

Catalytic Wood-Burning Technology

Presented By:



Agenda

- ▶ **Catalytic Combustors in Wood Stoves**
 - ▶ Historical Look
- ▶ **How Catalytic Combustors Function**
 - ▶ Catalytic Stove Operation
- ▶ **Catalytic Combustor**
 - ▶ EPA Requirements
 - ▶ Education, Facts and Fiction
 - ▶ Warranty
- ▶ **Efficiencies and Clean Burning**
 - ▶ Home Heating Comparison



Agenda

- ▶ ***Catalytic Combustors in Wood Stoves***
 - ▶ ***Historical Look***
- ▶ How Catalytic Combustors Function
 - ▶ Catalytic Stove Operation
- ▶ Catalytic Combustor
 - ▶ EPA Requirements
 - ▶ Education, Facts and Fiction
 - ▶ Warranty
- ▶ Efficiencies and Clean Burning
 - ▶ Home Heating Comparison



Environmental Evolution

Woodstove & Fireplace Inserts:



- **~1978** – First wood stoves manufactured with a catalytic combustor
- **1980** - Emissions of 40 to 60 grams per hour of particulate matter (PM) per hour
- **1985** – EPA emission standards
 - Regulatory negotiations
- **1988** – Phase I – 5.5 grams PM per hour
 - New mfg – July 1988
- **1990** – Phase II – 4.1 grams PM per hour
 - New mfg – July 1990 All sales – July 1992
- **2009** – EPA Re-Opens NSPS Regulations on wood-burning appliances for revision



Agenda

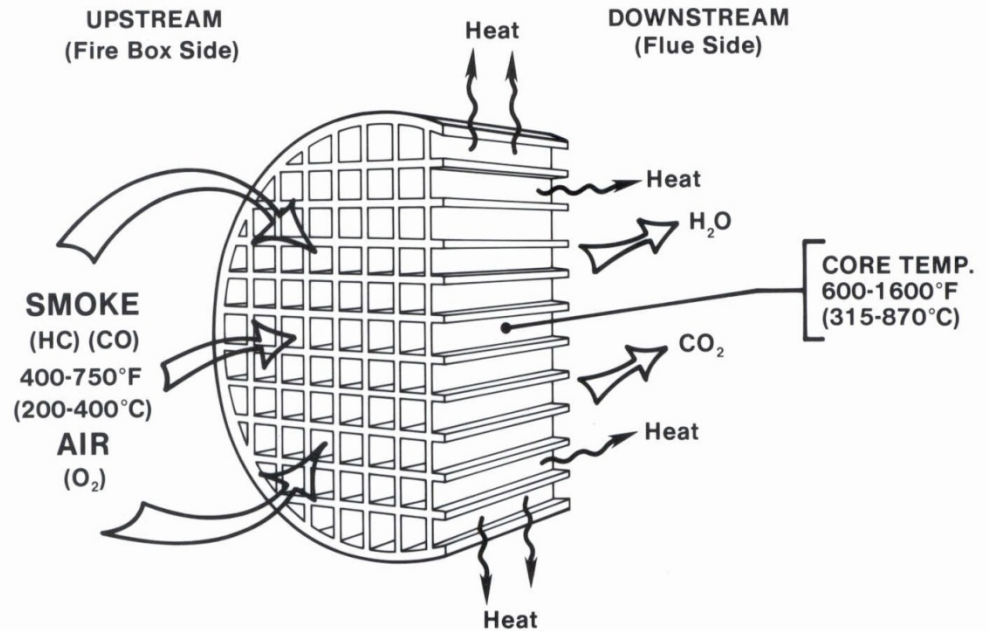
- ▶ Catalytic Combustors in Wood Stoves
 - ▶ Historical Look
 - ▶ ***How Catalytic Combustors Function***
 - ▶ ***Catalytic Stove Operation***
- ▶ Catalytic Combustor
 - ▶ EPA Requirements
 - ▶ Education, Facts and Fiction
 - ▶ Warranty
- ▶ Efficiencies and Clean Burning
 - ▶ Home Heating Comparison



What Is Catalyst

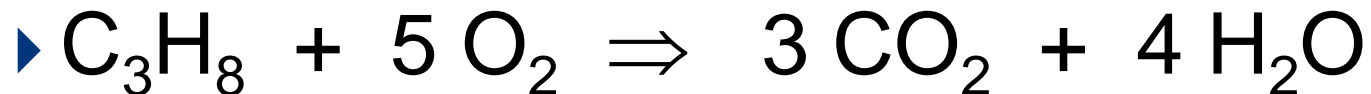
- ▶ Definition: A catalyst is a substance which lowers the activation energy for a given reaction, without being consumed by the reaction.

