Using Insulating Materials for the Construction of Salt Kilns

Peter Meanley has spent four years researching this subject and reports the results of his investigation here

THIS PAPER IS THE RESULT of a four-year investigation to try to find combinations of insulating materials which, when allied with different hot facings, might retard or even prohibit their deterioration so that potters might be encouraged to build insulated kilns for salt and soda firing. The original proposal submitted to the Arts and Humanities Research Board (AHRB) based in Bristol, England, who gave financial backing for the research was for two kilns to be built. The first kiln was to contain a wide range of brick types and tests allied with different facings. It was hoped to fire it approximately 50 times. The knowledge gained from this kiln was to be used in a second kiln, which it was hoped to fire 100 times. The number 100 was notional but it represented a base point of acceptability in comparison with the more conventional heavy brick kiln. The heavy brick kiln is rugged, takes more energy to fire and will generally have a longer firing cycle, but the basic bricks are not prohibitively expensive. The insulated kiln, in order to be considered effective should be significantly cheaper to fire and shorter in firing duration, but it should still have a reasonable life expectancy.

For my doctoral thesis which I undertook as a full time staff member of the University of Ulster, I used a 4 cu ft insulated kiln which, while it required considerable remedial attention, was fired 100 times. But the time spent plugging holes and filling cracks within a tiny kiln would not be feasible were the kiln to be scaled up. Nevertheless, I gained a confidence and some experience to hope that with a larger kiln, the problem could also be addressed.

It is the retardation of the formation of salt-glaze on or in the fabric of the kiln which is the key to a successful outcome. The more easily the salt-glaze is formed incorporating the silica present in the kiln bricks, the more the bricks themselves will be attacked and subject to deterioration. An insulating brick has considerably less mass than the conventional heavy firebrick and, also, whereas the firebrick is dense, the insulating brick is made up of a fine series of airpockets. Thus the airborne alkalis which result from the breakdown of the salt introduced into the kiln at high temperature can easily enter the brick through the pores in the surface to form a glaze not only upon the surface but also within the brick itself.

All bricks contain silica. It is the combining of silica with sodium (released from the salt or soda when subjected to high temperature) which forms the salt-glaze. This is the source of the problem regarding the deterioration of the kiln while at the same time providing the reaction required on the surface of the vessels in the kiln, which is what the potter wants. Alumina is an inhibitor of salt-glaze; an essential part of the reaction in enabling a fluid or less fluid glaze to result. The higher the alumina ratio in the reaction the slower or dryer

Kiln #1. Showing the exterior and interior with various bricks and refractory coatings in place.

Top: and centre: Kiln #1 after salt firing 63 before dismantling. Above: Some of the new tests fired at the top level in the kiln.

will be the glaze formed; the lower the alumina ratio the more fluid and vigorous will be the resulting glaze. The higher the alumina levels in the bricks the more expensive and denser they are, the lower the insulating properties.

At the commencement of this project it seemed to be a feasible proposition to coat the brick surfaces with combinations of materials known to inhibit the formation of the glaze. If enough combinations were produced, it should only be a matter of time before some were seen to be better than others. These could then be further refined to make an ideal combination.

From the outset I was aware of two products: American-based ITC and UK-based Nonvit Furnacecoat which claimed to be successful in already having addressed the problem. I decided to use these products as 'controls'. Also, during the building of the first kiln, I became aware of a book entitled *The Art of Firing* by Nils Lou in which the author made certain claims for ITC. On examining the text I noted that his tests had been with low grade bricks and for only six salt firings. The successes claimed, I knew from my own previous experience were insubstantial, as at least 15 or 20 firings are necessary as a minimum before any optimism can be expressed about a possible solution to the problem. Also many more firings would be necessary to be able to substantiate this supposition with confidence.

