PMC PRO Ring Tests

By Hattie Sanderson

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Hello fellow metal clay enthusiasts! In this report, I will share my testing and experiences to date for firing PMC PRO rings. It assumes the reader has a working knowledge of creating rings with fine silver metal clays. Because this is a new product, I expect that the approach and firing formula given here will change and evolve over time. My hope is that my fellow metal clay enthusiasts will use this information as a "jumping off point" as we all continue to experience and learn the best approach to working with this new product. Please "pay it forward" and share your experiences.

GENERAL OBSERVATIONS

The ring on the left is fired fine silver and the ring on the right is fired PMC Pro. The PMC Pro ring was allowed to cool for 30 minutes in the carbon post firing to avoid oxidation. The PMC Pro is a darker whitish color and will polish up easily just the same as fine silver metal clay.

Oxides will form on the piece if you remove the hot ring from the carbon. (Oxides form when the air mixes with the hot copper particles.) This dark coloring can take a little more work to clean off the ring.

For all testing I used a front loading kiln.

RING TESTING

I have fired several PMC Pro rings in activated carbon with no supports or ring sizing inserts. Most often, I have fired the rings on their side with good results. So far, rings fired on their side have held their shape. Rings are created 3.5 to 4 sizes larger than the desired finished size to accommodate for the 15-20% shrinkage during firing. I have tested several simple identical band rings and the resulting ring size is variable +/- 1 size. After doing these tests, I did several more firings using HattieS® Patties™ ring sizing inserts. I recently did three different series of testing and will share them with you in this report.

FIRING VESSEL

It is necessary to use activated carbon when firing PMC PRO to create a reduction atmosphere for sintering. However, tests are showing that a minimal amount of activated carbon surrounding the piece is ideal (10mm.) This is because the carbon is such a good insulator. The more activated carbon that is present, the longer it takes the 1400°F heat to reach the metal clay for sintering.

Therefore, I like to use a firing vessel that is sized to the metal clay piece to allow for the optimum amount of activated carbon. Unless otherwise noted, for all of the tests in this report, I am using an 8oz (227g) steel tomato sauce can for a firing vessel. It is 2.5" (63mm) in diameter and 3" (76mm) tall. The size of this firing vessel allows me to use as little activated carbon as possible. The can is rinsed, dried and any label and adhesive removed.

I use 300 grit sandpaper or a metal file to remove any sharp edges from the lid. Also, file the lid down just a bit so that it easily fits inside the can. This effectively creates a "floating lid" that will rest on top of the activated carbon allowing you to adjust the height of the carbon as needed.

Drill 2 holes in the lid and insert a piece of 22g steel binding wire to create a handle. This firing vessel will degrade and is only good for 3-4 firings. However, it costs less than 50 cents and comes with free tomato sauce! The binding wire handle can be used over and over.

TEST SERIES 1

For this series of tests I will attempt to answer the following questions:

- Can I fire multiple layers of PMC Pro?
- Is there a difference if I fire for 1 hour versus 2 hours?

Control factors:

For the following series of tests, I created several rings the same size and from the same design to eliminate as many variables as possible. The test rings are USA size 9. They are 4 cards thick and 1/8" wide band shapes. For tests 1A and 1B I used 30 mm of carbon between layers of rings because I wanted to simulate the layering of larger pieces (which would require more depth of carbon.)

1A – Layer 2 rings in 1 steel can, 10 mm of carbon on bottom and top, 30 mm of carbon between layers (total carbon depth is 50 mm), fire to 1400°for 1 hour

1B – Repeat 1A, but fire for 2 hours

1C – Use 2 steel cans side by side in kiln with 1 ring in each can, 10 mm of carbon on top and bottom of ring (total carbon depth is 20 mm), fire to 1400°for 1 hour

1D – Repeat 1C, but fire for 2 hours

Results:

1A – bottom layer ring shrunk to size 7.5, top layer ring shrunk to size 5.5
1B – bottom layer ring shrunk to size 6.5, top layer ring shrunk to size 5
1C – ring in can 1 shrunk to size 5.25, ring in can 2 shrunk to size 5
1D – ring in can 1 shrunk to size 4.75, ring in can 2 shrunk to size 4.5

Observations:

Firing in a single layer and for 2 hours yielded the most shrinking of the rings. However, there will always be slight variables in the shrinking of rings due to fluctuations in kiln temperature, the amount of carbon surrounding the ring, the type of firing vessel used (thick steel vs. thin steel, vs. fiber.) Also ring shrinkage will be affected by the rings wall thickness, width, design elements and inclusions.