- ▶ To oxidize organic compounds, **HEAT** is the activation energy necessary to complete the reaction.



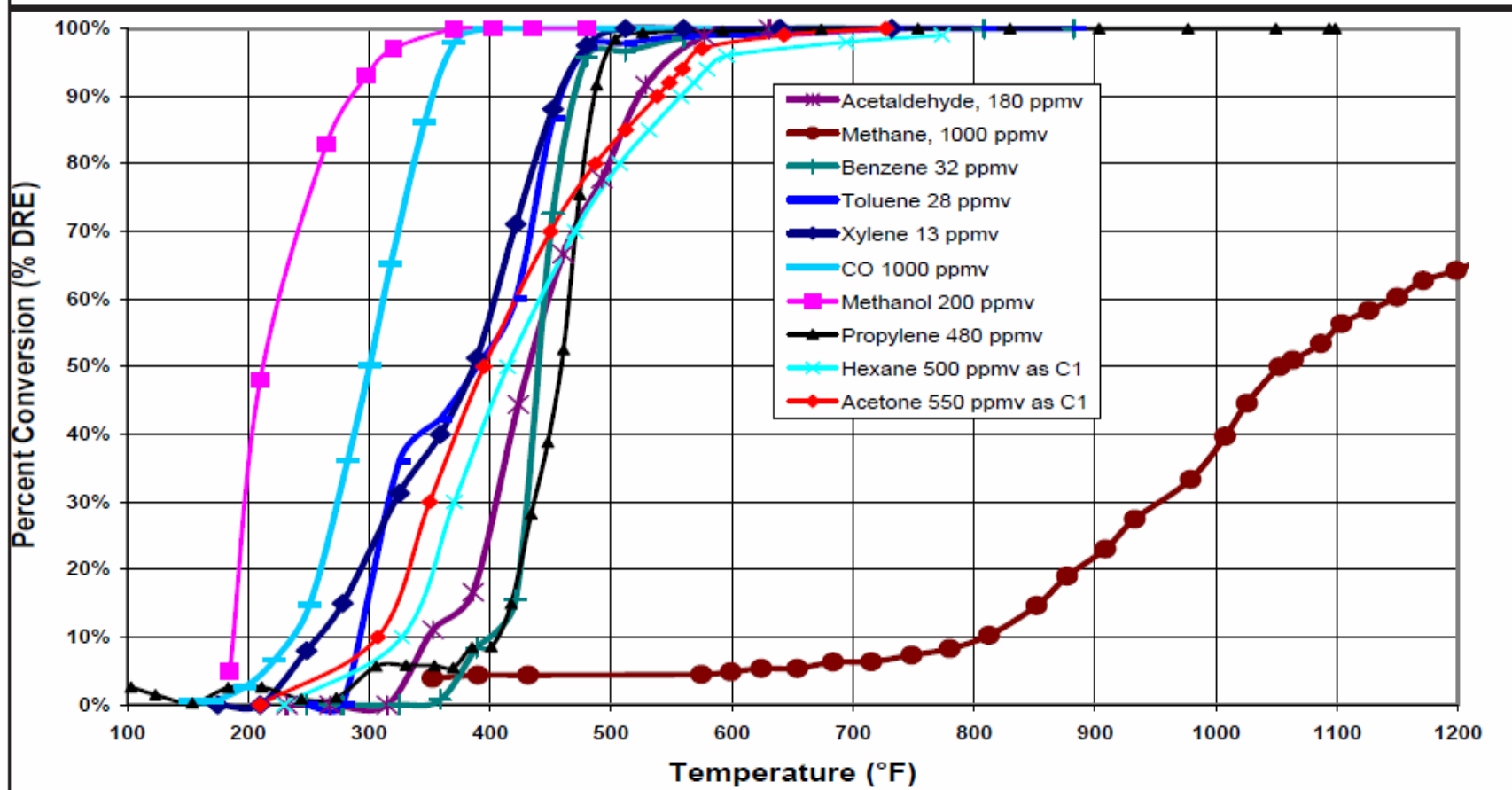
Combustion Reaction

- ▶ Catalysts create a **Combustion Reaction**
- ▶ Also Referred to As “Oxidation” Reaction
- ▶ Carbon in any compound Combines with Oxygen to form Carbon Dioxide and Water



VOC Destruction

NOTE: WHILE NOT ALL THE GASES BELOW ARE PRESENT IN WOOD SMOKE EMISSIONS, THIS CHART PROVIDES EVIDENCE AS TO THE POWER OF A COMBUSTOR TO DESTROY SPECIFIC GASES.



