well.

Smoke Spot Test

George Akers(talks about his experience in development work (On the Meridian stove) using a smoke spot test).

Skip: I think on a real time basis, your comparative colors, densities, spots - as long as your temperature is cool - I don't know if that would be the case or not. I remember working with that kind of thing and - whoosh you can get high temperatures. So then you go to a long collection line and then you can get condensation along the line. You get into the typical problem of retrieving particulates.

I understand your problems, your dilemmas. So that's what we might be able to do in the line of particulates. Does this answer the CO question so far? It may well come up again.

Method 5 Generic

Skip (talking about EPA method 5): (drawing) There is, strictly, a method 5, generic, which I want to show you first and then I'll put on the little tailings, here, and make it a 5H.

O.K., there's a stack, you have a probe in it, sample line, standard fiberglass filter - its kept at 250F. The point is, its kept warm, in fact its deliberately kept warm so that our condensibles, our particulates, are going to cruise through it. In fact, if in the front here you're going to catch any particulates you'd catch them over here, and in fact a lot of method 5s even keep this hot. So, a true original method 5 is a lousy collector for what we're talking about.

Nonetheless, when the woodstove thing became an issue, EPA funded to modify method 5.

So how they modified it was to pass it through these glass impingers, usually 4 of them. They're all sitting in a bucket of ice. Finally it comes out the rear end and you put it through a filter. That's going to trap pretty much everything, but a good 50% of the catch is in the rear end. That's the 5H part. 5H is the reference method.

If you use 5H for certification, they'll just take that number straight, no questions asked. If you use any other method, you have to establish a correlation between that method and 5H - an equation that you use to get a 5H number.

Recall from this morning how we took the AWES number and changed it to a 5H. That's how we come to take the Rosin's number and changing it from 10.4 grams per kilogram to 8.4, 5H style.

Implicit in that, of course, is that the AWES doesn't collect the same exact amount of stuff coming out of a woodstove as 5H does. Its a different method - you don't expect it to be the same.

An Unbelievable <u>Method</u>

Well, I don't think you guys want to use that method - even our test lab here doesn't use it. It is cumbersome, this is just an unbelievable method. You've got to clean this, you've got to weigh that, you've got to clean this, and worst of all, you've got to rinse those impingers out with acetone. You've got to get everything into beakers and then, about 4 days later, they finally dry out. So the turnaround time is not good for you.

I have to fight for this all the time - methodology. Because the turnaround time, here, is lousy compared to what I used to get. So, this method is out. I'm showing it to you because it is the reference method and also because it is very similar to the AWES system. I take 5H, put a little tee in over here, take it down over here, and run it through some XAD and then into the bag. XAD is a resin that is used to trap all the organics - it absorbs them. It does the same thing as all this complicated stuff in 5H over here.

An Upgrade

No question about it, this is an upgrade. You still have to take

these resin beads out of here and run them through an extraction solution for no less than 24 hours. And then you've got a beaker full of water, acetone, and the organics. Then, that again takes four days to dry down. So my turnaround time with the AWES is basically no better than with 5H.

Why do we use the AWES? Because, believe me, it is more simple and foolproof than to add that (5H) on the rear end.

Very Reliable

The AWES is a method that is very reliable. It is really about as reliable as anything. It is not that complicated, but it is certainly more complicated than I like to see things. I think you can see that with the AWES your negative is that the laboratory has to process your filters, strip all of these lines out with acetone, and then we would send you a sampler complete with a resin filter system ready to go. You would sample, put it in the mail to us, and your results would take at least a week - one to two weeks. So I don't think this is of any value for design work at all.

Long Term Sampling in the Field

What it is of value for though, is that it is the only system, and it does a tremendous job of, long time sampling. Once you get it started, the computer takes over and there is zero effort on your part. For example, let's say you have a design or an idea that you think is pretty good. You want to take a longer look at it, in people's houses, you really want to know what it's going to do that's the only way to do it.

The expense is not prohibitive because we rent it out to you and you send it back - you don't have to buy it. This is probably the lowest first cost way to get into any of the particulate sampling systems.

The Condar Method -Extremely Simple

O.K. let's look at the next alternative. It is a method that I

developed when I was designing woodstoves for people and I went to some length to define the criteria that we needed - quick turnaround, etc. It did satisfy those criteria very well. Its gotten The only disadvantage that I've seen with this system is that when we get some of these non-catalytic stoves, aside from the heaters, that we get stack temperatures of 600 -700 after time and that are really dirty and that are contributing in a few minutes over 50% of the total particulate or even worse.

You have to work out your design then to minimize the

"I have to fight this all the time - methodology."

a misnomer, but it is called the Condar method, after the company that I was working with at the time.

We have one down in the lab that we'll work with later. It is an extremely simple system. It is a dilution tunnel, but of the following interesting type: you have sampling probe sticking about a half inch into the stack. The gases immediately enter a 6 inch diameter cylinder which is attached to the pump. There's a filter right here, and in the back of that a little more tunnel and then a motor. Then there's an exhaust.