I am not a kiln builder bursting with theories about innovative kiln design and construction. The essence of this research is with the materials and their resistance to deterioration as a result of repeated salt (or soda) firings. The kiln should be of a certain capacity to demonstrate its usefulness to others as an example. Accordingly, I convened a meeting with 17 UK salt and soda glaze potters to take advice and also to find out whether others had experience or ideas which might be useful for me. A few suggestions of products were mentioned but the main outcome was support for the project and an agreement that a sprung arch kiln of about 1 cu m should be appropriate to test the theory. Also, it was suggested that I test as 'controls' various clay bodies including some with a significant iron bearing quantity; and that the firings be to cone 10+ under reducing conditions.

The kilns I built incorporated two courses of bricks throughout and an additional layer of fibre in the roof. They were based upon the recommendations of Fred Olsen in *The Kiln Book*. Olsen recommends that the most efficient form is a cube with a sprung arch. He also recommends that the sizes of kiln shelves or bats be considered from the outset and he recommends that the height and length of the firing chamber has a specific relationship with the diameter and height of the chimney. All this was undertaken according to his recommendations. I decided to do away with complicated ironwork for the door and simply build this up by placing 15 courses of bricks on their sides in the door recess into which were fitted two 'spy' bricks. Two LPG burners, one firing from the front into the left hand firebox and the other from the back into the right hand firebox completed the kiln. The kiln was fitted with a thermocouple and an oxygen/carbon probe. I wanted to test as wide a range of bricks as possible from several manufacturers. I appreciated that the higher brick grade/classification the higher the manufacturers recommended ceiling temperature and the higher (and presumably the better for me) would be the alumina content of the brick and the better it would be likely to perform. However, the higher the grade, the more expensive the brick. (A 23 grade brick is approximately £1t/$1.5 US per brick, a 28 grade brick £2 at $3 US per brick and a 34 grade £10/$15 US per brick) If in the final outcome the kiln is prohibitively expensive to build, few potters will do because of the cost.

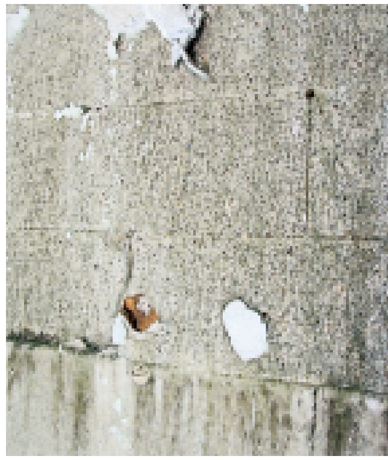
I was aware that there were various principles which needed to be tested, as follows: Certain products, that is, 'bubble alumina' (95+per cent pure alumina) might require little additional treatment and yet be resistant to the formation of the salt-glaze. The lower grade brick with a lower alumina content would deteriorate more rapidly but this may be delayed by the addition of a 'topcoat' to prevent the attack by the airborne gases. That an important factor might be 'fit' of the 'topcoat' to the base and that a more widely varying expansion/contraction range between 'topcoat' and brick would sustain damage more rapidly. That the brick with a highly porous surface might be induced to absorb the resist materials into its porous structure, building up a resist not only on the surface but also from within. That there might be an appreciable difference in effectiveness between that of a refractory 'cement' type coating and a 'glass' which seals up all the pores. And finally, that there might be other materials available, that is, fibres, laminates, foams or that it might be possible to produce or obtain castables with appropriate properties.

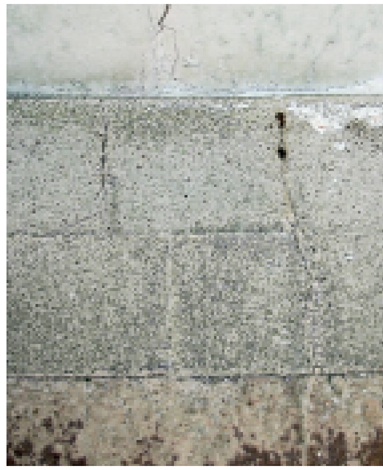
Early on, I made a visit to 'Ceram Research' in Stoke-on-Trent to discuss the problem and to find out the kinds of materials which a group of ceramic chemists believed might be useful. And although much of the discussion between them I did not understand, the following materials were recommended for consideration in different forms: alumina; silicon carbide; zirconium; magnesium; boro-carbide; mullite and sillimanite. It was stressed that the physical characteristics between the 'brick' and wash should be as close as possible. Proportions of mixes, bonding agents and the specific variation of materials were discussed but recommendations varied greatly. Foams, laminates and high-emissivity coatings were mentioned, as were specific manufacturers of cements and other materials. I came away without being given guidance on specific proportions and percentages or with any clear line of particular attack but with a confidence that if a broad enough range of different tests were to be included in the first kiln, some tests would be clearly seen to be much better than others. I begin to realise the enormity of the task ahead. This was further compounded when I considered factors such as particle size, method of application and the combined forms of the prime materials.

