Furnascote

Refractory Coating

General

Furnascote is the-collective name for a series of refractory coatings designed to protect the bricks, monolithics, castables and steel shells in furnaces, boilers and various high temperature vessels.

Furnascote refractories are characterised by a very high content of zirconia (as 62.9% ZrO_2) which imparts extremely high resistance to the aggressive environments typically encountered at temperatures up to 1900°C. Furnascote has better adhesion than most conventional zirconia based refractories.

The Two Main Furnascote Types

NONVIT	
Finish:	Matt, buff coloured, non-vitreous.
Temperature Range:	Up to 1910°C
HIGLAZE	
Finish:	Vitreous, highly glazed.
Temperature Range:	850°C to 1250°C

NON-VIT is the versatile, general purpose product. HI-GLAZE is used as a slag resistant finish to NON-VIT in annealing furnaces, spouts and funnels.

A 3mm protective layer of Furnascote can typically increase the working life of any underlying refractory by a factor of two to four times. Furnascote is supplied in the form of a powder which is mixed with cold water to the consistency of a paste, cement or slurry prior to application by trowel, brush or spray.

Main Uses for Furnascote

- To reduce the effects of thermal shock.
- To protect refractories against the aggressive effects of burning fuel oil, gas and solid fuels.
- To produce a gas tight surface and minimise energy losses.
- To reduce spalling.
- To eliminate cracking.
- To reduce slag adhesion.
- Generally, to increase the working life of furnaces and reduce the costs of maintenance shut downs.

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Furnascote is used regularly in the following industries and processes

- **Aluminium**
- **Brass and Non - ferrous**
- **Ceramics and Pottery**
- **Chemical**
- **Fertilizer**
- **Natural and Town Gas**
- **Iron and Steel**
- **Marine Shipping**
- **Nuclear Energy**
- **Petroleum**
- **Pulp and Paper**
- **Sugar Refining**

Preparation

Furnascote should only be applied to sound, clean surfaces. Old refractory surfaces must be thoroughly cleaned with a scraper or wire brush removing all loose pieces. Any glassy surfaces should be roughened with an abrasive disc. Cracks and holes should be cleaned out then filled with a cement of NON-VIT.

Mixing

Mix Furnascote with cold water to a smooth, creamy consistency as follows :

Mix Form	Litres of Water per 25 Kg	Method of Application	Thickness of Coating
	NON-VIT		
Cement	3 litres	Trowel	1 to 3 mm
Paste	4 litres	Spray	0.5 to 3mm
Slurry	3.75 litres	Brush	0.25 to 2mm
	HI-GLAZE		
Paste	4 litres	Spray	0.25 to 3mm
Slurry	3.75 litres	Brush	0.25 to 3mm

Use a mechanical stirrer. Allow to stand after mixing for at least 1 hour then re-mix briefly.

Application

Using a brush, trowel or spray, coat the furnace walls, hearth, ceiling, bridges etc. to a thickness of 1 to 3mm as required. After an hour, further coats of **NON-VIT or HI-GLAZE** may be applied. The mix should be stirred every few minutes during application to prevent settling of heavy ingredients. For spray application, use a gun suitable for textured paints fitted with a gravity fed hopper. Nozzle = 4 to 6 mm, air pressure at 80 to 100 p.s.i.

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Drying

The coating must be absolutely dry before firing. Under ambient temperatures, allow approximately 6 hours per 1mm thickness of coating. Warm air and good ventilation will shorten drying times. A minimum of 12 days should be allowed when NON-VIT has been used as a mortar for building with new refractory bricks or has been used in deep repairs.

Firing

Raise firing temperature as slowly and evenly as possible, typically at 50°C per hour, until 1000°C is reached. Thereafter, for NON-VIT, the furnace may be heated to its working temperature as usual. For HI-GLAZE the first firing must attain at least 1200°C, thereafter, any temperature up to 1650°C can be used.

Properties

Coverage	Approx 3Kg per m² at 1mm thickness.
General Properties	Odourless and tasteless, non-toxic.
Form	Dry powder, density = 3.32, Bulk factor = 2.12.
Packed	25Kg plastic drums.
Chemical Resistance	After firing, Furnascotes are unaffected by most acids and alkalis in liquid or gaseous form, NON-VIT being particularly resistant to Vanadium pentoxide. A 3mm coating is gas tight at normal pressures.
Physical Properties	Becomes slightly elastic above 200°C thus providing outstanding Resistance to thermal shock. Thermal expansion is approx. 1% over the range 0°C - 1910°C. Shrinkage is less than 0.25%. Emissivity Value = 0.58. K Value = 3.5 at 500°C. Resistance to powdering is excellent.

Chemical Analysis of NON-VIT*

Zirconium	62.97%	Aluminium	1.63%
Calcium	1.37%	Sodium	4.03%
Magnesium	0.34%	Silicon	28.06%
Titanium	0.25%	Boron	1.10%
Fluorine	0.25%	(as fluoride)	

*Mainly as oxides

Resistant to temperatures of 1900°C

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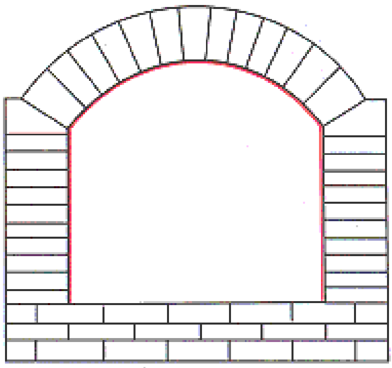
Furnascote Nonvit

Some Miscellaneous Applications

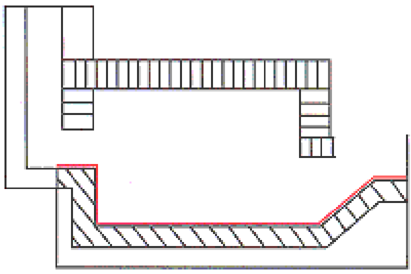
Incinerator / Crematorium



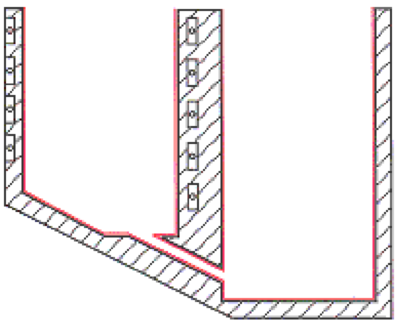
The usual problems encountered are those of thermal shock and slag formation. A coating of Nonvit at 2 to 3 mm minimises the life of the refractory lining.

Aluminium Melting / Holding Furnace (1)

The refractory lining is typically a high alumina castable which is subject to the destructive effects of high temperature and molten aluminium. The frequency of repairs is reduced by a lining of 3 to 6 mm Nonvit.



Aluminium Melting Furnace (2)



3 mm of Nonvit will seal the refractory against the leaching effects of molten aluminium. 6mm is used to line the connencting channel.

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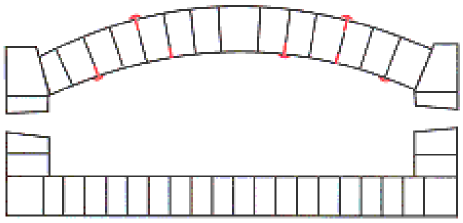
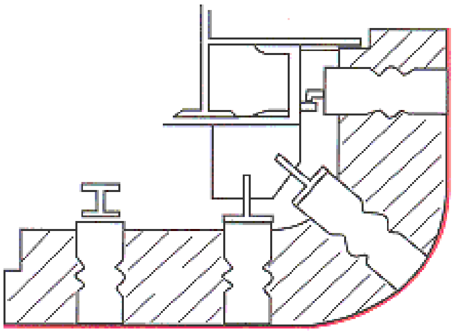
Glass Melting Furnace

Nonvit is used for patching cracks, crevics and joints on the crown. It may be applied by trowelling, ramming, tamping, pouring or caulking.



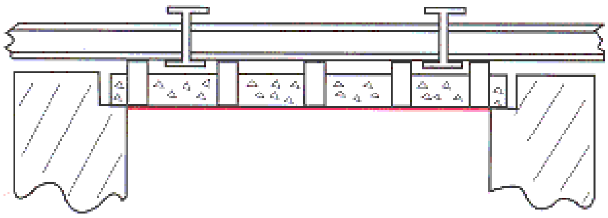
Nose Arch in Field Erected Water Tube Boilers



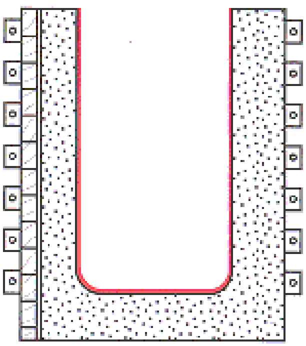
This part of the boiler is subjected to both hugh tempretures and slag attack from the products of combustion. A coating of 2 to 3 mm of Nonvit on the refractory sirface will minimise the effects of spalling, slagging and abrasion.

Suspended Monolithic Roof of Field Erected Boiler Usiong Both Oil and Solid Fuel

A coating of 2 to 3 mm Furnascote Nonvit applied to the refractory surface increases it resistance to the destructive effects of spalling, slagging, chemical attack and erosion.



Induction Furnace



The rammed lining is subjected to chemical attack by molten metal and to cracking and spalling from thermal shock, 1 - 3 mm of Furnascote Nonvit will reduce these effects, extend the life of the furnace and improve the quality of the processed metal.

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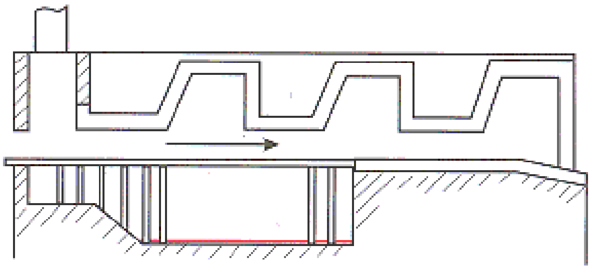
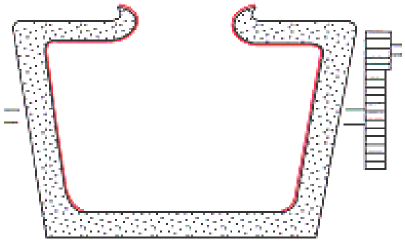
Reheating Furnace

A thin coat of 1 to 2 mm Nonvit reduces the adhesion of slags to the floor. The Nonvit makes it easier to remove slag when cleaning.



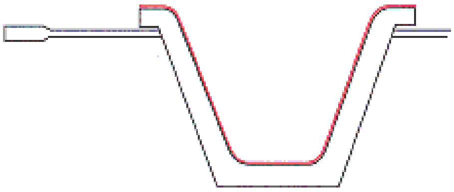
Receivers



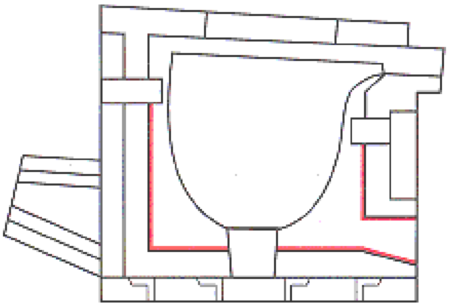
A coating of 2 to 3 mm Furnascote Nonvit on the walls and lips of receivers will prolong the life of the lining.

Small Ladles

Hand ladles lined with mouldable refractory can be coated with 2 to 3 mm Nonvit to increase the number of heats and increase production life.