Combustor Components

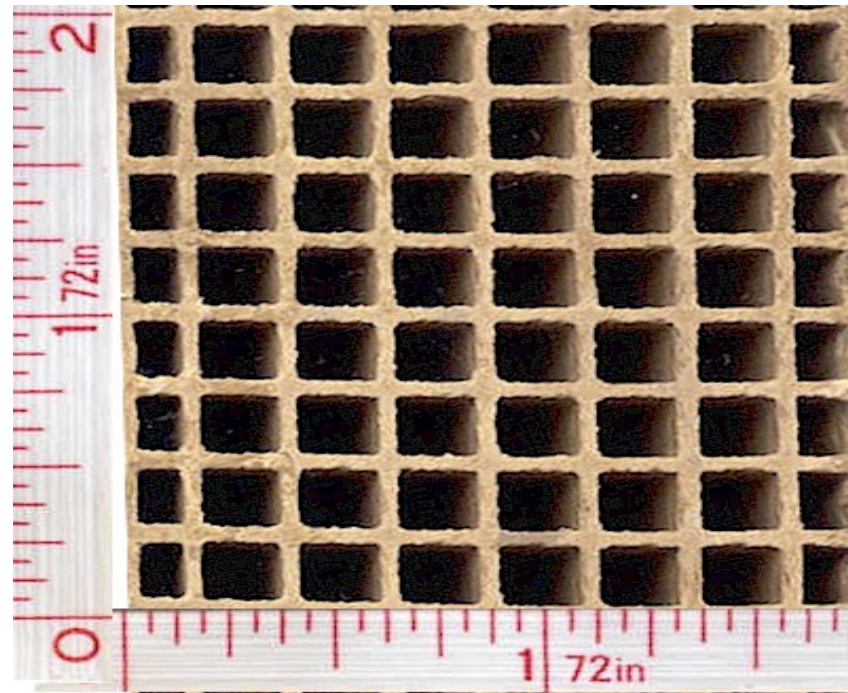


- ▶ **Carrier**-physical supports for active metal catalyst
- ▶ **Catalyst Coatings** – Precious (noble) metals or base metal elements which are “active in the combustion reaction”. Some catalyst manufactures also use a pre-coating, also known as a washcoat.



Cell Density

CPSI- cell opening per square in of ceramic



The Catalytic Stove

Evaluating a Catalyst Wood Stove

- ▶ Catalytic Stove design



The Catalytic Stove



- ▶ A combustor-equipped stove operates like any other – only more efficient
- ▶ You load it, light it, and adjust it to maintain it just as you would any wood stove



The Catalytic Stove

What to Watch

- ▶ Achieving Catalytic Light-Off
- ▶ Maintaining Catalytic Burning Conditions
- ▶ Recommended Fuels
- ▶ Understanding Stove Limitation

Visit the CHC website for Detailed Instructions.

www.chc-hpba.org



The Catalytic Stove



Maintaining Catalytic Burn Conditions

- ▶ During start-up a medium to high fire rate must be maintained for ~20 minutes with bypass open
- ▶ During refueling, fire the stove for ~10 minutes to ensure proper temperatures for catalytic activity to continue with bypass open

Visit the CHC website for Complete instructions.

www.chc-hpba.org



The Catalytic Stove

Importance of the Firing Procedure

- ▶ Keep a healthy combustor
- ▶ Prevent plugging
- ▶ Prevent peeling of the coating
- ▶ Prevent thermal cracking
- ▶ Prevent deactivation



Troubleshooting

Damage Prevention

▶ **DO NOT:**

- Drop combustor
- Run water through the combustor
- Remove the metal band from the combustor
- Remove combustor from manufacturer's holder
- Scrape the inside walls of the combustor
- Use compressed air to clean the combustor

Visit the CHC website for Advice.

www.chc-hpba.org



Care Guidelines

Cleaning Procedures

- ▶ “Hot” Fire Cleaning
- ▶ Minor Cleaning Procedure
- ▶ Major Cleaning Procedure

Visit the CHC website for Complete Instructions.

www.chc-hpba.org



Agenda

- ▶ Catalytic Combustors in Wood Stoves
 - ▶ Historical Look
- ▶ How Catalytic Combustors Function
 - ▶ Catalytic Stove Operation
- ▶ ***Catalytic Combustor***
 - ▶ ***EPA Requirements***
 - ▶ Education, Facts and Fiction
 - ▶ Warranty
- ▶ Efficiencies and Clean Burning
 - ▶ Home Heating Comparison





Environmental Evolution

Woodstove & Fireplace Inserts:



Current Standards:

Type of Device	Washington State Limit	EPA Limit
Catalytic Wood Burning Device	2.5 grams per hour	4.1 grams per hour
Non-Catalytic Wood Burning Device	4.5 grams per hour	7.5 grams per hour

“Questionable” Durability of the catalyst was cited as the reason for 2 Standards.