Subsequent to this, I discussed the project with a group of German potters in Höhr-Grenzhausen. Though their firing temperatures and salt coatings are generally lower and lighter than those with which I was familiar, they were generous with both time and enthusiasm and I was made aware of various German products; notably cements and bats which might be useful to test. Also, I maintained contact with Mick Casson whose enthusiasm and assistance and generosity provided me with a 'spur' when during lengthy series of firings, nothing seemed to be happening.

For the building of the first kiln, I wanted to include a wide range of bricks of differing grade sizes from different manufacturers. I was aware also that this first kiln had to fire 50 – 60 times. If I introduced a 23 grade brick in the firebox area or roof and the 'topcoat' test was not successful, I might lose the entire kiln prematurely. Therefore I resolved to be cautious and decided upon 26 grade as the lowest for the main structure of the kiln. This was augmented by higher grade bricks – 28, 30, 32 and 34 grades. The bagwalls and door were constructed from 23 and 25 grades as both could be replaced easily without adversely affecting the life of the kiln.

Most of the bricks used were manufactured by BNZ. These were augmented by some from 'Wolf' and 'Premier/Vesuvius' in the right hand wall. The entire right hand face of Kiln #1 was overlayed with vertical bands of 13





Top: Salt firing #50. Bricks HD 25 coated with NT8.
Above: Salt firing #50. Caldor 26 brick, NT8 coating.

Some German materials it was suggested to test:
Wolf:Lupucast VP 05/14
Wolf:Lupufest 901
Fleischmann:Obturit CWN 50-400
Fleischmann:Obturit H 65-800
Lafarge:Basagun 55 – 600 – 06
Lafarge:Basagun 65 – 600 – 06
Lafarge:Basagun 30 – 400 – 06
Lafarge:Linax 30 – 400 – 03
Lafarge:Linax 45 – 600 – 03

separate cements on top of bricks reducing from 32/34 grade at the bottom of 26 grade equivalent at the top. The left hand face bricks were all 26-60s except the bottom course of 32s. The roof was constructed from alternating layers of 30 and 32 grade bricks. Different 'topcoat' tests were applied to every two adjacent bricks in the left hand and back faces of the kiln. The inside front faces were overlayed with seven more cement or preparatory manufactured products. These included ITC and Nonvit Furnacecoat. The bagwalls and door bricks duplicated some of the tests used elsewhere to ascertain the results of these tests on lower grade bricks.

Uniformity of application of topcoat was difficult because the different grades of brick had different porosities. Also, some materials were more finely ground than others. But I decided to keep the water contents relatively consistent with the weight of the dry ingredients to produce a liquid of a thin cream consistency. Generally this varied between 500/750 gm of dry material with 1.1/1.5 litres of water. Into this was placed a 20 ml measured quantity of vinegar to keep materials in suspension. All bricks were dipped to ensure not only a flat 'topcoat' but also some penetration into the porous structure of the brick. The dipping covered not only the top face but also 2/3 cm of the side faces so that if some opening up between the courses did occur, some protection within would be in place. I would like to state that up to perhaps a 30 grade brick there was an apparent uniformity of pick up, but on the 32 – 34 grade bricks where porosity was so slight and particularly when using such a heavy material as silicon carbide 220, patchiness of 'topcoat' did result. On occasions this had to be augmented by a later brush coating.

