Burning Wood – Insulation Material Choices

JULY 11, 2013 BY SMATHIEU 10 COMMENTS

High Temperature insulation is an important component of an efficient wood burning stove or heater. Using insulation that is not rated for the application will result in pre-mature failure. Here we discuss various insulation options and why some are suitable for wood burning stoves or heating appliances and some are not. All materials can be purchased off the shelf and do not require molding or casting.

Why insulate?

The Dragon Burner

As you can read in the "How Dragon Heaters Work", efficiency is directly tied to keeping the combustion zones hot. The primary (burn tunnel) and secondary combustion chamber (the heat riser) must be well insulated to insure maximum combustion temperatures. The heat riser on the dragon burner is made of vermiculite board. The burn tunnel, though it is cast from an moderate insulative refractory, it requires an additional 2" (at a minimum) loose insulation to insure maximum burn temperatures.

Other Applications

Kiln and furnace designs require extremely well insulated chambers to capture the heat and raise the inside temperature to 2,000°F and higher. Any time you want to contain heat rather than release it into the surrounding space, you will need insulation.

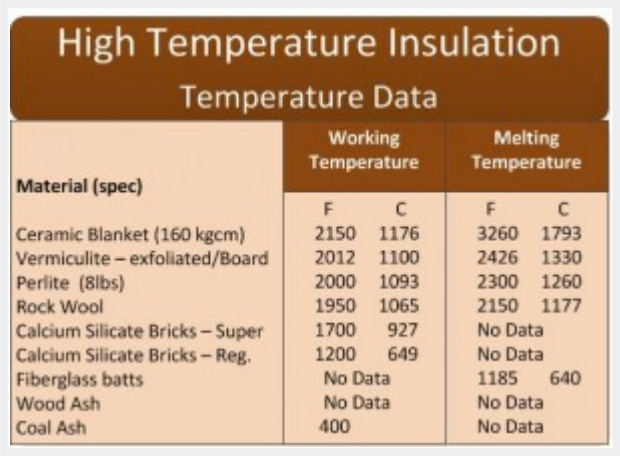
Factors to Consider

In order to choose the correct insulating material for your application, you need to consider:

- Working and Melting temperatures
- Thermal conductivity when hot!
- Form factor and strength of material
- Cost

Working and Melting Temperatures

Whatever insulation you choose must be able to withstand the temperatures at the given location. So it is important to know what the potential temperatures will be 1st. Using this information you can narrow or broaden your choices.



High Temperature Insulation
Temperature Data

Material (spec)	Working Temperature		Melting Temperature	
	F	C	F	C
Ceramic Blanket (160 kgcm)	2150	1176	3260	1793
Vermiculite – exfoliated/Board	2012	1100	2426	1330
Perlite (8lbs)	2000	1093	2300	1260
Rock Wool	1950	1065	2150	1177
Calcium Silicate Bricks – Super	1700	927	No Data	
Calcium Silicate Bricks – Reg.	1200	649	No Data	
Fiberglass batts	No Data		1185	640
Wood Ash	No Data		No Data	
Coal Ash	400		No Data	

You will notice in the chart above, the working temperature may be different from the melting temperature. A working temperature is the temperature that a material can endure over an extended period without undergoing some other physical or chemical change. A material can loose viability without reaching the melting point. They can change structurally and permanently in some way when kept above their maximum working temperature. So it is important to go by the working temperatures and not the melting temperature.

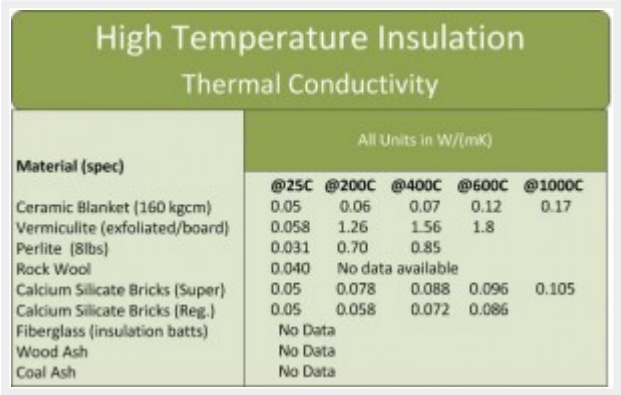
Low Thermal Conductivity

This is the technical term for “how well does this transmit heat”. Metals have high thermal conductivity; fiberglass insulation is fairly low. Materials with low thermal conductivity prevent heat from being removed. The lower the thermal conductivity, the less insulation material is needed.

A complicating factor is that thermal conductivity in most materials is decreased as the temperature goes higher. In other words, the insulating material becomes less effective at wood-burning stove temperatures versus room temperature.

So when evaluating a material for suitability, check the thermal conductivity of the material at the potential temperatures to which it will be subject. This information is not always available but you can see from the chart below, it can make a big difference. For example, although at 25C both vermiculite and ceramic blanket have a similar number, at 600C the ceramic blanket is much more effective.

Many kiln references will suggest 5-8 time more vermiculite, for example than if a ceramic blanket is used.