Where's the dilution? The dilution comes from these holes that are drilled in the front face here. Twelve to twenty four holes. Twelve typically gives a 10:1 dilution and twenty four gives a 20:1 dilution. Most of the work you would do with masonry heaters you would definitely go with the twenty four holes. Fireplaces you could go either way - we generally use 24 holes now anyway.

OK, so what's happening here is that you're sampling about 5% of the stack gases, on average. You do it through this 3/8 inch orifice at the end of the sampling probe. The orifice is calibrated, and the motor is putting out a certain pressure around .1 inches of water. So, you're always sampling the same amount because you're keeping the pressure at the same level. You control the motor with a little variac control, here, and as the filter starts to clog up you have to run the motor harder to compensate.

Fundamentally, that's how the system runs. We're able to keep the temperature here at generally less than 90.

degrees and the dilution air is not sufficient to fundamentally cool it down enough. We actually get 90 degrees back here, but up front here we don't get good enough mixing so that there are hot spots on the filter. We have done it with a longer barrel and gotten it down that way.

Tom Stroud: Where do you sample from in the stack?

Skip: With this system, I've found it to be another disadvantage - more so with you than with fireplaces - is that you sample from the stack and have to be high enough up so that you have well mixed stack gases. With woodstoves everbody samples 8 feet up, and you just have to go through some single wall pipe. With heaters and fireplaces you've got to be at least ten feet, and then you've got this brick chimney, so you have to go right to the chimney top. Every hour or so, you're up there changing the filter.

Or, Norbert was talking about real time with the CO, you can go real time with PMs by just pulling the filters out any time you want. I used to do that a lot. Sometimes every three or four minutes at the beginning when the loading was heavy. Just pull those filters and weigh 'em and you can get the same kind of imformation on particulates as you can for CO.

This is really the only method that you can do that with particulates and it is a big advantage in developing stoves.

Critical Times in the Burn

We did find and you will find and you're relating to this already - that there are certain critical times in the burn that just keep repeating themselves time emissions over a very short part of the burn. If you start observing the burn, you sort of start seeing these patterns going on inside there that are associated with these high emissions.

What we didn't have that you would have now is good video recorders - they would be very helpful to you if you have glass doors. So there's a little more power now at your disposal.

This method used to take me about a day to make the complete installation, which is a lot shorter than the other systems, and then it ran very quick. Every half hour or hour you'd go up and change the filter. Pull the filter, it's ready to weigh. Only in rare conditions would that not be the case. You'd run down to your scientific balance - at \$2800, by the way weigh it right away and know how you're doing in your series.

We've developed a computer program that I've been using for years that reduces the data very quickly. You need to to know a few things, and you need to record about every five minutes. With most of these methods, other than the AWES, you do have to sit there and record data on a timely basis. Every five minutes for stack temperatures and either tracer gas or pitot measurements in order to determine what the flow is that's going up your stack.

You've got two flows here, don't you? You've got the flow coming in here (into the Condar), which is .4 cubic feet per minute the way it's built. Then you've got the flow in the tunnel. You need to know the ratio of the two flows to determine what percentage of the stack gases you're collecting. That can be tricky at the outset.

Avoiding the Bullet

You people, I think you're going to avoid the bullet in both cases, with fireplaces and with masonry heaters. Because the amount of gunk in the flue That's a distinct advantage that you guys are going to have not having to deal with (in a tracer gas system of velocity measurement) the chemistry of Skip: Yes, the equivalence was already established. The computer program calculates equivalent 5H numbers. Its been used to develop, interestingly

...you can go real time with PM's by just pulling the filters out anytime you want."

stream is pretty low. Its low for fieplaces because its pretty dilute, extremely dilute. With the masonry heaters I think you're dealing with clean burning. And, in both cases here you've got very high velocities going up the stack which you did not have with woodstoves. We would have used pitot tubes with woodstoves except for the clogging and the low velocities.

We did some work with Rick (Crooks, engineer at Mutual) here a few months ago with pitot tubes and there is no question, no question that we can measure the flow directly. That's real nice if you can do that because it relates right back real quick.

By the way, this is not a draft measurement. It is a measurement of the pressure that is generated by the flowing gases.

Norbert Senf: The velocity head?

Skip: The velocity head, as opposed to the static pressure. What we did was we measured the velocity head at the very top of the stack so that there was no static pressure left, and it's very easy to do that. But you can put the pitot tube anywhere inside there and just have the two ends come out at opposite ends of your manometer. You cannot use a standard draft manometer for this, though. You need one that is very sensitive.

More Good News

But the good news is, you can do this. We were burning Jerry's down there yesterday and we weren't getting .01, we were getting .025 out of his. Apparently its just a good drafting system, and also the flue he put in there was pretty small compared to the old flue we had. the oxygen, the CO2 and so on. However, if you use an AWES, that's just all done for you. We crossed that bridge so long ago that it's just automatically done and the computer spits out the answer.

So, you can do it either way and you guys have both options.

Beauty (eh?)

Now, one of the beauties of the design (of the Condar) is that we have this very short nozzle so that we don't collect a lot of gunk in there. We don't have to go in with acetone, strip it out, put it into a beaker and wait for a day.

Jerry Frisch: You can test every day with this, or every half day?