I was uncertain what material to use as a 'binder' to ensure that these non/low salt-glaze producing materials would in fact adhere to the bricks after firing. I reasoned that materials with a natural plasticity or a silica content to stick the 'topcoat' to the brick during firing should be considered. Accordingly I selected: china clay; a high and low silica ball clay; bentonite; a fine and coarse grade kyanite (which has a low shrinkage); two cements which were known to have high alumina contents; and a low temperature frit. Later a wide range of high and low temperature glass melts were added to the list together with other cements.

The kiln was given a first pre-heat. The following day a high temperature pre-salt firing was undertaken. Some tests were given an additional brush coating to ensure a visual opacity to all tests. Additionally, a light infilling of a few joints within the vertical walls and sprung arch was made with cement, alumina plus silicon carbide. A second pre-salt high fire was followed by the first salt firing. Ten kg of salt were used and a few bottles of wine consumed.

An analysis was made after every firing, together with details of remedial attention given. Every firing was undertaken to reach top temperature in eight hours and incorporated the cones 06,3,6,9,10. Cone 10 was always flattened. Salting commenced at Cone 3 and was completed by Cone 9. This is my normal salting procedure. Four body tests on numbered beakers were always included as requested by the UK potters. The clay body of the beakers contained quantities of Fe_2O_3 ranging from 0.6 to 2.4 per cent. An oxygen probe and thermocouple were fitted to the roof of the kiln. Every firing was logged, and the fired tests, firing log and subsequent analysis of action taken was available for every firing. The fired tests demonstrated that a reasonable proportion of firings were undertaken under reducing conditions, sometimes in heavy reduction. Occasionally, I introduced a few of my spouted vessels which sometimes require an oxidised result.

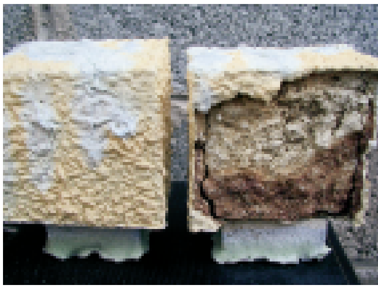
Kiln #2 after 80 firings. Sides and back walls.

From the initial 10 kg salt per firing, this had reduced in quantity to 3 kg by firing 15: A heavy orange peel glaze was a standard requirement for each firing on the four test bodies. After the third firing, the M23 and C23 bricks in the right hand bag wall were replaced. Also, many of the tests in the left , back and roof faces of the kiln were given repeat brush coatings of their original mixtures. After the fourth firing, several of the cements in the right face were given additional coatings as were roof bricks. After #5, a series of free standing tests on 28 grade bricks were introduced on the 2nd level back shelf. Following firings #6 and 7 a cement comprising Secar 71:10 pts, calcined alumina: 7.5 pts, silicon carbide 220: 1 pt, was mixed and applied to areas of the kiln sustaining damage, notably the left face bottom three courses, the right face 'Wolf' Lupudur bricks, and the bottom course of 32 grade bricks: The 23L and 23NF bricks in the right bag wall were also replaced. After #9, Lupufest 901 (a German cement) was used as an infill to areas of damage in the right and left hand faces. An additional 20 free standing tests again on 28 grade bricks were introduced into the second shelf level of the kiln together with 24 tests on the third shelf level of the kiln.

After firing #10 a major overhaul of the kiln was undertaken and both bag-walls were replaced. This is not surprising as the original bricks of only 23 grade were situated in the hottest and most violent part of the kiln. They were replaced with two layers of BNZ 30 grade bricks, first high fired with a brush coat of Purimachos Refractory Glaze Wash (PRGW) and afterwards with a cement coating comprising Secar 80 – 8 pts/calcined alumina – 4 pts, silicon carbide 220s 1 part. On top of the two layers were placed a course of BNZ 34 grade bricks untreated. The above cement mix was also applied to damaged areas in the left, right, back and roof faces of the kiln. The kiln was now showing extensive areas of damage after only 10 firings.