Crucible Furnace



Frequent repairs are necessary due to the damaging effects of high temperature and thermal shock. These conditions cause cracking of the refractory lining and heat losses. Nonvit coated at 2 to 3mm , will eliminate or minimise the problem.

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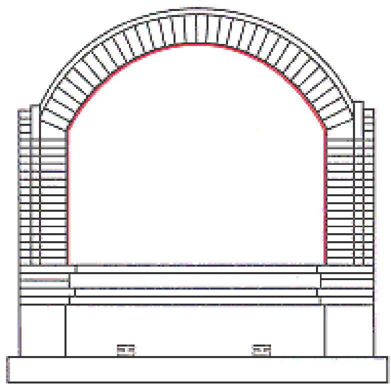
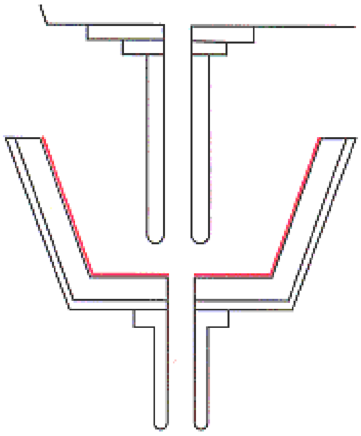
Tunnel Kilns

Thermal shock and slag formation are common problems with high refractory wear around burner ports. Salt glazes are corrosive to conventional refractories. A coating of Furnascote Nonvit at 2 to 3 mm mininises the destructive effects of combustion, glazing and thermal shock. Slag removal is easier and reject rates reduced.

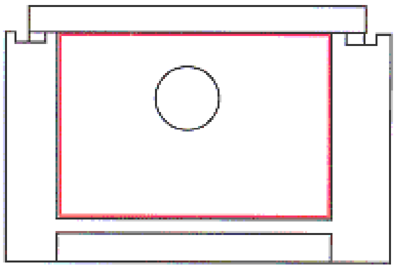




Steel Tundishes Frequent repairs and shutdowns are encountered due to the effects of high temperature and thermal shock. A thin coat of 2 to 3 mm Nonvit prolongs the life of the refractory lining.

Soaking Pits

High temperature and thermal shock lead to spalling of the refractory lining. These effects and hence the cost of maintenance can be reduced by application of 2 to 3 mm Nonvit.



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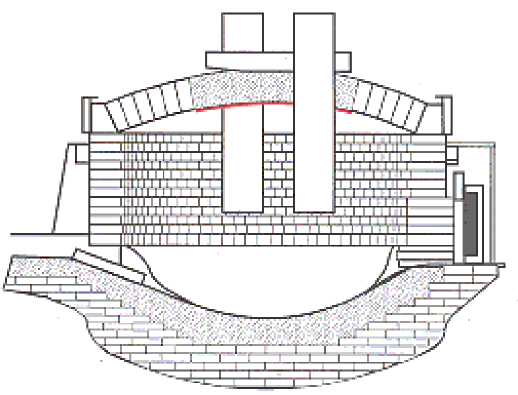
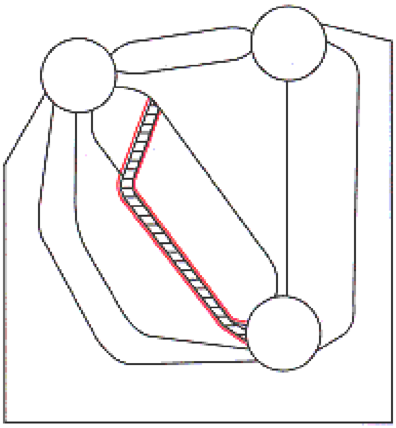
Electric Arc Furnace



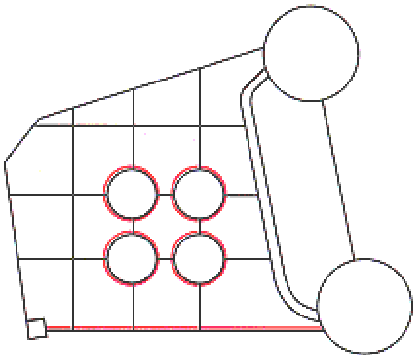
The centre section of the roof is made of either castable or plastic refractory. A coating of 2 to 3 mm of Nonvit will minimise the destructive effect of high temperature and thermal shock, prolonging the life of the refractory.

Baffles In Water Tube Boilers

A thin coat of 1 to 2 mm of Nonvit on the baffles prevents or minimises the effects of spalling, reduces the adhesion of slag and ensures a gas tight surface.



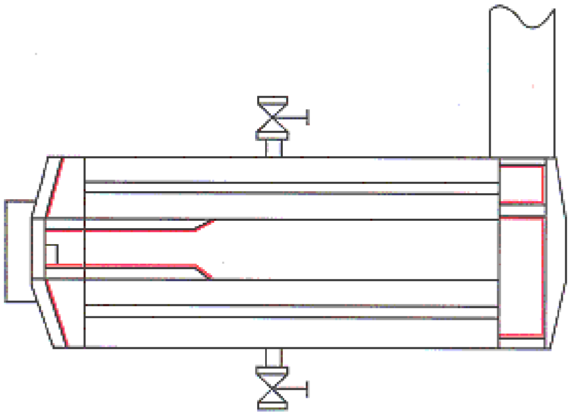
Watertube Oil Fired Power Boiler



The burner throat is subjected to intense wear and tear due to the effects of high temperature, slagging, chemical attack, erosion and thermal shock. A coating of 2 to 3 mm of Nonvit resists these combined effects on the refractory lining. A coating of 1 to 2 mm on the walls and floors minimises the adhesion of slags and helps in prolonging the life of the refractory life.

Firetube Package Type Boilers For Processing

High temperature, thermal shock, slags, chemical attack and erosion have a devastating effect on the parts exposed to heat, particularly the burner throat. A 2 to 3 mm coating of Furnascote Nonvit on the burner throat and a 1 to 2 mm coating the rear and front baffles will extend the life of the refractory lining.



Furnascote Nonvit

Improving Power Station Efficiency

Furnascote NONVIT can improve power station efficiency by increasing the life of the burner quarls and reducing down time.

Large modern burners benefit as much as older designs

Furnascote NONVIT Acts as a protective coating on silicon carbide pre-fired quarl tiles and surrounding areas and quards against the effects of vanadium pentoxide attack.

Renovation of Burner Throats with Furnascote NONVIT

(courtesy, Mitsui Babcock Energy Ltd)

Preparation

Any large build up of slag will be carefully removed from the burner throats. Small areas can be left if firmly adhered and is not detrimental to the setting. If the remaining slag is glazed, it will be roughened up with an abrasive wheel to give a key. All remaining loose particles and dust will be removed.

Application

A 1mm brush coat of Furnascote Non Vit will be applied filling in any cracks or voids. Allow to dry for 30 minutes before the application of a second coat which will be applied by trowel to a finished thickness of 3mm. The second coat will be trowelled to a smooth finish.

Dry out and bake in

The finished throats will be left to air dry for 48 hours. They will then be slowly heated at 250°C / hour up to 1500°C gas temperature where it will be held for 5 hours. The heating cycle will continue with a steady temperature rise over the next 48 hours up to the maximum furnace temperature.

When coming off load the refractories should be allowed to cool naturally.

Increasing the life of Burner Quarls

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Furnascote Nonvit

Let Furnascote Help You

Potters' kiln problems such as salt and soda damage can be reduced by a washcoat of furnascote NON VIT.

Kiln Problems

Your kiln has to endure a hard life. It fires pottery turning it from a damp piece of clay to a crisp pot. Many hours of heating will be involved before the kiln is allowed to cool. Most kilns are constructed from fire bricks with or without a monolithic, castable or some other refractory lining.

Salt Glazing - The practice of salt and soda glazing produces vapours which are highly corrosive to kiln bricks and linings and which reduces the working life of the kiln. The vapours of these salts and glazing compositions condense on the kiln lining as well as on the pottery items, then drip down on to the items being fired. These "droppers" create rejects.

Thermal Shock - Irregular heating and cooling creates thermal shock which eventually causes the lining to crack and break down resulting in loss of heat and further physical disintegration of the firebricks. Disintegrating lining and bricks causes damage to all types of finishes and glazes resulting in rejects and the waste of valuable time and artistic effort.

Energy Loss - Damaged kilns will of course, allow heat to escape resulting in wasted energy and unreliable temperature control.

Furnascote NONVIT

Furnascote is a zircon containing refractory composition which is refractory to 1910°C. It is supplied as a powder which is mixed with approximately 10% by weight of water to make a cement or slurry as required. It may be used both in the construction of new kilns and to repair and maintain existing units. Furnascote is highly resistant to both thermal shock and to the corrosive effects of the various vapours and fumes generated in furnaces and kilns. It reduces slag adhesion, minimizes droppers and prolongs the life of existing fire bricks and linings. It is easy to apply.

Brick Variations - Furnascote may be used with most of the refractory brick types commonly used for kiln construction. Before coating soft, lightweight insulating bricks, we recommend that new bricks be fired to their service temperature for a few hours to allow any permanent shrinkage to develop. We also recommend a subsequent test-patch of Non Vit to confirm adhesion under normal kiln operating conditions prior to a complete application.

New Kilns - Furnascote can be used as the mortar to bind the fire bricks during the construction of a new kiln. Make a cement of Non Vit and fresh water, leave to stand for at least one hour prior to trowelling or brushing the cement between the bricks to a thickness of 1.2 to 2mm. Assemble the treated bricks to form your kiln. Leave for 3 to 4 days to dry out. See note on Brick Variations. Then wash coat the walls, roof and hearth facing the source of heat with approx 1mm Non Vit as a slurry. Leave overnight to dry before heating slowly to around 750°C to set the Non Vit, although the temperature above 500°C will be satisfactory at this stage. Roof arches should be of accurate construction so as to be under minimum stress when heated. Test-patch if unsure.

Existing Kilns - Scrape and clean any cracks or holes and fill them with a Furnascote cement and level off. Allow to dry for 2 to 3 days. Abrade and clean all inside surfaces before applying Furnascote Non Vit to a thickness of 1 to 3mm depending on the degree of protection required. Leave to dry out for 1 to 3 days before firing as New Kilns above.

Coverage - Approx 3kg per sq metre at 1mm thickness.

Furnascote Zircon-Rich Refractories

General

Furnascote is a collective name for a series of refractory coatings containing high percentages of Zirconium compounds, designed to protect the refractory bricks, monolithics, castables, and steel shells in furnaces and boilers, etc. They are easily applied by trowelling, brushing or spraying, by semi-skilled labour.

Each of the furnascote types is designed to fulfill a particular function and to be effective within a definite temperature range. The various types are as follows:

		Temperature range	
		Fahrenheit	**Centigrade**
NONVIT	Gives a smooth matt white surface to refractory linings.	50 to 3500°	**10 to 1910°**
HIGLAZE	Gives a brilliant glaze to even the roughest refactory surface, used as a finishing coat over Mortar or NONVIT.	1562 to 2282°	**850 to 1250°**

The purposes for using Furnascote refractories are:

a. **To reduce slag adhesion.**
b. **To reduce spalling.**
c. **To eliminate cracking.**
d. **To give a gas-tight surface.**
e. **To attach refractory to metal walls.**
f. **To reduce the effects of thermal shock.**
g. **To protect refractories against the vicious attack and sand-blasting effect of burning fuel oil.**
h. **To increase the working life of furnaces.**

Furnascote is supplied in the form of powder, packed in Steel drums, each containing (25 Kg.). Designed to withstand arctic, tropical and monsoon climates, which enables stocks to be kept indefinitely in store without deterioration. HIGLAZE is packed (25 Kg.) per drum.