Skip: Innumerable times a day. As soon as you take the filters out of there you're ready to weigh 'em. The computer programs takes about 5 minutes to run, calculating averages of your data. Within 20 minutes you have a turnaround.

Official Method in Oregon

(Question about official recognition of these methods)

Skip: It was approved. It is an official method, in the state of Oregon. What it is not, like the AWES is not, is an official EPA method. It's not a method 5. There are some of us - well, it was political there. But, it was approved by Oregon. Its called a method 41 in Oregon.

(Question about equivalence with method 5).

The Cleanest Burning Stoves enough, the very cleanest burning woodstoves - have all come through this method of evaluation. And the reason is that it is extremely fast and extremely reliable.

All the other techniques, as used on location by manufacturers, have proved to be slippery. They're too scientific, too technical, too fidgety. So, they've been a problem, but this one is not. We used to take this one and take it around to 5H locations and got the same relationship between this one and 5H. You can't do that with a dilution tunnel. You probably can't even do it with 5H and 5H. Anyway, that's that method and we'll look at it tomorrow. When we're in the lab we can look at some of the finer points.

Three Choices

If you're going to measure particulates, I think you've got three choices. You can use the Condar method. You can use the AWES, but I think I've already outlined its limitations on a day to day basis, so that's out.

So actually if you're going to measure particulates you're down to two techniques, and if you combined the two of them you'd have it really exact. The last one, which is a viable candidate, is a dilution tunnel, a permanent, large, dilution tunnel like we use downstairs for certification.

(draws) Stove, stack, big collection hood, tunnel down here to a motor which spits it out, and then, here, you place your nozzle for sampling and then you have your filters.

The worst part about this system is the filters. The EPA, they're just so scientific and everything that this is traditonal glassware that lab technicians who are highly trained can work with, but it has no practicality outside of those people. That I think has been the main problem that you have and ratio it - ratchet it right on up.

In a Nutshell In a nutshell that's what that Yet, if you're testing fireplaces or probably masonry heaters, you're going to need a tunnel diameter that's larger than the 8 inches used for woodstoves. Your flow is at least ten times higher

"All the other techniques, as used on location by manufacturers, have proved to be slippery. They're too scientific, too technical, too fidgety."

in the use of this by manufacturers. Its the control of this sampling system right down here (points). You of course have to go through a motor, a bunch of flow gauges and all that kind of stuff, and this is where the whole thing bogs down.

Absolute Best

To cut through to the very bottom line, and I'll backfill a little bit later, the absolute best system that you could have on a location that would take everything into consideration would be to build one of these tunnels and then use one of these Condar samplers down here to sample the stuff. Because these will give you the instantaneous turnaround and they will work all the time and you don't have to fool around with flow rates or anything like that. So that's your bottom line. There's your best system right there. Its not super cheap.

Jerry Frisch: You said the minimum was eight feet away. Is there a maximum?

Skip: There is no maximum. But you do get wall cling. Static cling, right?

Jerry Frisch: I was hoping for that (laughter).

Skip: It isn't too much. These guys claim that they have taken that whole thing apart after a sample, stripped it down with acetone, and there's only 5% that caught. That's not worth worrying about. I would have thought more, but that's what they say.

No matter what method you use, you're going to be using a pitot tube to measure your flow in the stack and/or in the tunnel. The calculation then is very simple. Take the particulate catch system is. I think the big advantage of this is that you can pretty much wheel underneath here anything that you want. It does however give you a grams per hour output, but its not hard to come back and get grams per kilogram. But it is interesting that methods like the Condar, and 5H actually, give you a reading that's the grams per kilogram output and this gives you a grams per hour. You can convert to the other mode of expression in both of these, its not a big problem.

But the big advantage of this is - somebody down in California was talking about barbeques, a big issue, its new, which wasn't even thought about when we were first doing this. You can just roll a barbeque up to this thing, and away you go.

Jerry Frisch: Do I see double dilution here?

Skip: You block off the holes on the Condar.

You require about a 20 ft. ceiling in the building.

Jerry: The dilution is automatic, I assume. Or is it not regulated?

The Subtleties of it All

Skip: It is fundamentally non regulated, you're right. And in fact the dilution will change over the period of a burn. But, in the subtleties of it all, you can get a little bit better average emissions number if you sample in this type of dilution tunnel than any system. The so called proportional flow problem is overcome here. What you're doing is setting the whole thing up based on the empirical work of others before you as to what kind of a flow you need here in order to obtain a dilution that's reasonable.

in a fireplace because of the dilution that's going on inside the combustion device. You have to go to 12 inches.

The cost of setting up a dilution tunnel if you did it yourself appears to be somewhere around \$1000. The Condar sampler is around \$1000 -1200. Its in very limited production now and is very hard to get hold of. The laboratory balance is \$2800 and is needed for both.

Norbert Senf: and CO?

Skip: My feeling is that we ourselves are not in intimate touch with instruments that are of the type that could satisfy your needs of doing an adequate, but not laboratory quality, job and at low cost. Those instruments that we know about tend to be in the \$4000 -10,000 range. A gentleman came through here with a small one that was \$1000, but I don't think you're going to come across anything that reliable for \$1000 that'll give real-time.