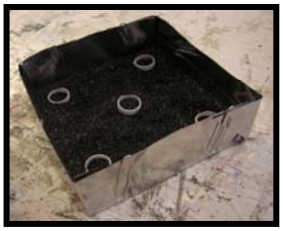
The bottom layer rings in both 1A and 1B are not fully sintered and broke when pounded on a steel mandrel. Need to fire longer for this depth of carbon.

From these results, firing for 2 hours versus 1 hour made a difference in the shrinkage. It looks like 1 hour is good, but 2 hours is better. When layering pieces, or firing taller pieces, I will use longer firing times based on the depth of the carbon.

Going forward with tests, I will use 2 hours for 20 mm carbon depth as a base for firing schedules. Here is the schedule I will try:
-first 20 mm of carbon depth, fire for 2 hours
-add 20 minutes for each additional 10 mm of carbon depth

TEST SERIES 2

For this series of tests I will attempt to answer the following questions:



- How do rings come out in single layer firing when using a larger firing vessel (which uses more carbon…does my 20 mm carbon depth/2 hour firing schedule work?)
- Does pre-firing the rings in atmosphere (open shelf) make a difference?
- Does placing the piece in the front, back or center of the kiln make a difference?

Control factors: For the following series of tests, I created several rings the same size and from the same design to eliminate as many variables as possible. The test rings are USA size 9. They are 4 cards thick and 1/8" wide band shapes. For the firing vessel, I used steel tool wrap to create a box that is 2.5" x 6" x 7" with a floating lid that rests on top of the carbon. All of these tests are fired to 1400° for 2 hours.

2A – five rings arranged in a single layer as pictured, 10 mm carbon on bottom and top (total carbon depth is 20 mm)

2B – repeat 1A, but pre-fire rings in atmosphere to 1400° for 30 minutes

Results:

2A – rings in back are size 5 & 4.75, center ring is size 5.25, front rings are size 4.75 & 4.75

2B – rings in back are size 5.25 & 4.25, center ring is 4.5, front rings are size 4.25 and 4.5

Observations:

In test 2A, the ring variance is only ½ size (approximately 1.3 mm in circumference.) The placement of the rings near the door, in the center, or in the back did not make a significant difference.

The rings in 2B shrunk approximately 2 sizes during the atmosphere firing, and shrunk a little more than the rings in 2A in the reduction firing. Many artists feel that the atmosphere firing is pertinent to burn off the binders before sintering in a reduction atmosphere. I tend to agree with this based on my experiences with base metal clays. (Also note that Nettie Landenwitch has had better enameling results on PMC Pro when she fired the piece in atmosphere first.)

Using a larger firing vessel (which uses more carbon,) for a single layer of rings does not appear to inhibit the sintering process when firing for 2 hours with a carbon depth of 20 mm.

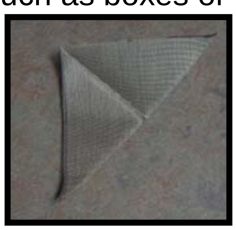
Note that the recommended atmosphere firing is 1000° for 30 minutes. I choose to do atmosphere firing to 1400° for 30 minutes. I fire at this higher temperature for no other reason than as a habit; I always fire my metal clay to the highest temperatures it can withstand. This is a personal choice as an artist.