The application of furnascote was described in a special leaflet "NONVIT/Spec/January 1969" which is now included in full on next page.

The use of Furnascote NONVIT has proved beneficial to many industries in solving two principal problems, "Adhering Refractory to metal", and " Thermal Shock". Therefore, these two subjects are dealt with in greater detail on the following pages.

Purpose of NONVIT

Furnascote NONVIT is designed to provide the following functions:

1. A protective coating inside furnaces, catalytic crackers, hydrolisers, reactors, heating and re-heating furnaces, heat exchange units, jet burner areas, sulphur recovery plants, and steam producing units.
2. To protect the refractory brickwork, or castables, from attack by corrosive chemicals at elevated temperatures. Chemicals such as sulphur compounds, gases, acids, alkalis, steam, catalysts, products of combustion, furnace atmosphere, chemical composition of reaction products. slags, fluxes, etc.
3.
    a. NONVIT is self supporting up to 1/4" (6 mm) coatings.
    b. NONVIT provides a gas-tight coating at the flame surface, and a gas-tight mortar to bond the firebricks.
    c. NONVIT provides protection against effects of Thermal Shock.
    d. NONVIT will seal spalls and cracks.
    e. NONVIT has a wide temperature range of operation from 100°C to 1910°C (212°F to 3470°F).
    f. NONVIT can be applied as thicker coatings using wire mesh as a reinforcement. (see under Rotary Kilns).
    g. Although the uses of NONVIT are directed towards the petro-chemical industries, and, examples are quoted from site applications, the same specifications should be used for MARINE and INDUSTRIAL furnaces outside the oil industry. Wherever fuel oils, coal, wood, peat, gas, etc., are burned in furnaces, the problems of containment, wear and tear, Thermal Shock, etc., are similar. Therefore, this specification is one for universal use.

Application of NONVIT

Building of New Walls

1. To seal new brickwork and produce a gas-tight bond between the bricks, NONVIT is used as the mortar with which to bond the refractory bricks.
2. Add fresh water to NONVIT dry powder to give a render consistency for trowelling on the bricks as a mortar. Mix the NONVIT mortar in an ordinary cement mixer for 5 minutes, in batches of 1 to 3 cwt. lots, (50 to 150 kg.).
3. Splash some water on the bricks to dampen the surface. Trowel on to the bricks at an approximate thickness of 1/16" (1.5 mm). Build up courses to required height. Quantity of NONVIT needed per brick is 1 lb. or 0.5 kg. at 1/16" thickness. (If the 6 sides of the brick are coated, the quantity needed is 2 lbs., or nearly 1 kg.). Size of brick used is 9" x 41/4" x 3", (22.5 cm x 11 cm x 8 cm).
4. If the bricks facing the flame zone are glossy and dense, scratch this surface with a revolving abrasive wheel to give a "key". If the bricks are porous, they require no special treatment.
5. Dilute the NONVIT cement with extra water to produce a thick cream, and brush two coats on to the brickwork to give approximately 2 mm. coating. Leave the brickwork for at least 7 days to dry out the mortar and the surface coating. Artificial heat can be used to get maximum drying. (i.e. warm air, electric heaters, torches, etc.).
6. When the furnace walls are completely dry, raise firing temperature at 40°F per hour to 1832°F. Bring up gradually (evenly) and continuously, so that you reach 1000°C within 96 hours. Thereafter, reduce to 7000°C

(1292°F) or lower, (whichever is the operating temperature) and leave at this temperature for 3 days. The furnace, or heater, is ready for operation.

7. Because of a wide range of conditions both in the use and the applications of NONVIT, we welcome your specific enquiries. These will enable us to submit the correct specifications with the most suitable means of application. For example:

Special types of Walls

Sometimes severe operating conditions require special treatment, for example: cyclic gas reforming plants, when live steam is injected into the chamber at intervals. This causes violent drops in temperature, followed by rapid rises. This starts violent Thermal Shock which damages brickwork and linings of the furnace. In this type of construction, it is necessary to use thicker coatings of NONVIT which must be reinforced with steel wire mesh to support thicker coats of 6 mm to 12 mm thick.

Method used is as follows:

1. Mortar the brickwork with NONVIT cement as in the building of new walls.
2. Dry out the walls for 3 days with hot air or torches to remove moisture from the mortar and the bricks.
3. Render on to the walls by trowel 1/8" (3 mm) of NONVIT cement. Whilst the cement is still damp, layover it high tensile steel wire mesh, 19 gauge S.W.G. 1/2" (12 mm) gaps. Hammer at 12" (300 mm) centres, 1" (25 mm) high tensile steel staples to secure the wire mesh into the NONVIT mortar gaps between the brick courses. A pneumatic hammer to punch the staples into the courses, should work at a minimum of 80 lbs. per square inch pressure. This will hold the layer of NONVIT tight to the wall.
4. Dry this first layer for 3 hours and whilst it is almost dry, trowel on another 1/8" (3 mm) layer of NONVIT. This gives a reinforced coat of 6 mm (1/4"). Leave for at least a week to dry out thoroughly. When completely dry, raise temperature at 40°F per hour at the start. Then bring up gradually (evenly), and continuously, so that you reach operating temperature within 96 hours. Now, the furnace is ready.
5. If 1/4" (6 mm) is considered insufficient, an extra 1/8" (3 mm) can be trowelled over the second layer to give a total thickness of 3/8" (9 mm). In this case, increase drying time to 5 days before firing. Drying can be improved by artificial means, i.e. hot air, electric heaters, etc.

Application of NONVIT to roofs of Heaters

The method of application is given in detail on page 6 of this booklet, and is as follows: Construction of furnace roofs poses the problem of gravity pull, which can cause loss of adhesion of refractories during the critical stage of first firing of the Heater. To eliminate trouble at this stage, we advise the following procedure:

a. Whilst the refractory bricks are being mortared in the ceiling, at intervals of 18" (45 cm) lap a length of 16 gauge mild steel annealed wire behind the brick so that it dangles from the roof 3" (75 mm) proud.
b. The Furnascote NONVIT will be setting as a mortar between the bricks and will secure the wire.
c. The next stage will be the application of the NONVIT at 1/8" (3 mm) on to the bricks, followed by a layer of wire mesh.
d. The dangling wire can be tied securely to the wire mesh and hold it firmly whilst the staples are hammered into the seams. Thus, the wire mesh is held firmly in place whilst the final coat of NONVIT is trowelled on.
e. By this means enormous strength is given to the attachment of NONVIT and the wire mesh, whilst initial heating is applied to the roof. Once the NONVIT has set hard, the composite mass has great strength.
f. Approximate quantities needed to meet the Specification for walls, roofs and floors, are:
    1. **As a bond to mortar the furnace bricks** at 1/16" (1.5 mm), (to cover the bottom and two sides of the brick), 1 lb. (nearly 0.5 kg) per brick. Size of brick is 9" x 41/4" x 3", (22.5 cm x 11 cm x 8 cm).

2. As a coating over the furnace bricks exposed to the heat, at 1/4" (6 mm) 41/2 lbs. per square foot (2 kg). Size of brick is 9" x 41/4' x 3", (22.5 cm x 11 cm x 8 cm). (This quantity will vary with the nature and area of the brick surface. A porous brick will need more NONVIT than a smooth one).

Genera1 application of NONVIT, on existing heating units made up of refractory bricks, mouldables and castables, the following is carried out:

1. Prepare the NONVIT with fresh water to form a creamy paste which can be applied by brushing.
2. Wire brush the surface of the bricks or mouldable. If the surface is dense and glossy, scratch it with a revolving abrasive wheel to give a "key".
3. Brush one coat on to the brickwork to give approximately 1 mm., and leave for 30 minutes. Brush a second coat; leave for 15 minutes. Build up to 2 mm final thickness.
4. If the bricks, or castables, are porous, one brush coat should be applied, left for 30 minutes, and a final coat trowelled on to give 2 mm thickness.
5. Leave the NONVIT to dry out thoroughly. A minimum of 48 hours drying should be sufficient. Commence firing at 40°F per hour, increasing by 5° per hour for the first 24 hours. Gradually increase firing temperature to reach 1000°C in 96 hours, (1832°F). Reduce to 700°C (1292°F) or lower. (Whichever is operating temperature), leave for 72 hours. This will set off the NONVIT to give maximum strength and refractoriness. The Heater is then ready for operation and injection of superheated steam at 1900°C (374°F) each day at the change of shifts, for cleaning out the Heater. This is a particular example, but the same procedure for firing applies where Thermal Shock occurs. Where other refractories, castables, mouldables, are used in the same structure, firing should be of the order of arise of 40°F per hour to operating temperature. This will keep in line with temperatures recommended by suppliers of other refractories, which are to be used together with NONVIT.

Upgrading of Heaters

Existing Heaters can be upgraded by applying 2mm of NONVIT on to brickwork, castables, refractory concrete, etc. If temperatures desired in the new processing exceed 1100°C (2012°F), we advise extra NONVIT to give a minimum thickness of 3mm.

If the upgrading of a furnace or heater is likely to increase effects of Thermal Shock inside the structure, we recommend that the coating of NONVIT be increased to 1/4" (6 mm) and be reinforced with steel wire mesh to obtain maximum strength; using method described later under "Special types of walls". In this application, securing the wire mesh to courses of brickwork by hammering steel staples to secure the mesh to walls, is straightforward. Should the walls consist of castables or refractory concrete, the steel staples securing the wire mesh can penetrate the concrete by use of a pneumatic hammer working at a minimum of 100 lbs per square inch air pressure.

Special applications of Furnascote NONVIT, such as attachment to metals.

Attaching refractories to metals involves special techniques. The purpose of the application is to provide protection of steel sections where castables, bricks, etc., cannot be employed, such as steel chimneys, rotary kilns, trunking, etc. The purpose of using NONVIT is to:

1. Stop the steel walls distorting under the influence of heat, as in the case of a rotary kiln.
2. To protect a steel chimney or steel trunking from corrosion by acids, alkalis, sulphur compounds, etc., at elevated temperatures.
3. To protect steel walls of heating chambers which are containing chemical reactions at high temperatures, such as hydrolisers.

Resistance of Furnascote

Furnascote is Resistant to the following:

- **Furnace atmosphere.**
- **Products of combustion.**
- **Combustion residues.**
- **Chemical composition of the charge.**
- **Composition of reaction products.**
- **Influence of air, humidity and steam.**

NONVIT is odourless, tasteless, and is non-poisonous to users or workers, and is unaffected by most acids or most alkalis in liquid or gaseous form.

Slag Formation

Acidic compounds give slight films of slag, but, generally, NONVIT resists corrosive attack by acids, such as sulphuric, hydrochloric, and organic acids at elevated temperatures. Alkaline compounds do tend to form slags, but once the slag reaches approximately 2 mm., it detaches from the NONVIT and falls off. Owing to its resistance to adhesion it takes longer for slag to form on NONVIT, than with most other refractories. When the NONVIT coatings have hardened off, under the influence of the first firing, the mat surface has great resistance to acids and alkalis.

Physical Properties of Furnascote NONVIT

1. NONVIT is a cream coloured dry powder, which is mixed with fresh water to produce a cement, or a slurry, (having a thin consistency to enable the mixture to be applied by brush, or spray, as thin coatings). When the moisture has dried off before first firing, and it hardens off, from ambient to high temperatures, it remains almost white in colour.
2. As a dry powder inside tropic proof drums, NONVIT remains inactive, so that its shelf life is infinite. When fresh water is added to the powder, a bonding action takes place and the material forms a smooth cement. This is applied to refractory bricks as a wet cement and moisture is dried off. Shrinkage is extremely low, so as to produce minimum distortion.