This thousand dollar one here has failed us continuously, and that has been our problem with low cost instruments - failure and loss of calibration or ability to calibrate. You're putting it through a pretty tough test here. You can't just put a tube in a stack and measure CO, because these gases are so dirty that you're going to clog the cells. You've got to set yourself up basically with a little method 5 impinger system in order to get the organics out.

The Next Day

(The classroom session was officially over, but before descending into the lab, some more discussion:)Skip : (commenting on the research that Naydene Maykut of PSAPCA quoted to back up her calculation of woodstove emissions):...I come away from all of that not(Commenting on a study looking at oil furnaces and woodstoves, among others): ...and it also looks at that one has to cross. And, not very much has been done. (Editors note: It is of interest that the Austrian stovemasons guild

"But I have looked at some the stuff that Naydene quotes. It's appropriate to check the strength of it. Jo-Ellen Lewtaswhom she quotes, her work was largely done in the early 80's, she's done some follow up, but, it was never intended to have legislation like that based on it."

knowing in any kind of a quantifiable way what the significance of the solution is.

There may be research that's out there, I haven't really pursued it hard. But I have looked at some the stuff that Naydene quotes. It's appropriate to check the strength of it. Jo-Ellen Ludis whom she quotes, her work was largely done in the early 80's, she's done some follow up, but, it was never intended to have legislation like that based on it. I mean, she took one woodstove, and it was this Jonhson Converter thing which, ah, was never really a factor in the market. More importantly, I don't think it represented a clone of anything that was common on the market, like the Fisher stove. It just didn't. I never saw one. It was a rare and fundamentally unusual beast. And, the way they were burning stoves in the lab then, it was much worse than the way they're burning them in the lab today, so that the degree to which it represents pollution coming from what's out there is questionable.

You can look at it from the point of view of counting the number of stoves, multiplying them by a reasonable emission factors (drawing on the chalkboard) you get up the the ridges - is it still 50% woodstoves? The pollution is very very much lower up there anyway. I can't answer that question.

In Ohio - what is the percentage? It really may not matter in most of Ohio, except when they burn the fields, you get excessive pollution. mutagenicity using one of these bacterial tests. It looked at the ratios there. Mutagenicity was somewhere around 10 to 30 times higher in a woodstove that in these oil furnaces.

Then he looked at a new retention head (a type of burner) and he also looked at one that was detuned. Some of us I guess have had some experience with oil burners - out of the totality of oil burners, most of them are relatively detuned as they are operated, and they are only fixed if something really dramatic happens - a belt breaks or something like that. But he claimed that there wasn't that much higher emissions, and most of the emissions from oil furnaces are oil, unburned oil. Not intermediate unburned by-products like you get with a woodstove.

Toxics

... One is particulates, and that's been around for a long time. And the second on is the one that is flanking us. And that is the toxics.

The EPA is approaching pollution from the burning process in two steps. First of all is particulates, and they are very active in particulates now with all of these State Implementation Plans and so on. And EPA regulations for woodstoves are all in response to particulates, you'll notice.

Austrian PAH Study

They have, however, listed 179 toxic compounds, right? Jim flashed that up real quick. That's the next phase, or the next hurdle commissioned the Austrian government testing lab to do a comparison study of PAH emissions from an Einsatzofen and a Grundofen in 1985. Heinz Flurer from Biofire made this report available to MHA members a few years ago. To quote the summary of the report (and not necessarily in context): "The content of unburned hydrocarbons in the exhaust of the Kachelgrundofen fired with Beech and Birch was under 100 mg/Nm3 (milligrams per normalized cubic meter). Particularly low is the proportion of PAH's under optimum burn conditions at 20 micrograms/Nm3.")

New Klamath Falls PAH Study

The PAH's, or polycyclic aromatic hydrocarbons have only been looked at in the field in pellet stoves. That's all.

As she left yesterday, Naydene said "I am putting in for approval for the project that we talked about for the study of PAH's in various types of woodstoves, this winter, down in Klamath Falls." (I think I've indicated that we're going to be down there studying woodstoves.)

We have recorded pellet stoves running for over a week on numerous occassions at around .33 (g/hr). That's good combustion. So, really, a lot of what was said yesterday is flying in the face of what's happening out there right now.

You can't really expect to get much below that because of that cushion of ash, right? And when you <u>are</u> there, you're taking the organics pretty much out of the picture.

Tom Stroud: So that takes out the PAH's right?

Skip: Yeah, that's right. (draws) If you draw a little sort of straddle (the Austrian numbers).

So, you're probably down around one milligram per kilogram, or a thousand micrograms. Pellets, the good pellets. were running better, but not that much better. If you guys were just in the fireplace business, I'd say you're still going to be broadsided by the toxics, and there isn't much hope. You just don't know how bad the storm is going to be. With your masonry heaters I think that is a different story.

"But we must reiterate again that these guys have pretty much disposed of their nasty organics and it is your responsibility to get the organic fraction down. Because as long as you have this, you're vulnerable to the next wave of EPA attack. "

graph, you all should be down in the .5 range down there, and that pretty much wipes it out.