After #11, additional free standing tests were introduced to the front shelf of level three. After #14, it was noted that new damage to the kiln was a result of the too 'hard' mix of Secar cement, alumina and silicon carbide being pushed into the vertical and horizontal cracks opening up in the brick courses. This is an important point; perhaps it is common sense – if in trying to repair damage, a mix of harder consistency than the surrounding bricks is introduced, the softer bricks will take the brunt during the later expansion and contraction of the kiln. A mix of one pt cement, together with three or four pts filler (alumina calcined) would have been softer. Firings #14 – 18 recorded two significant factors: That sheets of brick and 'topcoat' of perhaps 3 – 5 mm thickness were beginning to separate from the main body of some of the bricks; and when this happened a brushcoat of Secar 80 cement – 4 pts, Wades calcined alumina – 8 pts, silicon carbide 220– 1 pt, was painted over the exposed brick surface. Sometimes this separating layer was removed to try to protect the new hot face. This separation of the top layer of the brick was only localised.

Before salt firing #20, it had become apparent that much of the fabric of the original kiln had deteriorated to the point that most of the original tests within the kiln were defunct having necessitated subsequent coatings of additional mixtures. The free standing tests now provided the best hope for the future. It was also being speculated that perhaps any cement coating might present problems through the differing contraction/expansion rates between brick and top coat. It was recognised that the procedure and application might be as important as the materials being applied; and that several applications of resist material and infrequent light remedial attention to damaged areas might be part of the final solution.



Results of tests suing From the top: HD 25 brick and Furnacecoat. Calor brick and ITC, 43 firings. HD25 brick with NT& coating. Calor 26 brick and NT7 coating, 43 firings.

A glass or glaze top coat seemed a sensible alternative. This, I reasoned would seal the surface pores of the insulating brick to prevent the absorption of the gases. But it might also prevent subsequent damage to the brick through contraction. A glass is fluid for a wide temperature range and the hardening of the glass occurs gradually. If the glass is in excess it should run but still provide a thinner impervious surface. It was also questioned what was the function of silicon carbide as an addition to many of the previous cement mixes. It was noted that of the original applications of materials to the brick surfaces, those containing a high per cent of silicon carbide often tended to be among the best in resisting the breakdown of the brick surface. What seemed to happen in such cases was that initially the silicon carbide mixture formed a dark glass. This, after repeated salt firings bubbled profusely, perhaps by as much as 5 cm forming a honeycomb mixture. After many more firings, this bubbling reduced in size but the brick was still afforded significant protection. If the proportion of silicon carbide in the mix was of the order of only 10 per cent, bubbling did not occur.

After salt firing #19 and following further discussions with staff of Ceram Research, Stoke-on-Trent, an evaluation was made of the kiln fabric and the three levels of free standing tests. From this, several additional factors emerged: That alumina seemed to be the highest provider of non-glass. It was probable that fineness and purity of material would be a significant factor. Thus Wades' calcined alumina (99 per cent pure) is probably more effective as a resist than calcined alumina (95 per cent pure) but that this in turn is probably more effective than alumina hydrate (85 per cent pure); That Purimachos Refractory Glaze Wash (PRGW) which had been noted as providing significant resistance when applied to the surface of the brick, formed a glaze which became more fluid in subsequent firings. It was speculated by Dave Shepherd of Ceram Research that the initial success of the material might be the reasonably high sodium content in its composition and subsequent melt and that this, in turn, might prevent later penetration by the airborne (sodium based) alkalis resulting from the introduction of salt to the kiln; That a 'glass' may be ultimately more successful than the cements. It would be necessary to test various kinds of glasses with different melting temperatures. These in turn might benefit from a 'topcoat' of a different type; perhaps a cement or an alumina or silicon carbide based material; That a veneer of a low grade base brick given additional protection through the bonding with a thin slice of a high alumina 34 grade brick or even Saffil blanket was considered to be worth investigating in the next series of free standing tests. (Saffil blanket and 34 grade bricks were at this point showing significant resistance when subjected to repeated firings.)