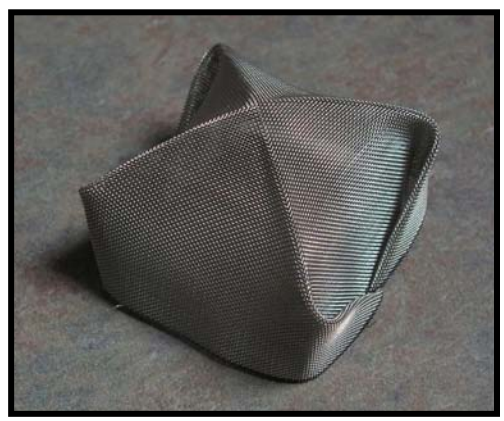
TEST SERIES 3
The series of tests uses HattieS® Patties™ ring sizing inserts to control the shrinkage of the rings. The sizing inserts were designed to work in atmosphere firing (open shelf) with fine silver metal clays. My tests attempt to answer the following questions:

- Will use of the ring insert in the reduction firing inhibit full sintering of the ring?
- Will use of the ring insert cause oxidation on the ring?
- How do I keep the activated carbon granules from getting between the ring insert and metal clay ring? (Because the granules will inhibit proper shrinking around the insert.)
- What is the best approach to position the ring insert in the ring so that it stays centered in the ring during firing?
- I fire the piece in atmosphere first to burn off the binders, however, I wonder if this pre-firing also helps the ring hold its shape during firing?

Control factors: For the following series of tests, I created several rings the same size and from the same design to eliminate as many variables as possible (with the exception of one band ring.) The test rings are USA size 9. They are 4 cards thick and have a dish ring top. I used a size 5 HattieS® Pattie™ for all of the tests. I used the same firing vessel (steel tomato can) and the same coconut carbon for all of the tests.

Create a Ring Cage:
It is very important to keep the carbon granules from getting between the ring insert and the ring so they don't inhibit proper shrinking of the ring around the insert. To do this, I made a steel mesh cage to cover the ring and insert during firing. The cage can be used over and over.
To make a ring cage, use scissors to cut a piece of 80 mesh steel screen to 2.5" x 2.5" (63mm x 63mm.) Fold the piece diagonally and form a stiff crease. Unfold the piece and then fold the piece in the opposite diagonal direction to form another stiff crease. The screen should now look sort of like a tent. Fold two corners together and use your fingers to form a crease on each side to create a wall. Repeat for the other side to form a square cage with a pointed top. This size cage works well in most cases. Make additional sizes as needed. The cage can also be used to keep carbon out of other items during firing such as boxes or other hollow forms.



Atmosphere Firing First:
Fire ring in atmosphere (open shelf) first to 1400°F for 30 minutes to burn off binders. The ring will shrink approximately 2 sizes during this firing. I like this shrinking because now the ring is only 2 sizes larger than the ring insert (instead of 4 sizes larger.) It allows me to steady the ring insert inside the ring in a more stable position.

I have a theory that by atmosphere firing first, a PMC Pro piece with a complex design such as domes, curves, boxes, etc. will hold its shape better and shrink more predictably during the reduction firing.

Reduction Firing:
For all of the test firings, I used a base of 10mm of activated carbon on the bottom of the firing vessel. The ring and insert were positioned in various ways using the steel cage. The goal is to keep the ring in a stable position so that it shrinks properly around the sizing insert during sintering and also to achieve the most predictable and even shrinking of the ring.
Once positioned, 10 mm of activated carbon was placed over the steel cage. Place the floating lid on top of the carbon.

Firing Schedule:
Based on previous testing, I will fire at full ramp to 1400°for 2 hours for the first 20 mm depth of carbon and then add 20 minutes for every additional 10 mm of carbon depth. This is to make sure that all areas of the activated carbon have had time to reach 1400°for full sintering of the metal cl ay. Longer firing times cannot hurt the metal clay.

Before firing, measure the height of the activated carbon in the vessel to determine the length of firing needed. (Example: If the height of my activated carbon is 50 mm, I will fire for 3 hours.)
-first 20 mm, 2 hours
-next 10 mm, add 20 minutes
-next 10 mm, add 20 minutes
-next 10 mm, add 20 minutes
-total 50mm = 3 hours

Note that the activated carbon not only creates a reduction atmosphere, it is also a good insulator. The more carbon that is present, the longer it takes for the heat to fully penetrate all areas of the carbon.

TEST 3A: BAND RING

The most stable position for a simple band ring with an insert is to place it on it side. Therefore, I cut out a circle of steel mesh to act as a base to set the band ring on.