And now, I'll go through this pellet report (OMNI has done two major pellet stove studies: Bonneville power administration:In-Home performance of Certified Pellet Stoves in Medford and Klamath Falls, Oregon prepared for: US Department of Energy and The Oregon D.E.Q. July 18, 1990 PS407-02 and In-Home performance of Exempt Pellet stoves in Medford, Oregon) and you'll see that we pretty much have done that.

But we must reiterate again that these guys have pretty much disposed of their nasty organics and it is your responsibility to get the organic fraction down. Because as long as you have this, you're vulnerable to the next wave of EPA attack.

(Tom Stroud hands Skip a translated copy of the Austrian report)All right! O.K., these are both (the Austrian report and the pellet report) in micrograms per cubic meter. I'll add them up real quickly (in the pellet report) and I think it comes to around 60 or 70, which is higher than your values. This is a Whitfield pellet stove. I have to refer back to what the particulates were, but they're pretty good. Not the best. Then we had another one called a Crossfire here and that thing is running less than 10 micrograms per cubic meter. So it looks like the two pellet stoves that we did

Mike Homchick: How does that relate to grams of PM10?

Skip: Well, we don't know whether there is a ratio between PAH's and particulates, but we suspect there is, and we think that the PAH's are somewhere around .2% of PM. From our limited data set so far.

So the pellets are running around 75 micrograms, and I'm estimating yours at around a thousand. I wouldn't be overly alarmed at that, because we had this Whitfield that was over a thousand. We don't know why we have the variation that we have with the pellet stoves.

Super Low Numbers

But believe me, those numbers compared to any woodstove work that's been done in the laboratory, they're super low. So it may be, it just may be, that as you get down close to this limit down here that you're differentially getting rid of these PAH's. Which would be really wonderful, wouldn't it?

They are some of the longer chain molecules, and they tend to break up first. So my recommendation to you would be to try and get into this safe haven down here, and I think that it's possible.

OK, I hope I put some perspective here and gave you some encouragement, I would think a lot of encouragement, that you can do it.

Broadsided by the Toxics I also think back to the woodstove folks. I think they're vulnerable. Your competition, they're vulnerable. Where they are 4 grams, 6 grams per hour particulates. We'll know after Naydene project maybe.

Mike Homchick: With fireplaces everything is normally measured with the doors open?

Skip: Yeah, there's nothing really normal about it yet.

Mike Homchick: If you close the doors, then you've got the same kind of control as any of these stoves. If you don't close the doors then you don't have any kind of control at all.

Skip: Your sole link to the metal side is the doors. The rest is masonry.

Tom Stroud: Mutual, you know, is really quite excited about it - let's talk about it, we've got to do something about it, we're going to get hit with it.

Two years ago they were saying it would never happen and dismissed it. Maybe a little bit of money came out of it. A couple of people probably thought there was some reality to it.

Walter Moberg: You know that for years we (WHERF - The Wood Heating Education and Research Foundation) have been pursuing the Brick Institute to develop a training program for masons for constructing masonry fireplaces. Finally, now, the president of the Brick Institute and the staff is well behind it and the board has voted money for 1992 to do that, and its a substantial amount of money that's going to go into a training program.

Now, we're not necessarily going to be improving the science here dramatically but I would say that much of the reason that they saw to go ahead critical gases oxygen, CO and CO2 down in the lab. And, there is a tendency to get in there and want to make that moment by moment tune on it.

Hear Me Now, Believe Me Later Walter Moberg: I realize that we're down here to find an emission testing method that is appropriate to check on the work that you and we are doing. To do that and to log the data I think is important.

But, I'm not aware of the

"So, you're probably down around one milligram per kilogram, or a thousand micrograms. Pellets, the good pellets. were running better, but not that much better."

with it was not that they see a great market for training masons. God knows they don't think that masons like them even that much. But I think that they see a need to try to respond to the problems that are facing the fireplace industry right now. And to produce a better image for masonry fireplaces and in turn for masonry and to try and protect themselves as well.

And that represents a dramatic change, from here to here on a scale of ten its still dramatic over a period of four years. So I really think that there will be opportunities to garner some of the support of the masonry industry.

Skip: Yeah I really hope the tide is beginning to shift a little and there is some reassurance in developers' minds and interest in pursuing this instead of backing out. Perhaps this group here is an appropriate group to start to work with them. Now, they're going to understand his (John Crouch's) position - putting in a lot of effort on your behalf, maybe going down and arguing enough points to get something to happen with some regulators and find out the fireplace industry, like in California, has decided that they don't want to build fireplaces anymore.

O.K., did you talk, think about any more on the emissions issue your measuring emissions. Are there any more thoughts on that yet? I'll understand if there are not.

(Question)

Skip: Yeah, you will see a continuous readout on the three But, you will learn from your experience - unless you can believe us now (laughs)- that an oil furnace or a gas furnace, you've got a constant rate of feed of fuel and the fuel itself chemically is not going to change at all. You can go in there and you can change the air coming in, for instance, the air/fuel ratio, you can read it all out and that's what allows the furnace technician who comes to your house to tune your furnace up well, inside of half an hour or so.