Coverage of Furnascote NONVIT

Furnascote NONVIT will give the following coverage on average surfaces. A porous surface will require more material.

- 1/16" (1.5 mm) thickness will need approximately 1 lb. per sq. ft. (4.6 kg/m^2).
- 1/8" (3 mm) thickness will need approximately 2 lbs. per sq. ft. (9.2 kg/m^2).
- 1/4" (6 mm) thickness will need approximately 4 lbs. per sq. ft. (18.4 kg/m^2).

Application of Furnascote NONVIT Refractory Coatings to Brick Built Kilns, Furnaces and Combustion Chambers.

A brick built kiln was required to withstand Thermal Shock. The Furnascote Engineers used the following construction based on past experiences :

1. NONVIT was used as a cement mortar between the firebricks at approx. 1/8" (3mm) sandwich, applied by normal bricklaying methods by trowel. The NONVIT was stirred in a cement mixer to give desired consistency.
2. On the walls and ceiling facing the flames an empty gap of 1" (25mm) depth was left between the bricks to act as a "key" for the final coating of NONVIT to adhere to the firebricks.
3. A 1/8" (3 mm) coating of NONVIT was rendered into the brickwork and filled the gaps, leaving the top of the staples (pins) proud.
4. Mild steel wire mesh (chicken wire) half inch gaps, was then pressed tightly onto the NONVIT wet coating and secured tightly to the staples with wire.
5. A final coat of NONVIT was rendered over the wire to give a total thickness of 1/4" (6mm). The chamber was then heated at approx. 200°C. to dry out moisture. Heated overnight for 12 hours.

Calculation of Costs

The time taken by a normal bricklayer to complete a kiln using 5,000 firebricks, was six days. He used 1 1/2 lbs. (0.7 kg) NONVIT cement per brick. 3 1/2 tons (3,700 kg) of NONVIT was used on this kiln, which included coating the inside walls and ceiling, and hearth. The kiln was heated for 7 days before going into continuous operation at 800°C.

Advantages Obtained By Using NONVIT

1. Resistance to vicious chemical attack from impurities in fuel oils and. processing of hydrocarbon compounds at elevated temperatures up to 1910°C.
2. A temperature range from 100 to 1910°C.
3. Protection given to expensive firebricks against Thermal Shock where operating temperature fluctuates violently.
4. The NONVIT coatings seal in all hot gases and prevent cracking of the structure.
5. Semi-skilled labour can be used in case of emergency.
6. The life of such kilns using NONVIT, in comparison with furnaces using conventional refractory, would be increased by at least three times.
7. Maintenance is reduced, and production is increased.

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Some Notes on Thermal Shock

The term thermal shock is defined and discussed in this article in relation to its effects on materials used to line process plant and equipment, such materials being generally defined as refractory and having low coefficients of thermal conductivity.

The Encyclopaedia of the Iron and Steel Industry (1956) defines thermal shock as 'stress induced in a material by rapid and uneven heating.' Such stress may not manifest itself physically if it is at a low level, but when it reaches the yield point of the material, failure results.

The mechanism of failure due to thermal shock may vary from material to material, so an analysis of the process leading to such a failure is in order here.

When a body of material having low coefficient of thermal conductivity is subjected to a rapid change in temperature, then differential expansion or contraction takes place within the body, 'and a strain is thus induced in the material.

Obviously, the coefficient of thermal expansion plays a part in determining the level of this strain but, in any case, if the thermal stress thus induced in the body exceeds the yield stress of the material, then cracking will result from the relief of stress. Whether the failure is tensile or compressive, shear or cohesive, depends on the direction of the induced stress and, to a large extent, the geometry of the material.

Several authors have produced formulae linking expansion and conductivity coefficients, Young's modulus, ΔT and shape factors, in order to try and quantify thermal stress levels, but these have been mainly devised for use with thin layers of materials like enamels or refractory films. As far as is known, no attempts have been made to quantify thermal shock and stress levels for macro thicknesses of refractory materials. Thermal shock, will, of course, be experienced by any material that undergoes rapid temperature change, but with metals for example: the high thermal conductivity of the material ensures that minimum damage will result from thermal stress, especially in view of the elastic nature of the material. Rather it is the other effects of heat on metals that cause damage-oxidizing, corrosion by contact with hot reagents, or bringing them near to, or above, their softening points.

Thus, when temperatures are required in metal containers-for example in chemical process vessels, or boilers-some form of protection is required to prevent damage to the metal which would otherwise shorten the life of the container to below its economic level.

The usual form of thiS barrier is a refractory material compounded of clays and other minerals, and these have the advantage of being cheap, whether they are applied as firebricks, monolithic coatings, or castings, and also easy to apply.

Their greatest inherent disadvantage is that they have a low coefficient of thermal conduction and this, coupled with the fact that they are usually brittle, means that they are susceptible to the effects of thermal shock, as outlined above.

In many industrial applications, refractories are heated slowly to the operating temperature of the plant and maintained at these temperatures for considerable periods of time. When they are cooled, the process is allowed to proceed slowly. In such applications, breakdown due to thermal shock is rare. In many processes however, rapid changes of temperature are the order of the day, and the avoidance of thermal shock by costly industrial subterfuge can only be justified on the grounds that if the phenomenon is not avoided, maintenance down-time is the result.

The Petro-Chemical Industry: As an example of problems with Thermal Shock

A vast amount of heat is required for the running of an oil refinery. Temperatures encountered on the 'hot' side of such an installation range from 500 to 3700°F. (260-2040°C.) and the longer a given hot process can be run, then the more profitable is the operation. Using such temperatures for long periods introduces the problem of corrosion of the plant, and this corrosion is often accelerated by the effects of thermal shock. To protect a plant from corrosion without compounding the problems by introducing thermal stressing, requires the use of very expensive refractory materials for which there are at present no substitutes. As efficient plant utilisation and long amortisation of capital, equipment plays an important part in keeping the capital write-off fraction of saleable product prices to a minimum, then refinery production and maintenance engineers must pay real attention to the refractory protection of their plants.

Examples of "Thermal Shock"

In some circumstances thermal shock can be forecast exactly, due to the type of process being operated, Examples of this are:

1. Heaters which operate at 1300°F (700°C) but are cleaned once a day with superheated steam at 374°F. (190°C.). This gives rise to a thermal gradient of 916°F. (490°C.) across the wall of the heater, twice a day, and a consequently high level of thermal stress which can shatter the refractory walls.
2. In the United Kingdom, refinery gas is converted to industrial heating gas, or town gas, in a cyclic 'make' process. The refinery gas is burned in the converter for 2 minutes at around 1800 of, (980 °C.), and then steam and gas mixtures are metered into the converter at a temperature of 221°F. (105°C.) for a two minute 'make' phase. Thus, the temperature bounces up and down inside the reactor with a rise or fall of around 1600 of. (870°C.) every two minutes.
3. A similar unit is used to convert heavy naphthas to town gas in the United Kingdom and the same thermal shock conditions are encountered as in 2 above.
4. Emergency shut off of a reactor from high temperature to ambient.

Prolonging Refractory Life

The most popular method of prolonging the operating life of refractories in industrial applications is to apply a barrier coating to them to resist breakdown as long as possible. The majority of these coatings consist of alumina or silica based materials which fuse at operating temperatures to form an even coating capable of resisting the heat. Many of these coatings are based on technology 20 to 50 years old.

Progress in heat exchangers, the use of higher temperatures; subjection to longer periods of non-stop working, the increase in rates of corrosion produced by modern fuel oils, make it necessary to improve the resistance of protective coatings to impart longer life to refinery equipment under modern conditions. New developments are in operation where firebricks are replaced by thick monolithic coatings, and heavy castables, all based on the ingredients used in refractory bricks, These systems are excellent in improving protection against corrosion, but, none of them have helped very much in reducing the effects of thermal shock. It is considered that the thicker and heavier the refractory, the worse are the effects of this shock. Therefore, there is not much prospect of conventional refractories solving its effects.

It would be desirable to try new systems for reducing effects of thermal shock by moving away from the old materials such as aluminas and silicas, and trying new basic heat-resisting substances which are available even though they are more expensive.

If new materials are costly, carry out tests on thinner coatings, using up to 1/4" (6mm) instead of massive bricks and castables of 4" to 10" thick (100mm to 250mm).

Work on the Problem of Thermal Shock in Furnaces

We have been interested in the problems of thermal shock. The Company has been involved for some time in the supply of refractory coatings to industry, but many engineers were approaching the firm at that time with problems of spalling and cracking in their furnaces, the direct result of overworking and non-maintenance of their plants.

The cause of most of the problems being brought for solution was identified as thermal shock, and Furnascote, embarked on a research program to find alternative refractories to those then in use, which would show maximum resistance to thermal shock while not possessing any serious drawbacks.

They abandoned earlier types of refractory materials early in the program and turned to formulations based on zirconium compounds. These materials offered resistance to high temperatures, immunity from the effects of rapid temperature change and good chemical resistance. They were based on mixtures of zirconium oxides and silicates found naturally as sands in Australia. Their greatest disadvantage was found to be their lack of adhesion to other refractories at high temperatures, a disadvantage that was later capitalized on in some applications.

This lack of adhesion was examined and tackled by increasing the zirconium content to give a material with optimum adhesion properties in the temperature range 212°F to 2000°F (100°C to 1090 °C.) this covered the most widely encountered temperatures in user industries. A material with a zirconium content of 62% was fixed 'on as ideal above this figure the adhesion fell off rapidly. The remaining 38% of material used, consisted of compatible fluxes and additives.

The final zircon-rich refractory material may be referred to as NONVIT (Zircon-Rich), as the fired refractory produced from it had a non-vitreous finish. Physically, it is a white powder, and on site is mixed with water to give a quality for mortaring firebricks or for use as a top dressing on bricks facing flames. The water is dried off before firing, and thin coats of the material-up to a" (6 mm) thick-are used. These give good adhesion in most furnaces. In films above this thickness, the high density of the NONVIT tends to reduce adhesion before the initial firing is complete.

In all applications thin layers of the material are recommended as these are less susceptible to the effects of thermal shock than heavier layers encountered with traditional castables or monolithic coatings. These thin coats were found to be useful in protecting heavy castables and monolithics from thermal shock, as NONVIT is compatible with most alumina and silica based materials.

Application of NONVIT was carried out in many plants handling a variety of materials in Europe, where it was used as a general refractory, and all successful work was achieved with thin coats. Experiments were tried with coats up to 2" (50 mm) thick, but these showed no advantages over the thin ones, and the work was discontinued.

Applications to other Refractories

Zircon-rich refractory linings can be satisfactorily applied to other lining materials and in many cases can be used to minimise the incidence of thermal shock damage. Up to 1/4" (6 mm) thick, layers are self supporting, but above this thickness, some additional support is needed. This is usually of the wire mesh type.

Careful attention has to be paid to drying the coat properly before firing as, in some cases, the refractory will be blown off the wall during firing, by trapped moisture from inadequately dried cements.

In the original research work on thermal shock resistant lining material mentioned above, one of the criteria that was applied was 'Will it stick to other refractory?'. Once a suitable cement had been formulated, there remained the problem of attaching it to a wide variety of substrates, this was ameliorated by recommending that surfaces be roughened to provide a bonding key, prior to trowelling on the NONVIT.