The function of the kiln had changed fundamentally after 19 firings. The kiln had now become the means of conducting further tests but would not provide the solution itself, as most original tests had been debased by being overpainted with other materials when they had become damaged through the repeated exposure to the salt gases. This meant that the kiln had to keep going for at least another 30 firings or so. Ten of the original tests on the bricks of the fabric of the kiln were still not totally discarded and these were duplicated within the new series of free standing tests. When the kiln was totally emptied to introduce the freestanding tests it was found that: The quarter cut 34 grade bricks used as props were, except for a slight discolouration still in excellent condition; The silicon carbide shelves had erupted on all surfaces with small rounds of green glass. This cleaned off easily with a chisel leaving the shelf intact and in good condition; and the new tests (numbering now 173)

Top: The new enclosure for Kiln #2. Above: Chimney cowl with adjustable top.

included all the better previous tests, a wide range of different glasses, both high and low temperature, together with several with a high sodium content. It also included many tests on which Purimachos PRGW high temperature glaze wash was first fired to 1200°C to provide an initial melt, after which a 'topcoat' was applied. Most of these new tests were applied on top of a BNZ 28 grade quarter-cut bricks.

Salt firing #20 was high fired without additional salt to try to protect and harden the newly applied 'topcoats' preparatory to the exposure of the normal heavy salt atmosphere. Salt firings #21 – 30 displayed the continued gradual deterioration of parts of the walls of the kiln. This was, where appropriate, remedied by additional brush coats of Secar cement together with an increased quantity of alumina and a little silicon carbide (to provide a softer fired surface from that previously applied). At this point it was felt that again the kiln should be emptied of all tests and a new sequence of tests introduced to test the more successful results. Now, however, instead of quarter cut 28 grade bricks as an individual test, it was hoped to simulate the nature of a kiln wall, which is made up of course upon course of bricks. Bricks were obtained from Premier Vesuvius to augment the range provided by BNZ.

Fired body tests demonstrating effective salt-glaze throughout the kiln.

The plan was to apply an individual resist to a pile of bricks of different specifications. Twenty additional tests were included as well as the 22 piles of bricks. A Saffil blanket test and a test of a laminate of a 23 grade brick bonded to a 34 grade 'bubble alumina' brick by Secar cement was also included. Those tests in which a cement resist was applied on top of a previously fired glass used a high vinegar/low water base to thicken the mixture and aid application. Vinegar was also used where silicon carbide was a necessary ingredient to keep it in suspension.

Salt firings #31 to 63 were undertaken between September 2001 and February 2002. During these successive firings the roof and walls of the kiln deteriorated seriously. From salt firing #43 onwards regular attention to the roof through the application of Purimachos Refractory Glaze Wash. (PRGW – NT7), did make a significant difference in limiting further deterioration.

After salt firing # 63, all new tests had undertaken 33 firings and the time had come to make a thorough analysis preparatory to the dismantling of Kiln #1. The Saffil blanket and 23/34 grade laminate were recorded as being worthy of further testing. Of the new tests, as a general principle, those tests which featured a cement on top of a glass displayed a fragmented top coat after firing. In many instances the glass beneath was still good and protecting the base brick. What was also interesting, was that in some instances, the lower grade brick was as good as or even better than a particular higher grade brick. It was recorded for instance, that a BNZ 23HD brick was, at the end of 33 firings, in a better state than a BNZ 30 grade immediately below it in the pile of tests.