If this woodburning thing were like that we would have licked all of these things long ago. The woodburning process is so incredibly dynamic - things are changing inside that firebox, your fuel is changing so rapidly that people who have taken detailed looks at this - its amazing.

I used to do this a lot, and I still do this with catalytic stoves a little bit, to change the air and watch the temperature a little bit. What I found is, that if I do something like that, then the change more often than not is reflecting a change in the fuel bed that is changing dynamically the whole system is changing such that I get misled, that's what it boils down to. In fact, this has gone so far, that in developing a woodstove, you make one change and you run, not one test, but two complete tests - in a masonry heater this would be two two-hour tests, the second to verify. Then, that little bit of tuning is effective on its own.

...

Masonry Heater Association having developed a real specified inventory of products and designs. And, for masonry heaters perhaps even more so than with woodstoves, where our burning environments are so long not just in time but in the fireox and channels and in the system and all the different constructions that all the different heater masons do here - It seems like it would be useful for us to put together a fairly large inventory of either existing models or existing installed versions and come up with significant parameters and see if there is some consistency about the kinds of emissions that we get with different kinds of units.

And, right now, we have some of that, because you have measured and catalolgued the two heaters done so far fairly well. But I'm not sure that we have a consistent format for that. I'm a little concerned that we're putting the cart before the horse here in doing emissions and studying our product without really knowing what the product is. I mean, let's really identify the product and then change it and change it in a direction that we can relate to compared to a starting point. What do you think about that?

Skip: Well, yes, I really agree with that. Just looking at it from a standoffish point, there are I don't know how many, but there are a number of different forms of heaters out there.

We have no clue. Or not much of a clue, really, as to how they all perform relative to one another. And hence, like what you're saying, what design factors are most beneficial to this?

Reinventing the Wheel

A whole lot of time could be wasted reinventing the wheel if think are important and we can focus on those. They might be firebox size, firebox volume, chimney pressure and...who knows?

There are things that we can identify as priorities and we should try and catalog them. Efficiency - Some Pellet Stoves are Very Low (The discussion turns to efficiency) Skip: Some pellet stoves we

"Yeah I really hope the tide is beginning to shift a little and there is some reassurance in developers' minds, and interest in pursuing this instead of backing out. Perhaps this group here is an appropriate group to start to work with them. Now, they're going to understand his (John Crouch's) position - putting in a lot of effort on your behalf, maybe going down and arguing enough points to get something to happen with some regulators - and find out the fireplace industry, like in California, has decided that they don't want to build fireplaces anymore.

you start off with the limited knowledge that you have now.

(other comments)

Walter Moberg: ...Put together a catalogue of dimensions and information about the different models and try to track the testing and the development of these products in relation to their defined attributes.

Nobert Senf: But along with identifying the different heater types, we have to figure out what the parameters are that we need to study. To do that, we need an easy testing method that will yield some useful data. For example, we need to know some very simple things, like is there a difference between softwood and hardwood, underfire and overfire air, etc.

In a sense that's an extension of the inventory idea, because those are the lines that some of the heaters differentiate on - firebox size, flue length, etc. If you can vary that with one model and see if there is a difference it would also help you to select the appropriate classes for the inventory. What are the parameters you want to use?

Walter Moberg: Well, we can't identify everything, and we probably already have some clues in terms of things that we Skip: Your situation is very similar to the woodstove situation in 1980-82, where the American stoves had made no attempt whatsoever at clean burning, but the Europeans had made some form of attempt and a lot of the stoves that were sold in the U.S. at that time were European. First, to fill the production gap but then as candidates when the emissions issue became bigger - for the long haul.

So, quickly, we evaluated the emissions of these one by one and in this case the results were that none of them were adequate. So I think that, probably, this is where the story changes here there'll be one or more that will turn out to be quite adequate. And with some tuning, very adequate.

But I think the approach of screening what's out there is really important. And to relate it to your dimensions and so on, however you want to screen them.

(Some more comments)

Skip: O.K., that specific issue, with the D.E.Q. in the early days - basically it was rejected in that form of expression. Indeed, the regulatory process does at least consider not only the emissions factor, but also the efficiency. tested had air to fuel ratios approaching 100:1. Doesn't that suggest to you that maybe they're bringing in a lot of outside air and heating it up? Well, it turned out that we found a couple of pellet stoves that were pretty low on efficiency.

As a result, I've already heard that Jim King of the Colorado Health Department has already issued a proclamation that they're not going to allow exempt pellet stoves to be sold in certain jurisdictions as a viable product because the efficiency is so low. So, its starting to come back into fashion.

Efficiency Paydirt

We got the ear - I've been pushing on this efficiency for so long - we got paid zero dollars for doing the efficiency on our projects, but I did it anyway. Because I knew it would come back - remember how it was a big thing in the 70's?

We finally hit the paydirt here in 1991. But I think its going to stay. I would not discourage you.

(Comment from George Akers)

Skip: So you see, we don't get into pollutant per joule or anything or something - they go "what the hell does that mean?" But you say - here's the grams per kilogram and, by the way, here's the efficiency.