NONVIT becomes slightly elastic above 200°C. (392°F) and this enables it to withstand thermal shock to a greater extent than firebrick. Where it is coated over firebrick, thermal shock may crack the brick, but the NONVIT layer will bind the fragments together and, to a certain extent, fill in cracks that form in the substrate surface. One of the advantages thus gained from the use of this material, is that furnaces and other plant remain gas-tight despite a breakdown in their primary refractory layer. Zircon base refractories also resist flame erosion, and the use of a thin layer of NONVIT at flame impingment points in furnaces and thermal destruction units, protects the brickwork from rapid wear by flame blast.

Prevention of Thermal Shock in a Waste Furnace

An engineering company in the United Kingdom were trying to destroy waste oils, while performing the operations within the requirements of the Clean Air Acts. This meant that smoke emissions had to be controlled very carefully. Many types of refractories were tried in the furnace, which operated on the DuPont system, but these all suffered from breakdown due to thermal shock. The temperature in the furnace surged from 2000°C to 2500°C. (3632°F to 4532°F), and where the flame impinged on the brick liners, these quickly melted. The process was worked on an eight hour shift burning 2500 gallons of oil, and the furnace lay idle all night and at week-ends. This produced severe thermal shocking to which no easy answer could be found.

It was eventually decided to use a firebrick on the flame side of the furnace and to coat this with NONVIT. After 18 months of operation, the lining was still satisfactory, and the flame impingment point produced temperatures up to 2000 C. in hot spots on the furnace wall. This melted the zircon coat and vitrified it so that it enveloped the bricks used and, due to its elasticity, moved with them during the thermal movement cycles. No cracking or shock damage has been detected in the furnace after 30 months of operation. The major advantage to the users, is that the furnace has remained gas tight, although the top courses of brick lost 2" (50 mm) in thickness during operation. The critical part of the furnace remained gas tight.

Future Study of Shock Phenomena

We carried out some investigations into measurement of thermal shock resistance, these have tended to be either 'go' or 'no-go' values. No measurement of the degree of resistance has yet been found practical, although Searle (in 'Refractory Materials') suggests that 'Various methods of repeatedly re-heating and cooling bricks are in use for this purpose; the condition of the bricks (or test pieces sawn from them), being noted at the end of several such treatments. If a sample will withstand thirty such treatments, it may be regarded as having a high resistance to Thermal Shock'.

If we extend this theory to operating plants such as the town gas unit discussed earlier, then we could derive some empirical yardsticks for assessing thermal shock resistance.

In this gas plant there are 720 thermal shocks of 1600°F (870°C) every day, and Searle's idea of thirty shocks being regarded as a pass level for a refractory, is a borderline statement compared with this.

It would be logical to examine refractories every six months in such a plant, which would yield 131,040 shocks. If the refractories are still good for use after this period, we could then class them as 100 points on the resistance scale. For higher temperatures, other systems would have to be devised, and a shock range for each level of temperature settled on.

Such research would properly be carried out at University level and/or in the laboratories of the refractory manufacturers.

Conclusions

Thermal shock is a problem in many types of process plant used in virtually every industry, and its successful elimination is mandatory if economic plant operation is to be achieved. The problem has been largely solved by the development of zircon-rich refractory cements, and these have been successfully applied to several types of equipment, in the hydrocarbon processing and other industries. The problem of meaningful measurement of thermal shock resistance of refractories has yet to be solved and it is recommended that further work be carried out in this direction.

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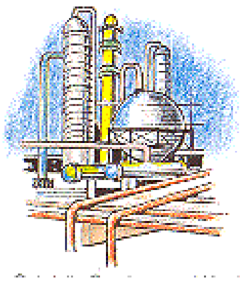
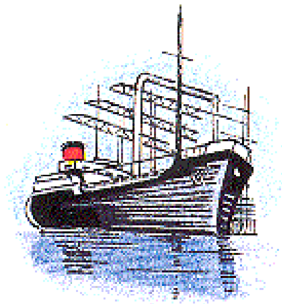
Some Industries Which Use Furnascote

Electricity Generating Stations Using Fuel Oil, Coal, Peat or P.F.



Catalytic Crackers and Heat Exchangers in Oil Refineries and Chemical Works.



Tankers and Ships using Steam Turbines.

Aluminium Industry

Furnascote NONVIT has been used with much success in the aluminium industry both in the production of ingots, and in the casting of aluminium ingots and its alloys in industry.

The main problem in furnaces melting pure aluminium or its alloys is, that the refractory bricks or linings in the processing, crack and spall quickly and have to be replaced. This involves stoppage of production and replacement of brickwork. The frequency of repairs and stoppages introduce high costs of production. If these can be reduced. there is great saving in final costs, plus increase of production as a bonus.

As aluminium is a low melting metal, around 660°C (1218°F) ordinary refractories do not set efficiently. Furthermore, high melting refractories. of the order of 1500°C. plus are damaged by the molten aluminium quickly. Molten aluminium tends to leach out much of the aluminium content of the bricks, leaving a porous brick after a short time, so that the furnace becomes weak and friable and breaks down quickly, requiring urgent repair. Patching is carried out easily with NONVIT cement. Thus, the working life of the furnace is increased enormously, and financial loss in production is eliminated.

Fortunately, Furnascote NONVIT, with its high Zirconium content is incompatible with molten aluminium and as a thin coating of 1/8" to 1/4" (3 to 6mm) on top of most refractory bricks, acts as a barrier coat and arrests the leaching action of molten metal.

The same results are achieved when using alloys of aluminium with higher and lower melting points.

Many Aluminium Smelters and firms using ingots are regular buyers of Furnascote.

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Brass and Non-Ferrous Metals Industries

In general use furnaces smelting such things as Brass, Copper. Tin and Zinc, pure metals and alloys, the temperature operation ranges from 230C (446F) to 1300C (2370F). With these metals, there is also a severe leaching effect by the molten metal as occurs with aluminium and its alloys. Breakdowns and frequent maintenance does occur, which adds to costs.

Furnascote NONVIT, because of its high Zirconium content acts as a superb barrier coat at thicknesses of 1/8" to 1/4" (3 to 6mm) on top of bricks, monolithics, and castables. The NONVIT can also be used for patching damaged areas on furnace walls quickly.

Chemical Industry

In many chemical processes waste gases and chemicals at high temperatures, because of their corrosive nature, cause havoc to structures such as chimneys, ducts, furnaces, etc.

Waste gases such as sulphur dioxide, trioxide, sulphuric acid, carbonic and other acids at elevated temperatures damage chimneys in particular. Even at low temperatures of 200°C (392°F) where acid-resistant bricks are used, the cements used as mortars decay in a short time and brickwork collapses; especially below the dew point of sulphuric acid which disintegrates cements.

The solution to these particular problems, and many others, is to employ Furnascote NONVIT grade refractory as a cement and mortar and to apply a brush coat of NONVIT over the brick face inside the chimney. The reason for recommending NONVIT is because it is made from ZIRCONIUM compounds and contains 62% of this material. ZIRCONIUM compounds are known to be chemically resistant to sulphuric and other acids, from low to very high temperatures of operation.

Furthermore, Furnascote NONVIT is designed to set-off and produce a hard, tough, chemical resistant cement at 200°C (392°F) which other types of refractories cannot match. When applied correctly the working life of chimneys can be made to last up to 20 years without special maintenance.

The Engineers at AMT are always pleased to give advice, free of charge, on combating problems of severe corrosion of chimneys, furnaces, trunking, etc., where high temperatures and corrosive chemicals are involved.

Fertilizer Manufacturers

Among our many clients are some of the leading producers of fertilizers. Their production units have been plagued by frequent breakdowns in the chemical processing with consequent shut-downs that have proved expensive. All efforts to cure the problems in the high temperature zones had failed, until the engineers tried Furnascote NONVIT as a barrier coat between the heat transfer walls and the corrosive chemical gases at elevated temperatures. They employed the NONVIT specification at 3 to 5 mms coating thickness, and succeeded in stopping costly breakdowns. Fertilizer plants in Britain, Iraq, India, Brazil and Europe now buy NONVIT regularly for maintenance, and now get continuous production of fertilizers without worrying about sudden stoppages due to breakdowns in their heat transfer units. We advise the use of specification NONVIT/Spec/January, 1969, described earlier.

Gas and Natural Gas Industry

Production of town gas from coal has declined in recent years but an enormous growth of production of gas for domestic and industrial use is increasing annually from the use of waste raw materials in the petroleum refineries and the vast quantities of natural gas coming from North Sea deposits outside the United Kingdom. The same situation applies in America, Europe, and wherever industry is expanding.

In the conversion of chemicals from oil refineries to industrial heating gas, or town gas there is a "cyclic" make process. Waste refinery gas and heavy naphthas are heated in converters for a 2 minute period, when a rise from 105°C (221°F) to approximately 980°C (1800°F) occurs and a new charge enters the heating unit at 105°C. Thus, the temperature bounces up and down every 2 minutes in the "make" phase. The differential in temperature every 2 minutes is 870°C (1600°F). All refractories exposed to this violent rise and fall of heating are subject to the effects of Thermal Shock which can shatter the linings in seconds, put the plant out of operation and cause explosions of semi-burned gases under pressure. Therefore, production engineers face some nasty problems.

Furnascote NONVIT, because of its ZIRCONIUM content, is one of the few refractories which can withstand this violent Thermal Shock and is used regularly to line reactor chambers of gas-producing units. In fact, it is attached to steel chambers by the system described earlier in the article "Securing of Refractory to Metals", in order to avoid normal refractories shattering inside the reaction chambers. Coatings of the order of ½" (12 mm) maximum thickness will operate satisfactorily for 12 months continuous service before maintenance is necessary.

The life of Heat transfer units can be improved by brush coating 1/16" (1.5 mm) of NONVIT over existing refractory brickwork. The surface bricks deteriorate through chemical attack of hot gases. NONVIT acts as a barrier coat against this attack so that the working life of the brickwork is extended considerably. Maintenance costs are reduced as restoration to original strength of brickwork is attained in a short time by brushing on a further 2 or 3 coats of NONVIT.

All gas-fired furnaces, domestic and industrial boilers, heat transfer units, etc., can be made more efficient by coating refractory bricks or monolithics with NONVIT.

Our advisory staff at Refractech are pleased to give you advice free, on any problems which you may encounter in prolonging the life of furnaces using coal or natural gas.

The Iron and Steel Industry

Furnascote refractories have been used in many applications in the production of cast iron.

NONVIT, which is refractory to 1910°C is well above the melting point of cast iron and is widely used in such things as:

1. Lining between the gannister and the steel shell of the heating chamber of the cupola where it gives a longer working life to the furnace. A coating of ¼" (6 mm) of NONVIT is required.
2. For patching receivers, ladles, funnels. spouts. etc.
3. As a protective coating over the refractory bricks in re-heat furnaces, soaking pits, open hearth floors, furnace doors, sloping floors.
4. As a cement mortar for bonding high temperature resistant refractory bricks in all types of furnaces used in excess of 1700°C.
5. As a lubricant on castings to give a smooth finish.

In Steel production Furnascote NONVIT is used in the same type of operation as with Cast Iron. The additional applications are:

1. As a lubricant in the preparation of ingots which manifests itself in the production of better quality finished steel such as plate, castings, etc.
2. As barrier coats in the linings of electric furnaces producing special grades of steel.

Where a glaze is required and the maximum temperature does not exceed 1250°C. Furnascote HIGLAZE is used on:

1. Annealing furnaces.
2. Spouts and funnels.

HIGLAZE is used trowelled on top of NONVIT to give a glaze which reduces slag-formation.