Generally, the following bricks, all classified as 'bubble alumina' grade were in a reasonably good state irrespective of the applied resist. These included HR 33/180; HR 185; HR 185 HP; BNZ 34. They had on occasion cracked because of a higher than normal thermal contraction, but the brick was not significantly damaged through attack by the sodium vapour. However, of the lower grade bricks it was specific ones which were less damaged and also a specific resist was quite often responsible for a better than normal result through the entire pile of bricks. From analysis (and a series of photographs) various groupings of bricks were considered to be worthy of inclusion in Kiln #2. The base of the kiln was completed in March 2002. This comprised: A base of breeze blocks equipped with air spaces; a base of heavy firebricks running

Peter Meanley. ***Spouted pouring vessel.*** *2003. Kiln 2, firing #82*

The overview of the analysis recorded the following information:
NT8 (Pyruma 1A) is believed to be the best resist, on the 25HD and Calor 26 bricks.
NT7 (PRGW) is believed to be a good resist. On lower grade bricks it runs easily but on BNZ30 it produces a drier glass which leaves some areas subject to a slight 'pulling back' of the glaze which can leave the brick vulnerable. On 140HSR, NT7 produces a vigorous crystalline glaze which runs heavily as a viscose mix and in doing so, some surface lamination of the brick results.
NT9 Pyruma (1SLM) provides substantial protection on the arched 155PB bricks. By salt firing #32 slight 'flaking' of the glaze is beginning to take place.
NT43 on 130 HSR produced a brown crystalline glaze which runs profusely but which is still protecting the brick. It was not tested on other bricks.
By firing #42, NT8 had become the standard resist for 'touching up' damaged and exposed parts of the kiln.

across the line of the breeze blocks; A hearth comprising on the left BNZ 26 grade bricks and on the right BNZ 26/60 grade bricks.

The building of Kiln #2 presented a fine balancing act as the kiln was expected to fire up to100 times. If the entire construction was made from the 'bubble alumina' grade bricks, it appeared that these bricks would provide the numbers of firings required, yet the insulating properties of these bricks would take the kiln out of the category of one which could truthfully be called an insulating kiln, and also the cost would be high. If on the other hand the insulating 23HD brick was used throughout, it would have required a considerable act of good faith to believe that this brick, only classified at 1260ºC would be refractory enough for the numbers of firings required, let alone the continuous bombardment from the salt vapours. Yet this brick had performed well in earlier tests.

The distribution of the selected bricks was as follows: 1800ºC 'bubble alumina' bricks for the bottom four courses; two courses each of the high spall resistant 155/PB, 140/HSR, and 130/HSR; The top two wall courses comprised: Calor 26, 25HD, 23HD, in banks on the left, back and right faces. The roof was constructed from 155PB arched: 22 bricks making the full span and resting on the skewbacks on the left and right face walls. A layer of fibre covered the entire roof, topped with molars (diatomaceous brick). A layer of molars backed up the side, back and front faces of the kiln. As with Kiln #1, a thermocouple and oxygen probe were positioned in the roof.

The door bricks were built course on course and comprised 23NF, 23L, 23/130, B25, 25 grade, 26/60, 28 grade bricks. All were painted with NT7 as this seemed likely from the outset to be the most protective glass on these low grade bricks (these bricks had previously not performed well with the earlier cement facings in kiln1. But as door bricks can be replaced easily without jeopardising the kiln, it seemed a useful test to make.

As with kiln 1, kiln 2 was built without any kind of mortar. An amendment to the top of the chimney through the inclusion of a top cowl which included an angled top vane to deflect the wind and thus prevent the fierce 'blow backs' experienced with kiln 1 proved a success. Also the inclusion of two fitted wires to enable the cowl to be moved easily to face the wind without having to climb onto the roof to effect the change, greatly assisted the operation of firing.

Whereas the majority of tests in the fabric of Kiln #1 were 'blind chances', and many proved by as early as salt 9, not to be effective, those tests included within Kiln #2 had been found to offer significant success even after up to 30 firings. Thus, after salt firings #7 – 13 I recorded the following in my accompanying logbook. "The kiln is performing well with little need for remedial attention". That which was necessary was as follows: 23HD bricks – some peeling back of the glaze from the soft bricks underneath; These were painted over with NT7; Some brick courses in walls and roof showed signs of movement but is not considered dangerous. Again, an appropriate "touch up" with NT7 and NT8 remedied this; Some silicon carbide shelves were better than others. It was decided to make a study of this; Some damage was occurring to the various types of bricks which made up the door. This was to be expected because, after all, the test resists incorporated into Kiln #2 were all fluid and the glaze would run down the hot face of the bricks. The damage occurred when the individual door bricks were being taken out and bricks had stuck together. The running was more noticeable on the 23 grade bricks than on the 26/60 and 28 grades. But the damage to these door bricks was solely through this cause and not through the penetration of the alkalis from the salt vapours.