Walter Moberg: I saw some results on five channel contraflows from Sweden where they had measured efficiencies of 70%. Now you see woodstoves best - and then they go down from there.

(Ouestion)

We're looking at the last thing that happens in the system, after all the interactions with the middleman. And I'll talk about Skip: We have some nice tricks that you can use to really crank that efficiency up - force yourself up against that condensation wall, which is typical.

The efficiency that I'm going to talk about here is the net overall

"As a result,... Jim King of the Colorado Health Department has already issued a proclamation that they're not going to allow exempt pellet stoves to be sold in certain jurisdictions as a viable product because the efficiency is so low."

that are measuring up to 85%. It may be that we are dumping more heat up our flues and lowering efficiency even though we are burning clean. Maybe a pollutant per joule factor would be better for us?

Skip: Really, you don't have anything to compare against when you're talking to the regulators. Its all foreign to them.

"Efficiency Hits Roof!" - Marketing Dep't

You brought up a point though that's valid and it's sad. Namely, that all possible claims to efficiency have already been made - the escalation of efficiency claims. Some years ago, it hit the top of the roof! And you're hearing, yes, over 80% on a number of things that are being advertised. Particularly with these pellet stoves. Right? Well, that's just not the case.

The theoretical maximum on some of these is just about 80. Theoretical maximum. If everything is working real well. You've got air/fuel ratio that is reasonable. We're going to look at this in a minute, because that pertains to you people here.

And reasonable air to fuel ratios are usually not attained in pellet stoves. They're usually too dilute. They can never get to the theoretical maximum. So the best that we saw was about 74% That one's off the market. Some claim that it was too concentrated, you got condensation in the flue. Sixties is where we're finding most of the pellet stoves that are efficiency in a minute. (BREAK)

Skip introduces Patti McCarthy from Technical Glass Products, who gave us a very useful presentation on catalysts and on possible approaches to applying them in a fireplace. Also, an interesting discussion on ceramic glass.

...

At this point, the group convened in the lab for a tour.

Jerry Frisch had brought down a Firecrest Rosin unit and set it up underneath one of the exhaust hoods. Unfortunately, the pipe on the hood was too small and we couldn't do any serious burning without smoke spillage from the collection hood into the lab.

In another corner, Jerry and Stan Homola had spent a previous Saturday building a masonry fireplace and chimney that duplicated the dimensions of one of the field testing sites. It was instrumented with an AWES and with gas analyzers and a test firing was underway.

We spent a couple of hours of hands on lab time, and while waitng for the fireplace test to complete, reconvened upstairs for some more discussion on questions that were raised.

We rejoin the efficiency discussion partway through:

Efficiency Tricks of the Trade

efficiency. That's one way to phrase it. Sometimes its called the thermal efficiency, although that's a little confusing.

We're talking about, if you're burning a pound of wood in there, how much of that energy do you actually get into that living space. The net delivered efficiency is another way to put it.

It is a function of two things, and only two things. One is how efficiently did you combust the wood in the first place. What percentage of the chemical energy that's locked up in that piece of wood was released as heat energy? That's the combustion efficiency.

Then, the second major area to look at is: Once you've combusted the wood and produced x amount of heat, what percentage of that heat that you produced, is then released into the living space? That's called heat transfer efficiency. You've got the two of them, combustion and heat transfer.

Let's Look at Combustion

Let's look at combustion just a little bit here. You've got chemical energy that you're converting. Would it not stand to reason that you could measure the combustion efficiency if you could measure how much uncombusted material is left over?

I'll give you a perfect example: Carbon monoxide, we know, is left over. We've been thinking of it as a pollutant, Jim Houck was talking about it as partially combusted byproducts. Really, you can burn that CO that's left over. Therefore you can prove to yourself that there's energy left over in there. In fact, its very easy to measure the amount of energy in CO. Just know how much there is and go to a The heat of vaporization. And, indeed, with wood that usually accounts for 8 - 12% (of the energy is used in boiling water).

That means already that you're not going to get 100% efficiency out of this system. In the case of wood, that 8 -12% also includes fireplace there is going up as smoke. The smoke is your energy. And the carbon monoxide is also your energy.

As you get up into the pellet stoves you're coming very close to 100% right now. Some of the masonry heaters are probably

"...all possible claims to efficiency have already been made ..."

chemical tabel and it'll tell you the amount of energy per amount of CO, no problems at all.

All right, you can take the CO that's left over and you can take all these ugly hydrocarbons that are left over and find out how much energy is left in all of them. Then, you've got the amount that wasn't burned.

Holy Grail #1

A good masonry heater is probably combusting at an efficiency in excess of 95%. That's pretty good. Your goal of course is to get close to a hundred, right? If you get rid of all those hydrocarbons and the CO, you're going to be approaching 100%.

(Question) Non-cats? Probably around 90, because they're not too good on the old carbon monoxide in the latter part of the burn.

Most of the energy that's not burned is in the CO. So, we're down there measuring CO for yet another reason: to determine the combustion efficiency. Also, we're using the particulate measurement as an indicator of the amount of hydrocarbons that are left uncombusted.