Marine and Shipping Industries

Although there is a trend for Tankers, merchant and passenger ships to use diesel propulsion instead of steam turbines, designers of 50,000 tons and more tend to prefer steam turbine propulsion. Especially in oil tankers there are two important requirements for steam, Le. for propulsion, and for use in heating pipes and tanks carrying crude oil. Most large tankers have at least 2 to 4 boilers operating, so that in emergency, three boilers can be working and the odd one shut down for urgent repairs at sea.

The furnaces producing heat for steam are nowadays fired by fuel oil. On journeys they are working 24 hours per day and in the case of a non-stop trip from England to Arabian Gulf via the Cape can work non-stop for as much as 28 days. Therefore, the refractory get severe wear from the hot, corrosive gases from fuel oil. At elevated temperatures the presence of small percentages of sulphur dioxide, trioxide, vanadium, etc., plays havoc with the brickwork and wears them out from sheer hard work, aggravated by chemical attack. Therefore, the furnaces need regular attention-otherwise a breakdown at sea can jeopardize lives, the ship and the cargo.

Furnascote NONVIT has been used for many years regularly on marine furnaces where standard firebricks are used and mortared with NONVIT. The repaired or re-constructed furnace walls and roofs are then brush coated with a 1/8" (3 mm) paste of NONVIT. Furnascote HIGLAZE is brush coated over the NONVIT to a depth of 11/16" (1.5 mm) to give a glaze to reduce slagging. This treatment has been found to increase the working life of ships furnaces and reduce the danger of breakdown at sea. These ships carry half a ton or more of Furnascote in tropic proof steel drums and on long hauls, stop one furnace and carry out a major overhaul at sea. Normal maintenance is straightforward and speedy when using Furnascote.

Material costs to repair a ships furnace 18 feet long, 12 feet wide, by 10 feet high (approximately 6 by 4 by 3.5 metres), at present prices would be about £1,500 ($2,550) using a total coating of ¼" (3 mm) thickness. Neglect to service and repair oil fired ships furnaces could involve the loss of millions of dollars, plus valuable lives.

A half ton of Furnascote NONVIT in the store on board your ship is the finest insurance you can have. It is there for emergency repair wherever your ship may need it.

Nuclear Energy Stations

The development of electrical power from nuclear sources is expanding rapidly all over the world. The construction of new stations has created a demand for new materials to cope with problems introduced in the handling of this new form of power.

Barrier coatings are needed in nuclear reactor chambers for insulation but most refractories are unsuitable and are rejected.

The chemical analysis of refractory must be studied intensely to make certain that definite elements are not present. Elements such as aluminium, boron, iodine, potassium, etc., are absolutely forbidden because they destroy the retention of dangerous nuclear rays inside the reactor and permit their passage into atmosphere where they can destroy animal and human life in the vicinity of the station. They also form isotopes which are also dangerous.

Furnascote NONVIT, because of its high ZIRCONIUM content, is being tested in nuclear power plants as a barrier coating and it is expected to be accepted as a standard material for power stations.

There are other applications in the Nuclear field such as standard refractory coatings on the steam turbine side of the station.

One important application is envisaged for NONVIT that must be pursued by nuclear engineers and that is, in the manufacture of the concrete dome which shields the nuclear reactor from the atmosphere. These domes are enormous structures up to 100 feet high and 16 feet thick walls. They protect the reactor and prevent dangerous nuclear rays from penetrating the atmosphere, and insulate the heat inside the reactor chamber. NONVIT can be used as a barrier coat on the inside of the dome, where it will increase heat insulation; reduce escape of dangerous nuclear rays; and strengthen the concrete against Thermal Shock and surface cracking.

Additional Industries which use Furnascote

Brick-making, Cement, Ceramic, Domestic Boilers, Glass, Mining and Pottery use NONVIT in various applications, and any industry which employ fuel oils for heating purposes.

One Special problem which occurs in these industries that is solved by our refractories, is that of Stalagmiting or Stalagtiting in roofs of heating chambers.

An example which is commonplace occurs in the roof of Kilns, and particularly, Tunnel Kilns where fuel oils are used for heating.

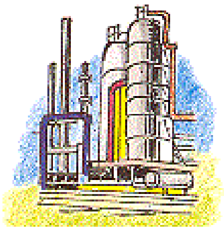
The refractories used in ceilings are designed to withstand certain temperatures, above which they tend to melt. For example, a brick compounded to withstand 1500°C, will soften at 1600°C. at its hot face. Continuous attack by hot corrosive gases containing sulphur, vanadium, etc., in small percentages in fuel oil, will form new chemical compounds of the brick at its hot surface. This new brick compound invariably has a lower melting point than the original brick. Thus, after a few months continuous working inside the hot zone of a horizontal kiln, the surface roof bricks melt and form stalagmites. As these get longer they strike the fired pottery on the moving trucks and cause damage, and also drop pieces of stalagmite from molten bricks on to the floor of the chamber. The roof bricks get thinner and weaker, and, unless repaired, the roof collapses and production is stopped.

By using Furnascote NONVIT as a thin coating, over ceiling bricks, of the order of 1/8" (3 mm) which should penetrate the course gaps between the bricks, a barrier coat is formed which is resistant to chemical attack up to 1910°C. Whilst NONVIT adheres to the bricks, it cushions the attack and stops the formation of stalagmites so the roof brick is protected.

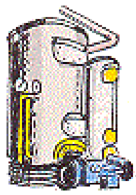
Advice on special applications in these industries is obtainable from us.

Wash Coatings of NONVIT are effective at 1/32" to 1/16" (0.75 to 1.5mm)

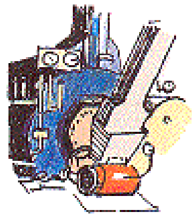
It is worthwhile to mention the case of a wash coating of NONVIT on a carbonising furnace where the company concerned (name is available) usually had to reconstruct a carburising furnace every 4 years, and often less. This firm used a wash coating of NONVIT in one of their furnaces and found that year after year the carburising furnace was in excellent condition until they were obliged to alter the design of the furnace and stopped production. After 11 years in continuous use, the NONVIT was still intact and protecting the furnace walls. This use of thin wash coats demonstrates the enormous resistance which ZIRCON RICH NONVIT exhibits against chemical attack.



Town and Industrial Gas producing plants using coal, fuel oil or mixed fuels.



Oil Fired Boilers in industry, homes, schools, hospitals, laundries etc.



Boilers using Solid Fuels.

Petroleum and Hydrocarbon Industries

Examination of a high invisible cost

Refractories represent a substantial investment in oil refineries. As production of fuel oil and by-products increases throughout the World, so the expenditure rises in getting the best from capital investments. If refractories are treated lightly, they become part of the invisible costs which build up huge maintenance bills in oil refineries. Therefore, for present and future control of high maintenance costs, the refinery production and maintenance engineers must look after the refractory protection in their plants.

A vast quantity of heat is vital for the smooth and efficient running of a refinery. High and low temperatures, from 260°C to 2,000°C (500°F. to 3,632°F) are employed for continuous periods to break down crude oil into useful, saleable components. The longer the heating process can be kept unbroken, the more profitable the refinery can become. Using such high temperatures continuously introduces the problem of corrosion of expensive plant. To protect valuable plant from corrosion involves the use of large quantities of most expensive refractorys. Thus we are faced with unusual conditions to prevent corrosion. In other industries to prevent corrosion special types of paints and chemical coatings are applied. These work very well to resist chemical and general corrosion, but, at normal temperatures. Once operating temperatures rise above 212°F (100°C.) the presence of heat accelerates corrosion, especially when the range rises up to 3,632°F (2,000°C). The increase in corrosion becomes violent in refineries because of the necessity of using high temperatures. Thus, expensive refractorys have to be used to bring production up to present-day standards.

Where Breakdowns occur

Once the refractory has been installed into the refinery plant the installation work must be of high standard in quality and installation. When refractory breaks down this becomes serious to the management. Production ceases, and vast losses can be incurred. It is more expensive to stop production, than to start it. Costs are incurred in replacement of plant. Efficiency of production drops rapidly. There is a severe maintenance problem involving squads of skilled men working day and night to get refining of crude oil on 'stream' again. This is very costly, and worrying to production engineers.

What types of breakdown take place with refractories in refineries? Aluminium and silicon based bricks and monolithic coatings, when subjected to continuous violent heating, tend to spall, crack, and chip inside heating, and heat exchange chambers except for Thermbond chemical bond refractories. Erosion takes place in bridge areas. Rapid physical wear occurs through the sand-blasting effect of burning fuel oil at elevated temperatures, and bricks can lose half their thickness in a few months inside a furnace. Crowns inside vertical and horizontal retorts crack and gases escape into the atmosphere. Temperatures change, even a few hundred degrees drop, can cause 'thermal shock', which produces deep cracks and fissures in fire bricks. Breakages in monolithic coats take place too often around the jet burner areas in oil fired furnaces. At elevated temperatures many refractory bricks and linings actually melt away. Valuable catalysts get sooted-up, involving stoppages of 'cracking' processes.

Examples of Thermal Shock

Examples of Thermal Shock which can be forecast are:

1. Heaters which operate at 700°C (1,292°F). Where superheated steam is used daily to clean out pipes, at 190°C (374°F), there is a rise and fall of 510°C (918°F).
2. In the conversion of refinery gas (and gas from other sources) into gas suitable for industry, or town gas. As the refinery gas is burned during the heating phase, and can reach 1,000°C (1,832°F) for a two minutes duration. Then, there is a two minutes phase of gas making, during which, steam and refinery gas mixed, are fed into the reactor during the "make" phase. Thus, there is a repeated Thermal Shock in each cycle of 4 minutes. The temperature is bouncing up and down inside the reactor from approximately 105°C (221°F) to 1,000°C (1,832°F). There is a rise and fall of 895°C (1,600°F).

This Thermal Shock plays havoc with refractories, castables and bricks in the structure of the Heater, especially if any vanadium pentoxide or sulphur compounds are present. Stoppages occur through breakdowns, followed by expensive maintenance and loss of production. Thermal Shock occurs in many other instances in the refinery.

Influence of Fuels used

The life and behaviour of refractories are influenced by types of fuels being used to provide heat volume. Many refineries utilise waste fuel oil for burning. These contain an average of 1 to 5 per cent free sulphur. When they are consumed from 260°C to 2,000°C (500°F to 3,632°F), sulphur compounds are formed. Sulphur dioxide, trioxide and sulphuric acid, with many other chemical compounds to a lesser degree, and attack surrounding solid materials, more so at elevated temperatures. Sulphur compounds seep through refractories, especially at lower temperatures; they build up pockets of sulphuric acid between the fire bricks and the steel, or other metal casings, creating weak spots, which break down at unexpected moments. Vanadium compounds also play havoc with refractory coatings in refineries. This demands special attention at elevated temperatures, and is a source of much trouble in production.

Methods of Protection

The most popular method to prolong the life of refractories in oil refineries, and other industries, is to apply a barrier coating over them to resist breakdown as long as possible. The majority consists of alumina and silicon based coatings, which fuse at operating temperatures to form an even coating to resist the heat. Many of these coatings are based on recipes used 20 to 50 years ago. Progress in heat exchange, the use of higher temperatures; subjection to longer periods of nonstop working, the increase in rates of corrosion produced by modern fuel oils, make it necessary to improve the resistance of protective coatings to give longer life in refineries under modern conditions.

Benefit obtained by using Furnascote

Improvements in formulation must be found. Tests and experimental work showed that a high Zircon content was necessary to give superior protection to the older methods. Zirconium compounds have enormous resistance to chemical attack at elevated temperatures of up to 2,000°C (3,632°F). By blending a high Zircon content with conventional materials, and conducting site tests, for as long as three to four years, the best recipes were evaluated commercially, and have been marked as 'FURNASCOTE' refractory protective coatings.