High Temperature Insulation
Thermal Conductivity

Material (spec)	All Units in W/(mK)				
	@25C	@200C	@400C	@600C	@1000C
Ceramic Blanket (160 kgcm)	0.05	0.06	0.07	0.12	0.17
Vermiculite (exfoliated/board)	0.058	1.26	1.56	1.8	
Perlite (8lbs)	0.031	0.70	0.85		
Rock Wool	0.040	No data available			
Calcium Silicate Bricks (Super)	0.05	0.078	0.088	0.096	0.105
Calcium Silicate Bricks (Reg.)	0.05	0.058	0.072	0.086	
Fiberglass (insulation batts)	No Data				
Wood Ash	No Data				
Coal Ash	No Data				

Thermal Conductivity of High Temperature Insulations

Form Factor and Strength

Some materials on this chart are loose and must be contained in some way; for example, exfoliated vermiculite or perlite. Some come in a particular shape and can only be cut (vermiculite board, ceramic fiber paper, and calcium silicate board). Others can be molded by the user and dried or cured in place (clay slip with perlite added). Each of these form factors may have a place in your design.

A word about Perlite

Many rocket mass heater designs include a recommendation of clay slip with perlite. Clay can tolerate the temperatures created by an efficient wood-burning stove. However, it has high thermal conductivity (low insulation value). Adding the perlite (which can also tolerate high temperatures) makes the end result insulative. The clay dries and keeps the perlite fixed in a particular shape.

Types of Perlite

There are two types of perlite, massonry and horticultural. What is the difference between the two? Masonry perlite coated with silicone, which keeps water from getting trapped inside the perlite. Horticultural perlite is used precisely for the purpose of storing extra water; it does not have the silicone coating.

Consequently, masonry perlite is recommended for applications that will be exposed to water, such as when mixing with clay slip or ***it is used outdoors***. Water trapped inside the perlite, when heated could theoretically cause steam and ruptures. Having said that, people who have more hands on with this issue than myself at the Donkey32proboards indicate they have not had issues using the horticultural perlite. So I guess I will just leave it there.

While it possible to treat vermiculite to resist water intake, it is not as commonly found as perlite treated the same way.

Wood Ash

While it cheap and available it's insulating properties derive primarily from the trapped air. But since there is no structure to maintain the trapped air it tends to settle and loose effectiveness. If you want to mix it with clay slip, I think the sawdust burned out of the slip would perform better, but I could not find in thermal conductivity test data to support any ash options. Perlite and Vermiculite are relatively inexpensive and offer better micro structures for insulation, it does not seem worth going with a sub par option.

Fiberglass and Rock wool

…have binders in them that limit their "working" temperatures. I could find no exact numbers showing this since. Rock wool does serious off -gassing at 400F. (not to be done inside) Check the MDS for the material you are using. Fiberglass should just be eliminated for consideration almost everywhere. I have seen it used around burn tunnels and heat risers, and as you can see from the chart its thermal numbers are way too low.

Rock wool, even though it has a high melting point, is never placed in extreme heat locations, only as a 2ndary insulator behind fire bricks. I suspect this is due to deterioration from the binders used in its manufacture but I don't know for sure.

All the numbers shown are from various manufactures data sheets. Check out the data sheets for any product you are considering. The numbers can vary from the charts on this blog a lot. Also be careful to compare apples with apples. Some vendors report thermal conductivity using btus and other Watts. It matters, they are not the same!

FILED UNDER: HIGH TEMPERATURE INSULATION, REFERENCE

Comments

maillot de foot says:
August 4, 2013 at 9:13 am

I loved your post.Thanks Again. Really Great.

Reply

swarovski says:
February 26, 2014 at 4:20 pm

I every time spent my half an hour to read this website's posts every day along with a cup of coffee.

Reply

SMathieu says:
February 26, 2014 at 4:31 pm

Thanks! I am glad to know it is read!

Reply

Chris Miller says:
November 26, 2014 at 10:00 pm

Good post and it helped answer some questions I had about rock wool. I actually bought a bunch of Roxul to use in a couple of experimental stoves because I just couldn't find any other insulating material locally and even though the temperature rating is there, I just havent felt good about putting it to use. I took a torch to it and it didn't burn right away but it sort of shriveled and off-gassed a little. That pretty much did it for me.

Thanks for the info….

Reply

j p makwana says:
November 10, 2015 at 3:54 am

is there any data regarding surface temperature of the stove insulated by expanded perlite pipe? If available than please send me.

Reply

SMathieu says:
December 1, 2015 at 10:23 am

We are not familiar with expanded perlite pipe.

Reply

thermofoampk says:
February 27, 2016 at 8:24 am

The best Insulation Material Pakistan accessible today is called an Aerogel, this is not a brand but rather the sort of material which has compelling strength and warmth protection properties inside of

the presumable working temperatures in any environment on planet Earth.
Insulation Material Pakistan

Reply

SMathieu says:
March 14, 2016 at 2:03 pm

I did a little research on aerogels in general. They are a very interesting material, but they do not insulate infrared. Quoting Wikipedia: “Aerogels are poor radiative insulators because infrared radiation (which transfers heat) passes through them.” Warmth from a wood fire does radiate heat, so this material would not be particularly helpful.

Reply

tanvir fakir says:
November 10, 2017 at 8:24 am

why ceramic wool is better than other?

Reply

SMathieu says:
November 10, 2017 at 12:16 pm

not sure what you are asking, I don’t know how it achieves its low thermal conductivity, but if you look at the chart you can see the vastly better performance of it.

Reply

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