Pretty simple, fundamentally, but I think you'll find that it's not simple, in fact it's hard, to go in there and measure every single little bit of hydrocarbon that's unburned.

Making Water From Wood

(Question) The wood gas has a lot of hydrogen in it, and in fact what you are doing is producing and boiling water. And it takes a lot of energy to boil water, right? the moisture that's in the wood. There's roughly about half as much energy in the moisture boiling as there is in the chemical production and boiling of water. When you put the two of them together, you've got yourself about 10 or 12 per cent of energy that you just cannot retrieve again. Unless you do one thing. And that is go up there and condense all the water back in the pipe, which is of course the principle of the natural gas condensing furnace. So far we haven't been able to do that so good because you not only condense the water but you also condense all kinds of hydrocarbons, and you produce a mess in the process.

So, combustion efficiency is the first part of it, and its obviously very important. We're very acutely aware of combustion efficiency because of the emissions it produces when combustion efficiency is not that good.

(Question)No. In the technical sense, we sort of take out that boiling water. Its a physical phenomenon in the heat transfer category. OK? We're saying for combustion efficiency, as we express it.

(Question) We're saying that, although its almost instantaneous, combustion occurs first, and then you have to boil it. Therefore, we're taking that energy loss in the heat transfer category.

Smoke is Energy

The efficiencies would vary from a fireplace or a conventional woodstove at about 25 grams per kilogram, in the 70 to 75% range. Literally more than 25% of the energy in that very close to 100%.

In fact for the discussion of masonry heaters in about a minute, I'm going to assume that the combustion efficiency is essentially 100%. And that's really what you're dealing with in terms of the overall efficiency of your unit, is really forgetting about the combustion efficiency because it's so close to 100, and taking a look at the heat transfer. There's where you can make big gains and big losses. And we talked about the pellet stoves that were doing so lousy with their heat transfer efficiency entirely, nothing to do with combustion efficiency.

Heat Transfer Efficiency - The Name of the Game

We should look at the heat transfer efficiency then, right away. OK, so there's about 10 percent or so that's immediately lost due to the vaporization of the water. So let's just set that aside. Its unretrievable energy.

The 80% Pipe Dream

So that already puts the ceiling on the efficiency of your unit at around 88%. You're going to see that there are additional ceilings that come into play that are going to take you down a bit lower and put the overall ceiling at around 80%. That's about as far as you're ever going to go. And, as I said yesterday, claims of over 80 are fallacious, based on nothing sound, not possible, unless there condensing and somehow getting that water back into the house (laughs).

OK, let's see if I can relate this heat transfer business to you. You've got a fireplace going down there right now. You've combusted all that energy, and a lot of it is going up the stack. Not all of it, but a lot of it.

Could you envision that the perfect heat transfer efficiency

Let's do it

(Question about dilution air) Skip: It's time to do it. Let's pass these around.

"I submit to you that when you get designing for efficiency, dilution air is going to be far more important than stack temperature."

would be such that by the time the stack gases left the living space the exit temperature was room temperature? You would have extracted all the heat from the fire, wouldn't you? So then, you're closing in on 100% heat transfer (setting aside the boiling water). So your stack temperature is 70 degrees.

So, what's the practical limit for stack temperature? Well, its based on a couple of things. One of them is condensation. Norbert up there in Canada is going to run into it before you will down south here. A couple of hundred degrees is about it. You get below that and its going to start condensing.

Then, also, the stack temperature is what generates draft, too, isn't it? Again, you end up with about 200 degrees.

This, then, obviously is going to put another, lower, ceiling on what your efficiency can be. Between that and the water you end up with about 80% efficiency being max.

Maxed Out

That's it. And I spent a lot of time designing the most efficient stove I possibly ever could, considering all these variables here. And we did run it under real good measurement for efficiency. A calorimeter house.

You've heard of a calorimeter room? Well this was a calorimeter house. We had two of them going. One year we hit 78% and one year we hit 76. And that's as high as you're gonna go. In fact I haven't seen anything commercial in the catalytic stove area that's come over 70, 71, something like that. What Jim is saying - OK, you've discussed stack temperature, but dilution air is also important.

I submit to you that when you get designing for efficiency, dilution air is going to be far more important than stack temperature. Because stack temperature you can sort of dial in to a relatively narrow limit, but dilution air you have a lot more possibilities. And a lot more effect on the outcome.

Let's see if we can envision it, what dilution air can do. We have a fireplace going downstairs, and its effective stack temperature is about 250 degrees as you all saw on the computer. OK, so that's a pretty low temperature. Yet, this thing is not efficient at all. So, temperature is not the whole story, its part of the story in heat transfer.

Why isn't this thing more efficient? Because it's taking HUGE quantities of room air and passing them up the stack and heating them to 250 degrees. Your house is sort of acting as a big makeup bin for a large quantity of air - like, 200 cubic feet a minute is going up that stack. That's a lot of heat. It's coming up through the cracks in the house and is being warmed up from outside temperature to inside temperature at 200 cubic feet per minute and then it's being heated up to 250 degrees going out the stack. You just gotta believe that a lot of energy is needed to do that.

(At this point the tape ends.)