- Fire ring in atmosphere to 1400°for 30 minutes an d allow to cool
- Place a circle of steel mesh on a 10 mm base of carbon to act as a base for the ring
- Position the ring and insert on top of the mesh circle
- Place the cage over the ring and insert
- Cover the highest point of the cage with 10 mm of carbon
- Place the floating lid on top of the carbon
- Height of the carbon was 50 mm, so I fired at full ramp to 1400°for 3 hours

- Ring was allowed to cool down in the carbon for 30 minutes to minimize oxidation
- fired ring shrunk well to the sizing insert as expected
- Ring had both white and oxidized areas
- the ring was pounded heavily on a steel mandrel to test it for strength and held up well, I annealed the ring after sizing up each half size
- I sized up the ring 1.5 sizes, this of course thins and weakens the metal structure but shows that the ring strength does not appear to have been compromised by use of the ring insert

- See “POST FIRING” and “FINISHING” to se how I finished the ring from this point

TEST 3B: DISH RING FIRED UPSIDE DOWN

If this ring was made out of fine silver metal clay, I would fire it upside down on the kiln shelf with a bit of fiber blanket underneath the dish to support the shape. I would then position the ring insert in the shank. I would feel confident that the ring would be stable during firing and would hold its shape.

I know that for base metal clay, you are supposed to fire a dome shape on its side so that it doesn't flatten out during firing. However, to do this, I would have trouble positioning the ring and the insert inside the cage in such a way that it would shrink without distortion. This test was to see if the same design made from PMC Pro would hold its shape if fired upside down. Would the carbon granules support the dish shape of the ring? Does my theory that the pre-fire in atmosphere help the dome hold its shape?

- Fire ring in atmosphere and allow to cool
- Use 10 mm of carbon as a base in the firing vessel
- Nestle the ring and insert upside down in the carbon, being careful not to allow any carbon granules to come between the insert and the ring
- Place the cage over the ring
- Cover the highest point of the cage with 10 mm of carbon
- Height of the carbon was 60 mm, so I fired at full ramp to 1400°for 3 hours, 20 minutes

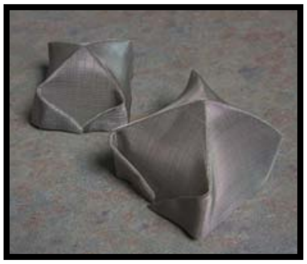
- Ring was allowed to cool down in the carbon for 30 minutes to minimize oxidation
- After firing, parts of the ring are white and parts of the ring are oxidized
- The ring shrunk tightly to the insert
- the dish shape of the ring slumped some, becoming flat
- I assume that this happened because of the weight of the ring insert, the carbon does not act as a support for the clay like vermiculite or fiber blanket does for fine silver clay

- DOES THIS SQUASH MY THEORY THAT PRE-FIRING IN ATMOSPHERE HELPS THE RING HOLD ITS SHAPE BETTER?...I will attempt to answer this question in the next 2 tests.

- See "POST FIRING" and "FINISHING" to se how I finished the ring from this point

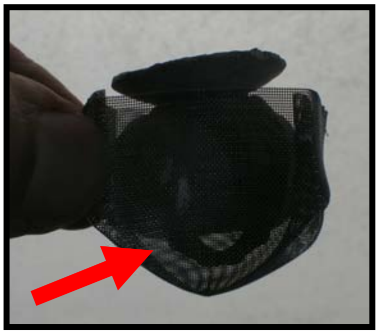
TEST 3C: DISH RING FIRE RIGHT SIDE UP

I still think that pre-firing the piece in atmosphere helps complex designs to hold their shape during reduction firing. This time, I will fire the ring with the top side up so there is no pressure on the dish shape. To do this I will need 2 cages. I will use the 2.5” x 2.5” cage upside down as a base and create a second cage from a 3” x 3” sheet of steel mesh to use as a top.

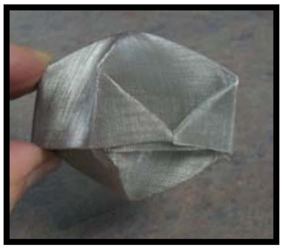


Fire the ring in atmosphere to 1400°for 30 minutes and allow to cool.