Environmental Evolution

Woodstove & Fireplace Inserts:



Current Standards:

All catalyst used in an approved EPA wood-burning appliance must receive approval from EPA.

Test result cannot show an increase from the appliances certified emission rating of more than 2.5 g/hr of particulate matter to demonstrate catalyst equivalency.



Agenda

- ▶ Catalytic Combustors in Wood Stoves
 - ▶ Historical Look
- ▶ How Catalytic Combustors Function
 - ▶ Catalytic Stove Operation
- ▶ ***Catalytic Combustor***
 - ▶ EPA Requirements
 - ▶ ***Education, Facts and Fiction***
 - ▶ Warranty
- ▶ Efficiencies and Clean Burning
 - ▶ Home Heating Comparison



Life of a Combustor



- ▶ The anticipate operational life is 12,000 to 50,000 hours.
 - ▶ Confirmation Studies were performed independently by Omni Environmental Laboratories
 - ▶ The Omni aging study conducted in December of 2009 showed limited reduction in activity after multiple seasons of use
 - ▶ Study Parameters
 - ▶ Results
-



Results - Stove A



Owner / Combustor Information	Particulate Matter (5H Adjusted (g/hr))	Carbon Monoxide (g/hr)	VOC as Carbon (g/hr)
Blank (No Catalyst Coating)	7.80	279.11	23.58

Effects of Catalyst in Stove A

Owner / Combustor Information	Fuel Usage (Cords/Year)	Reduction of Particulate Matter (5H Adjusted (g/hr))	Reduction of Carbon Monoxide (g/hr)	Reduction of VOC as Carbon (g/hr)
New ¹	n/a	85%	98%	83%
Used (5.75 Years)	3	83%	91%	56%
Used (8.5 Years)	More than 2	81%	96%	64%

¹Aged based on EPA Method 28 Guidelines

Results - Stove B

Owner / Combustor Information	Particulate Matter (5H Adjusted (g/hr))	Carbon Monoxide (g/hr)	VOC as Carbon (g/hr)
Blank (No Catalyst Coating)	31.95	335.64	39.45

Effects of Catalyst in Stove B

Owner / Combustor Information	Fuel Usage (Cords/Year)	Reduction of Particulate Matter (5H Adjusted (g/hr))	Reduction of Carbon Monoxide (g/hr)	Reduction of VOC as Carbon (g/hr)
New ¹	n/a	83%	93%	74%
Used (5.5 Years)	4 to 6	78%	74%	45%
Used (9 Years)	3	80%	89%	56%

¹Aged based on EPA Method 28 Guidelines

Results – Summary

Change of Particulate Emission in an Aged Combustor

Less Than 1 g/hr Average Change in Emissions After 9 Years

Stove A	New ¹	Used 5.75 Years	Used 8.5 Years
Particulate Matter (5H Adjusted (g/hr))	85% Reduced Emissions	0.14 g/hr Increase from New	0.3 g/hr Increase from New
Stove B	New ¹	Used 5.75 Years	Used 8.5 Years
Particulate Matter (5H Adjusted (g/hr))	83% Reduced Emissions	1.9 g/hr Increase from New	1.04 g/hr Increase from New

¹Aged based on EPA Method 28 Guidelines

Regulations Revisited:

Current Standards:

Type of Device	Washington State Limit	EPA Limit
Catalytic Wood Burning Device	2.5 grams per hour	4.1 grams per hour
Non-Catalytic Wood Burning Device	4.5 grams per hour	7.5 grams per hour

With An Increase of ~1 g/hr over 9 Years

A Washington State Approved Catalytic Stove will not reach the same emission levels as a Washington State Non-Cat Stove for *18 Years*.