FURNASCOTE NONVIT, because of its high Zircon content, has been found to give exceptionally improved resistance to corrosion and attack by sulphuric acid and sulphur compounds, both at low and elevated temperatures. Furnascote NONVIT grade is exceptional in its resistance to Vanadium compounds, and catalysts.

Can NONVIT be used with conventional refractories ?

Compatability of Furnascote NONVIT with other refractories already used in Refineries. NONVIT is compatible with most castables, monolithics and refractory bricks used in refineries, therefore it can be welded on top of existing refractories and reinforced with mild steel wire mesh to increase working life and protect against Thermal Shock. This is advised for new and existing structures, in the following manner:

1. On new constructions in refineries, chemical works and gas works, whilst the basic castable etc., is green. Trowelling on 1/8" (3 mm) NONVIT, then a layer of mild steel ½" mesh (12 mm) pinning down with 1" (25 mm) mild steel staples followed by a final coat of 1/8" (3 mm) NONVIT. Leave to dry out thoroughly before firing.
2. On old, or existing structures, using the same procedure as in (1), but drilling ¼" (6 mm) holes at 12" (300 mm) intervals, into which ¼" (6 mm) mild steel bolts are screwed, in order to attach and secure the mild steel wire mesh The new method of exploding bolts into the steel wall has increased adhesion.

A complete system of application is given in the specification Furnascote Commentary No. 25.

Once set by slow firing, the NONVIT will take all the chemical attack and the heat any spalls or cracks will be sealed, and above all, the operating temperature of the Heater or furnace can be raised several hundred degrees above optimum temperature, because the NONVIT will resist passage of heat to the castable or refractory bricks.

NONVIT is used in new constructions as a mortar for bonding refractory bricks.

Reduction of Sooting of Catalysts

Sooting up of Catalysts can be diminished by using NONVIT, thereby increasing heating efficiency of the Heater.

Upgrading of existing Heaters

Upgrading of existing Heaters and Combustion Chambers can be achieved quickly by using NONVIT. For example, an existing Heater has the feed stock altered owing to change of origin of crude oil and needs a higher operating temperature, such as a rise of 260°C (500°F) to increase efficiency. Application of NONVIT over existing refractories will permit a higher operating temperature to be used without damage to the walls, as the NONVIT insulates the existing firebricks against an increase in heat.

Attachment of NONVIT to Steel Shells

NONVIT can be attached to metal shells to prevent distortion of the steel, where firebricks, castables, etc. cannot be used for certain reasons, such as, weight, volume, etc. The basic method of attachment is described earlier.

Other applications of NONVIT

NONVIT can be used on normal furnaces in boilers producing steam for production, heating, processing, etc. where it will increase the working life of the combustion chamber by resisting the corrosive attack of burning fuel oils. Quarls can be improved to combat Thermal Shock.

Low Temperature application at minus 44°C (-48°F)

NONVIT when set at a temperature of 500°C (932°F) will act as an insulation on metal, concrete, bricks, etc., to temperatures of -48°F (-50°C). Applications of NONVIT could prove invaluable in refineries situated in cold climates such as North America and Northern Europe. NONVIT coulc be used to insulate concrete structures.

The Aluminium Industry

Although the temperatures for smelting aluminium and its alloys are much lower than steel, of the order of 700°C to 900°C as against 1500°C to 1600°C, the violence of aggression and frequency of breakdown with the lower temperatures are greater than with steel.

Molten aluminium leaches out many ingredients of the furnace refractory linings, forms reactive compounds inside the resulting ingots or castings, with disastrous consequences to the finished products; quality vanishes and rejections soar.

For example, aluminium cylinder heads on motor car engines, various castings in the car and engineering trades. The castings look good but have large bubbles in vulnerable, critical areas. So their appearance is deceptive.

NONVIT has solved this problem by its use in lining furnaces where it acts as a barrier coat resisting leaching, and chemical attack by aluminium. The quality of refractory used is high grade Al_20_3 70% and $S0_3$ 37% and is refractory to 1650°C. Ref.: FR.165 Li. See section on Aluminium, page Another major problem in protecting induction furnaces and oil fired types for aluminium is that of preventing slagging and blocking the flow of metal in the furnace, in areas difficult to get at during melting. One example is the two channels inside the base of an electrically heated furnace, through which the metals flow. These channels carry metal downwards at 45" angle. They average 3 feet (1 metre) long by 10 cms. (4 inches) diameter.

This problem, which also occurs in other inaccessible areas of furnaces, was solved by having an aluminium tube 9½cm (3½") diameter coated on the outside with 6 mm (¼") NONVIT.

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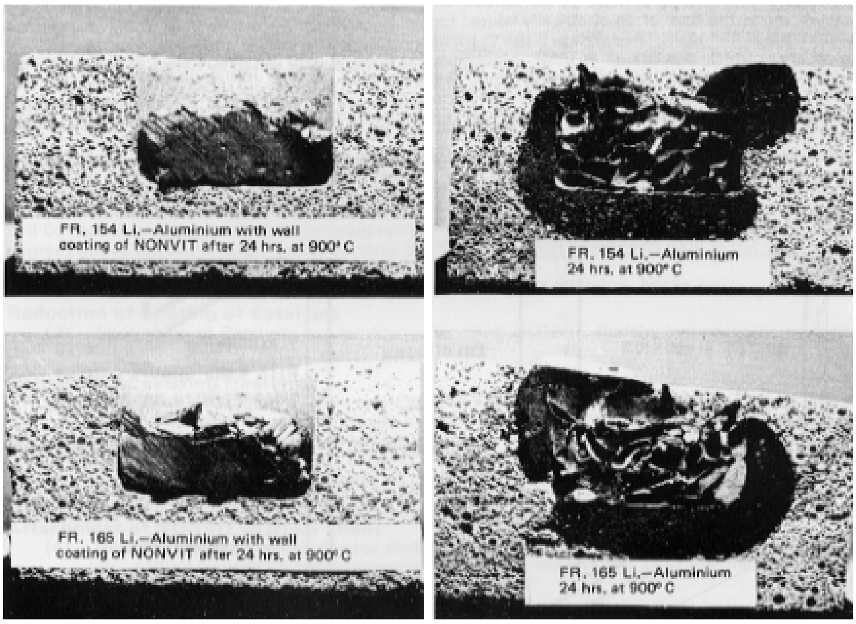
NONVIT Cement, which was then wrapped with cotton tape to secure it to the surface, was them dried thoroughly to remove moisture and warmed at 150°C to 200°C to set it off hard. All of this taking place when the furnace was being overhauled in the cold.

The wrapped tube which was flanged at one end (2 tubes were made) was then thrust into the hole with the flanged end at the top, and jammed into position.

The temperature of the furnace raised to the melting point of aluminium and the metal charged into the unit for smelting. The first heating strengthened the NONVIT and burned away the cotton tape. This tough tube of NONVI~ flanged at the top end, formed a protective barrier on the wall of the tube. The molten aluminium could then flow through the tube of NONVIT without attacking the refractory or metal furnace wall. The aluminium metals formerly supporting the NONVIT skin then dissolved into the mix, leaving behind a solid wall of NONVIT. The melt could not attack the refractories, nor the metal structure, slagging was reduced, and the resulting aluminium ingots were purer with no bubbles. The NONVIT needed replacing once a year at the annual overhaul. The quality of the melt and the rate of production rose considerably.

An illustration of the effectiveness of FURNASCOTE NONVIT (zircon-rich) refractory coating when used as a lining inside an Aluminium Smelting furnace can be seen here. The same effect is achieved in other types of furnaces by the use of NONVIT such as heat transfer units in chemical processing where corrosive compounds at high temperatures damage walls and often ruin production.

This picture shows a furnace having 3mm of NONVIT. | This picture shows the furnace without NONVIT.



These tests were conducted by a leading European refractory manufacturer of linings for smelting Aluminium, namely Gottfr. Lichtenburg, of Siegburg.

Aluminium metal in each test was identical; heated at 900°C for 24 hrs. All tests were made together in one furnace. The references FR. 154, etc., are of the types of high grade refractories used in smelting Aluminium. The temperature of 900°C used is above that of the melting point of this metal, but, this increase was deliberate in order to demonstrate the violent upheaval which takes place inside the molten Aluminium and which causes rejects in cast Aluminium products. NONVIT proves its effectiveness as a barrier coat to prevent these chemical changes taking place in the melt at high temperatures. For this reason NONVIT is used in ferrous and non-ferrous smelting, and, especially in oil refineries and chemical heat transfer furnaces, where higher temperatures are frequently employed.

One of the largest Motor Car Engine Block makers in Europe uses Furnascote in large quantities, regularly, because the problems of "blow-holes", illustrated in the above experiments, caused enormous financial loss when engine blocks failed, due to a build-up of unknown proportions, when they were cast from aluminium alloys. Sometimes as much as 50% production was rejected. Since the Company started to use Furnascote NONVIT 10 years ago, the percentage of rejects due to "blow-holes" has diminished to less than 3%.

Any Company producing aluminium or alloy ingots, or producer smelting these ingots for casting intricate shapes, where strength and purity of the matrix is essential, must use Furnascote NONVIT to achieve the desired quality, at a low cost of preventing many rejects.

The Copper Industry

Electrical Induction heating is increasing in use in the smelting of copper and its alloys, as it enables a higher quality end product to be obtained, and is cleaner and easier to handle.

Temperatures used here vary from 900 to 1100°C, depending whether it is brass, bronze, copper or alloys, but the principle followed is identical.

Below the induction furnace, the molten copper has to flow through a bed of rammed silica for reasons of processing procedure. The system used to obtain a channel in the silica, is to employ a copper tube as follows:

This tube is placed vertically into a strong steel refractory lined box beneath the induction furnace where two feed holes are lined with the top orifice of the tube so that molten copper can flow down and upwards, and circulate freely.

Normally, the copper pipe is placed in position under the furnace and is rammed with silica sand to hold the pipe in position. The furnace is set in motion. Molten copper flows into the pipe, and the silica becomes very hot until the pipe melts and becomes part of the fluid metal, leaving the pipe 'shape inside the rammed silica through which molten copper can flow freely.

The process continues for several months until the slag blocks the pipe, and very often the silica ruptures and molten copper escapes to atmosphere, then the unit must be stopped owing to loss of metal and danger to workers.

NONVIT can be used to increase the period of production and reduce danger of silica cracking by lining the pipe area. This is achieved by coating 8mm. NONVIT cement outside the specially designed copper pipe and wrapping with cotton tape to hold the damp cement in place. The wrapped tube is kept in a warm area for some time to dry off moisture and to set off hard the NONVIT. When a furnace is being prepared the shaped tube is placed in position below the furnace and rammed with silica and heating started. As soon as the molten copper flows into the pipe and the silica reaches 1100°C, the NONVIT becomes set tough, the cotton wrapping disappears and the silica has a protective wall of NONVIT which then resists the aggression and the slagging produced by the molten copper, and increases the inside strength of the silica ramming material. This system increases the production life of the furnace many times and yields a purer metal.

This method of protecting furnaces with NONVIT offers a tremendous future for getting better quality finished metals and reducing rejects in cast products, increasing productivity rate of furnaces, and thereby increasing profit margins considerably. As NONVIT is used in thin coatings and even wash coatings of less than 1mm, material costs in relation to resulting benefits are infinitesimal.

Induction Furnaces for Melting Ferrous and Non-Ferrous Metals

What is Induction Melting?