Place the insert and ring right side up in the cage base. Position the insert so that it is on a diagonal in the cage. The cage walls will hold the insert in place. The pointed bottom of the cage allows the ring to rest on the insert free of obstruction so that it will shrink properly to the insert.



Position the larger cage over the top of the base cage to enclose the ring.



- Use 15 mm of carbon as base in firing vessel, (the extra 5mm accommodates the bottom point of the cage)
- Nestle the cage 5mm down into the carbon so that it sits in a stable position
- Cover the highest point of the cage with 10 mm of carbon
- Height of the carbon was 60 mm, so I fired at full ramp to 1400°for 3 hours, 20 minutes
- This time, the entire ring (including the dish,) shrunk perfectly and did not distort at all

TEST 3D: REPEAT TEST 3C – THIS TIME NO ATMOSPHERE FIRING
For this test I am repeating the previous test, only this time I will not do the atmosphere firing first. I want to test my theory that atmosphere firing first is beneficial and helps to prevent the piece from distorting during reduction firing.

- DO NOT fire ring in atmosphere
- Load ring in cage, top side up the same as test 3C
- Use the same reduction firing schedule as test 3C
- This time, the dish curled, I assume this was because of the "pull" of the ring shank as it shrunk around the insert
- This test shows that atmosphere firing first is beneficial to the piece keeping its shape during reduction firing, I think this would be true for any kind of dome, box or complex design shape

TEST 3E: REPEAT TEST 3C – USE BITS OF FIBER BLANKET TO SUPPORT RING
For this test, I duplicated test 3C. The only difference is that I used tweezers to carefully place small bits of fiber blanket on either side of the ring and insert. The fiber blanket helps keep the ring in place and will be very useful in ring designs that are top heavy. I wanted to see if the fiber blanket inhibited or changed the firing results.

During firing, the fiber blanket turned a dark color. There was no more oxidation on the ring than if I had not used the fiber blanket. It does not appear to have interfered with the sintering process or the strength of the piece. Fiber blanket should be helpful to support rings and other shapes during reduction firing.

Observations:
I have not found the oxidation on the ring, or use of the ring insert to be detrimental to the structural integrity of the ring. I have pounded several test rings severely on a steel ring mandrel using a mallet. The rings hold up well to the abuse and are very strong.

I conclude that an atmosphere firing first is beneficial to the reduction sintering of the piece and to help keep it from distortion.

The firing times I am using may be "overkill," but I am having consistently good results and am confident that my pieces are fully sintered. Continued testing may show that the same results can be achieved with shorter firing times.

Based on these tests, I will continue firing rings with HattieS® Patties™ sizing inserts, with the ring positioned top side up in a steel mesh cage. I will use fiber blanket as needed to support the piece.

POST FIRING

After firing, remove the firing vessel from the kiln and let it sit for about 30 minutes before removing pieces for safety and to minimize oxidation. Usually, the rings are white in some areas, but have a layer of oxidation where it meets the ring insert.
When the ring has cooled, dissolve the ring insert in water according to manufacture directions.

FINISHING

Use a steel brush to scratch brush the ring and remove oxides. The result has a “steel” look to it. (Note the color difference in the ring top area that did not oxidize.)

I like to use a steel rotary brush tool first and then a 400 grit 3M radial bristle disk to remove as much oxides as possible without compromising the texture of the piece.

Alternatively, you can completely remove all of the oxides from the surface of the piece. I have had difficulty achieving this by simply steel brushing and then placing the piece in a warm pickle when the piece is exposed to some oxygen during the reduction phase of firing such as using ring inserts in a steel cage and also when test firing in a fiber blanket box where oxygen can penetrate through the walls, making the piece black. These oxides are a bit more stubborn to remove.

In this case, I use the following protocol. Use a steel brush and then a 400 grit 3M radial bristle disk to remove as much of the surface oxides as possible, and then depletion gild the piece. (Heat the ring with a torch to a dull glow, and then place the piece in a warm pickle. Rinse the piece and repeat the heating and pickling process until all of the oxides are removed and the piece is all white.) Proceed with finishing as usual.

I hope that you are able to find this information useful. It is very exciting and fulfilling to be a part of exploring this metal clay frontier.

All the best,

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