These same bricks, which had disintegrated quickly when situated in Kiln #1 and when covered with various cement facings, were now immediately seen to be more successful when covered with a glass. After salt firing #13, it was recorded that there was slight damage to the bricks adjoining the door in the side walls of the kiln and where localised glass was being formed. After firing # 17, the door bricks were replaced with 25 HDs overpainted with NT7. At this point, the following appeared to be the least damaged, of the tests. Up to this point, the pack system had always been made up of silicon carbide shelves. Different shelves had been tested with differing results. But always, whether after five or 20 firings, the green glass accumulating on the top and bottom course of the shelves had caused the ultimate demise of the shelves.

By firing #59 NT8 was the standard 'touch up' material for all parts of the kiln requiring light attention. This was particularly so for the entire arch where the peeling back of the original NT9 was exposing parts of the roof to the possibility of attack. Prior to each firing, a five minute remedial 'touch up' by a two-inch brush attached by tape to a two-foot long stick enables all parts of the kiln to be easily accessible. For some serious damage to some bottom course 'bubble alumina' bricks close to the burners and the areas where the side wall meet the back walls and where a significant hole has occurred, Lupufest 901 cement was applied and overpainted with NT8.

Before firing #59, a major crack to the left hand wall had given cause for alarm. This was the result of inferior metal work rather than attack by the sodium vapours. The top of the kiln appeared to have moved slightly forward. (because diagonal stays were not introduced from the outset).

In October 2003, the 80th and last salt firing was undertaken. The final 21 firings had been undertaken with little to comment upon. Each firing was, and always had been preceded by a visual inspection and a light 'touch up' with NT8. A visual analysis of the kiln and a photographic session after the final firing revealed: The difference in deterioration between the 25HD and Calor 26 bricks was slight; The differences between these two types of brick treated with NT7 and NT8 was also slight. This evidence can be assessed from those tests placed in the kiln before firing #38 and which received no 'touch up' before any of the successive 43 firings. The other tests of the same bricks were in place from the outset of Kiln #2 before the 80 salt firings. The bricks which have undertaken 80 firings were a little more debased but I am confident that the life expectancy of both types is good.

Peter Meanley. ***Spouted pouring vessel.*** *2003. Kiln #2,*

The main points learnt are as follows: That with an insulated hot faced brick kiln, a glass is likely to be far more effective than any kind of cement; That a specific high density brick is likely to be more effective than a higher grade non specific insulating brick; That the method of application of the 'topcoat' is important. This should be made from thin rather than thickly applied coatings. Also, if any parts of the hotface peels away it must be immediately replaced. The coating mixtures are diluted with water and mixed to the consistency of a thin cream before being painted on the surface. The painting of the surface is thus easy, but care must be taken to ensure that no holes or patches remain untreated. It is advisable to high fire the kiln to melt the glass 'topcoat' before commencing with salt firings.

NOTES:

The materials: NT 7 (Refractory glaze Wash PRGW) and NT 8 (Pyruma 1A) are manufactured by Purimachos.

The bricks prefaced by HR are manufactured by Premier Vesuvius. All other bricks used are manufactured by BNZ, the numbers denoting the grade. The higher the number the higher the grade classification.

Peter Meanley is a maker of salt glazed pouring vessels with 20 years of experience as a salt glazer. He writes: "My kiln site is a farm owned by Lady Blackwood (and to her I owe a great debt of gratitude) in the country and away from any possible complaints. I am also grateful for the assistance throughout the project of Brian Porter, a friend, former student and retired civil servant. His enthusiasm and reliability throughout the four years making a high proportion of the accumulated firing numbers has been vital. David Maybin of Scarva Pottery has taken an active interest and provided me with many samples and tests."