An EPA Approved Catalytic Stove will not reach the same emission levels as a Washington State Non-Cat Stove for *30.6 Years*

Using the original NSPS Logic of Course



Combustor Condition

► Stove A

Blank (No Coatings)	New (Aged 50+ Hours)	Used 5.75 Years 3 Cords Per Year	Used 8 Years More Than 2 Cords /Year
			

All combustors pictured post vacuuming

Combustor Condition

► Stove b

Blank (No Coatings)	New (Aged 50+ Hours)	Used 5.75 Years 3 Cords Per Year	Used 8 Years More Than 2 Cords /Year
			

All combustors pictured post vacuuming

Agenda

- ▶ Catalytic Combustors in Wood Stoves
 - ▶ Historical Look
- ▶ How Catalytic Combustors Function
 - ▶ Catalytic Stove Operation
- ▶ ***Catalytic Combustor***
 - ▶ EPA Requirements
 - ▶ Education, Facts and Fiction
 - ▶ ***Warranty***
- ▶ Efficiencies and Clean Burning
 - ▶ Home Heating Comparison



Combustor Warranty

- ▶ EPA requires each stove and/or catalyst manufacturer provide a 6-year pro-rated warranty on original combustors

0.4% of OEM Combustors are replaced in the first 3 years of Service (most failures involve over temperature conditions)

Less Than 10% of all OEM Combustors are replaced during the EPA Mandated 6 Year Warranty Period

-
- ▶ Contact your stove manufacture for more details.

Agenda

- ▶ Catalytic Combustors in Wood Stoves
 - ▶ Historical Look
- ▶ How Catalytic Combustors Function
 - ▶ Catalytic Stove Operation
- ▶ Catalytic Combustor
 - ▶ EPA Requirements
 - ▶ Education, Facts and Fiction
 - ▶ Warranty
- ▶ ***Efficiencies and Clean Burning***
 - ▶ ***Home heating Comparison***



Efficiencies:

Where Catalytic Wood Stoves Excel

- ▶ **Any Time:**
 - ▶ Uninterrupted continuous low burns are needed
 - ▶ Infrequent fuel loads are made
 - ▶ Consumer is an efficiency nut and drives a Prius TM



Efficiencies:

Where Catalytic Wood Stoves Excel

Example Scenario:

- ▶ Let's assume for a moment there are two homes, located next to one another in the same community in a suburb.
 - ▶ Both Homes Have:
 - ▶ The same number of occupants
 - ▶ Exact same floor plan
 - ▶ Same desired indoor temperature during a cold winter day.



Efficiencies:

Where Catalytic Wood Stoves Excel

Example Scenario:

- ▶ Both homeowners also purchase their winter fuel from the same supplier on the same day from the same pile of cordwood.
- ▶ Both homeowners also expect their wood stove to be their main source of heat in their homes.



Efficiencies:

Where Catalytic Wood Stoves Excel

Example Scenario:

Home 1:

A non-catalytic wood stove that is Washington State approved at a maximum 4.5 grams/hour and 75% efficiency.

Home 2:

A catalytic stove rated at 1.76 grams/hour and with an efficiency rating of 82.5%.



Efficiencies:

Where Catalytic Wood Stoves Excel

Example Scenario:

It is obvious the catalytic model in Home 2 is much cleaner burning overall and is also much cleaner burning as discussed earlier, in the low & medium burn settings. The catalytic wood stove will therefore produce fewer emissions over the winter, but how much less?



Efficiencies:

Where Catalytic Wood Stoves Excel

Example Scenario:

- ▶ To reach the actual answer and to have a total appreciation for the very nature of *efficient*, catalytic wood stoves, look at each of the stoves' individual efficiencies.

EFFICIENT

- ▶ **a.** Acting or producing effectively with a minimum of waste, expense, or unnecessary effort.
 - ▶ **b.** Exhibiting a high ratio of output to input.
-



Efficiencies:

Where Catalytic Wood Stoves Excel

Example Scenario:

- ▶ There is a 7% difference in efficiency between the Appliance in Home 1 vs. Home 2.
- ▶ Home 1 with the non-catalytic wood stove will actually burn more wood and produce even greater levels of particulate over the same winter.
- ▶ It isn't enough to just look at grams of particulate produced each hour without taking into consideration overall efficiency



How Are Stoves Used



COMPARE	PM (g/hr) (Particulate Matter)			
	Low	Medium	Medium High	High
	Stoves spend 80% of their life in this range			
Burn Rate (kg/hr)	<0.8	0.8 to 1.25	1.25 to 1.9	MAX (3 to 5)
Heat Output (BTU/hr)	<10,000	~12,000	~15,000	~40,000+
AVG Washington State Certified NON-CAT Stove	3.45	3.85	3.05	2.70
AVG Washington State Certified CAT Stove	0.29	0.83	1.24	4.67



On Behalf of the
Catalytic Hearth Coalition

Thank You !

Become a CHC Member today!