The induction furnace consists of an electrical transformer unit with a primary coil, a laminated iron core and the bath arranged for completion of the secondary circuit. Heating is accomplished by the induced current in the secondary circuit. The transformers are arranged as bobbins which encircle the outside wall of the furnace.

The majority of these furnaces in use are low frequency systems with very few high frequency types in operation.

The number of low frequency furnaces in industry is increasing, especially where electricity is cheap.

For example, In Sweden, where electricity is a cheap energy form, the cost of smelting one ton of copper by low frequency heating is approximately one pound sterling. The estimated average amount of electricity needed to melt one ton of metal is as follows:

Brass: 220 to 350 kw per hour
Copper: 250 to 400 kw per hour
Steel: 500 800 kw per hour

The advantages of electrical smelting are:

1. Purer finished products, and less pollution of the atmosphere.
2. Elimination of dirt, foreign bodies, during processing, and a lower percentage of slag.
3. More accurate quality control during processing. Reduction of percentage of rejects in use of ingots in casting and extrusion.
4. With escalation of costs of coal and fuel oil, electricity could prove to be cheaper.

What Problems Have Arisen With Existing Electrical Smelting?

1. Pure silica sand is used as the ramming material. It is an excellent insulator but has mediocre tensile strength and can crack when thermal shock intervenes.
2. Slagging and obstruction of flow of metals, necessitating frequent rebuilding of the furnace, with loss of production and costly 'down time'.
3. After few melts, the silica ramming erodes and cracks, and hot metals can escape, with danger to workers.

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4. The molten metals tend to become aggressive and leach out quickly chemical constituents present in refractory bricks or linings, leaving spongy, weak structures in the bricks-often producing cracks through which metal escapes and is lost. At this stage the furnace is dangerous to operate.
5. These leached constituents form reactive compounds in various metals which produce bubbles and subsequently create a high percentage of rejects in case products. This can make the process expensive and uneconomical.

What has been done in the Past?

Many methods have been tried to improve quality control and reduce rejects but little progress has been made.

Refractech, have devoted much research to resolving these difficulties and recommend the use of Furnascote NONVIT. Furnascote NONVIT contains 62.5% Zirconia, and thus being ZIRCON RICH, has superior resistance to aggressive chemical attack by molten metals at low and high temperatures to 1910°C (3470°F), and has good resistance to the effects of Thermal Shock. These chemical and physical properties of NONVIT have improved quality in many industrial applications on Heat uses in various industries for over 35 years.

Applications of NONVIT in Induction Heating Furnaces

Production of special steels and steel alloys.

1. The metal acts as conductor of the field of high electrical current which is converted into heat.
2. The pure silica sand is rammed on the hearth and between the refractory bricks and the steel sleeve. Silica is a superb insulator of electricity.
3. The brick lining between the electric bobbins and the ramming (silica) is the vital part of this system and is sensitive to thermal shock and physical wear. Breakdowns occur first in this area and the furnace is stopped to be rebricked and rammed with silica. The average working life is 3 to 4 weeks. Rebricking and delay in production is costly, so that, if it is possible to extend the working life at a reasonable cost, efficiency and profit would increase.
4. NONVIT was used to strengthen this lining by trowelling or spraying 3mm on the outside and 5mm coatings on the inside brick walls. 10 to 12 hours artificial drying was carried out by placing a perforated steel barrel of hot coke inside the furnace. This dried off and set hard the NONVIT.
5. A steel sleeve or tube replaced the drum of hot coke and silica sand was rammed carefully between the NONVIT coating and the sleeve to an average wall thickness of 200 mm. The melting was started and the sleeve allowed to melt away and dissolve in the liquid steel. This left a tough coating of silica on top of a strong wall of NONVIT.
6. The brick wall was now reinforced by the NONVIT and became super resistant to wear, tear and sudden breakdown.
7. After many applications of NONVIT on these induction furnaces up to 5 ton melts, the results were superb. Instead of breaking down after 3 to 4 weeks work the furnaces lasted from 35 to 40 weeks continuous operation, An increase of 1000% at the small extra cost of the NONVIT and 2 extra hours of preparation. Approx. amount of NONVIT used was 100 kg.
8. Reasons for this success are due to the silica ramming having been strengthened, particularly against Thermal Shock which occurs when new stock of cold scrap metal is charged into the hot chamber. The refractory built wall has been strengthened by a sandwich of NONV IT whose presence has resisted damage to the bricks such as shock, chemical attack by molten metal which often seeps through cracks in the silica, and resistance to the high temperature used. Furthermore, possible damage to the electric bobbins is also reduced.

Other Industries Using this System

We have discussed Induction heating for the steel industry. The additional applications are being applied in major industries in Europe and elsewhere as follows:

1. Aluminium and Aluminium Alloys.
2. Copper and non-ferrous metals and alloys.

An Interesting Experiment at Exceptionally High Temperature.

Report on High Temperature Application of Furnascote NONVIT (zircon-rich)

Furnascote NONVIT is a zircon-rich refractory which is used in many industries up to 1910°C (3470°F), It has excellent resistance to severe corrosion at elevated temperatures and is, therefore, in great demand in industries where these conditions prevail.

Above 1910°C, the demand for specialised refractories is at present non-existent. Much research work, however, is being conducted in specialized areas of industry to find a refractory which will line a chamber to contain heat above 2000°C (3632°F) for long and short periods.

Furnascote NONVIT offers possibilities for use as the lining of a heating chamber where insulation and protection of the heating zone from radiation, conduction and leakage of hot gas to atmosphere is desirable. Being economic in price, NONVIT could help solve many practical difficulties which, so far, are considered insurmountable. Several independent laboratories have tried NONVIT as a protective coating on heating chambers where source of heat has been by oxy-acetylene flame, and also by electric arc. The following show some of the results that we found.

High temperature effects of Gas Flames. (Oxy-acetylene and other gases).

The average operating temperature of the gas flame was 3000°C (5472°F) and the effect on NONVIT is as follows:

1. The NONVIT is pre-set at 500°C to form solid blocks ½" (12 mm) thick. The block should be heated slowly to approximately 2000°C before projecting the gas flame onto it.
2. The cone of the flame after 120 seconds application, penetrates the NONVIT to one millimetre only and the surface bubbles, but does not disintegrate and remains intact. This converts the surface into a glazed material.
3. The rest of the NONVIT below the surface remains solid and insulated against the penetration of this high temperature.
4. Most other refractories disappear under the flame at 3000°C (5432°F) melt, volatilise and disintegrate. They are also shattered by the effects of Thermal Shock, whereas NONVIT has the property of resisting the effect of Thermal Shock and only glazes the surface.

Effects of electric arc heating on NONVIT.

1. The normal electric arc operates at an average of 3000°C (5432°F) with a peak temperature of 10,000°C (18,032°F).
2. The NONVIT is pre-set at 500°C to form solid blocks. The block should be heated slowly to approximately 2000°C before applying the electric arc onto it.
3. The cone of the arc does exactly the same to the NONVIT, as in 1b.
4. The rest of the NONVIT below the surface remains solid and insulated against the penetration of this high temperature.
5. Most other refractories disappear under the flame at 3000°C (5432°F) melt, volatilise and disintegrate. They are also shattered by the effects of Thermal Shock, whereas NONVIT has the property of resisting the effect of Thermal Shock and only glazes the surface.

These special properties of Furnascote NONVIT offer the opportunity of lining heating chambers for high temperature production, or research work, where 3000°C is needed, or where one must reach 10,000°C for short periods. The NONVIT could line the chamber at 1" or 25mm thickness, which is preheated at 500°C to set it off hard.

The Pulp and Paper Industry

Furnascote refractory coatings deserve serious consideration by engineers concerned with the selection, usage and maintenance of refractories in the pulp and paper industry.

The heavy consumption of thermal energy necessary for the chemical conversion of wood into paper pulp and the subsequent recovery of unreacted chemicals, involve a correspondingly substantial reliance on refractories within this industry. Refractory failures, especially those leading to closures of portions of the plant, can prove enormously disruptive and costly. This problem is heightened by the arduous conditions to which refractory surfaces are exposed in certain locations. Regions of high mechanical abrasion (as in ash flumes, the hoods of lime kilns and boilers in which heavy fuel oils are burned) often suffer from rapid erosion or sand blasting of the refractory. Severe spalling can occur when refractories are subjected to violent and frequent thermal shocks such as in hog fuel boilers where cold and often wet fuel comes in contact with hot furnace walls.

In the pulp and paper industry, as with many chemical processing plants, problems of normal refractory wear arising from thermal or mechanical stresses are further complicated by chemical attack from reactive substances present in or produced by the pulping or recovery processes.

Furnascote refractory coatings, because of their high zirconium content (62.5% $Zr0_2$) are exceptionally stable and durable under most conditions of thermal, mechanical and chemical adversity encountered in the pulping process. A protective layer of NONVIT, trowelled, brushed or sprayed over bricks, castables, etc. to a depth of 1/8" (3 mm) to ¼" will usually increase the working life of the underlying refractories by a factor of two to four times. The following properties of Furnascote account for its effectiveness in reducing refractory wear:

Abrasion Resistance

Experience gained over several years of actual in-plant usage in many industries coupled with the results of independent tests have shown that Furnascote possesses mechanical strength and resistance to abrasive forces which are superior to most conventional refractories.

Resistance to Thermal Shock

At temperatures above 200°C, NONVIT is slightly elastic and can accommodate rapid and considerable temperature fluctuations because of its ability to move with the differential expansions and contractions of the walls, whether they are made from metal or lined with refractory materials. This property enables Furnascote to survive dramatic temperature changes which would quickly destroy most conventional refractories. In addition, the protective layer of Furnascote will tend to cushion the underlying refractory from the full brunt of rapid temperature fluctuations.

Stability to Chemical Attack

Waste gases and chemicals at elevated temperatures are encountered at many points within the pulping and recovery processes where they can attack refractories and metal surfaces in boilers, ducts, chimneys, etc. A layer of Furnascote can be bonded securely to both refractories and metals to form a continuous, gas tight coating which is impervious to attack and penetration by oxides and oxy-acids of sulphur, other acids, and most chlorine compounds and other corrosive substances.

Plant shut-downs or low ambient temperatures can cause stack temperatures to fall to the point where some of the gaseous components in the waste gases will condense on the inner surface. The nature of the condensate will vary from stack to stack but is mainly acidic and almost always corrosive. Unfortunately most conventional coatings are at least partially permeable to these substances which penetrate and accumulate within and behind the refractory layer, leading tochemical deterioration of the refractory itself and corrosion of the steel shell to the extent that its structural integrity might be threatened. Further, the absorbed liquids may revapourise when normal operating temperatures are re-established and the resultant pressure can lead to detachment of the refractory from the walls of the stack.

In such instances, Furnascote, with its superb chemical resistance and its capacity for bonding to refractories or directly to metal surfaces has proven an excellent protection against chemically induced corrosion.

Reduction of Slag Adhesion

Although slag shows less tendency to adhere to NONVIT surfaces than to most ordinary refractories, a wash coating of **Higlaze** applied to a thickness of about 1/16" over the NONVIT will provide a smooth, vitreous surface which will reject almost entirely the build-up of slag deposits.

Temperature Operating Range

Although NONVIT will harden at 200°C it will withstand sustained temperatures up to 1910°C and can survive temporary temperature surges as high as 3000°C.

Higlaze requires a temperature of 850°C for vitrification and will operate with working temperatures up to 1650°C.

Furnascote refractories are recommended for the following applications:

- **Power boilers burning heavy fuel oils.**
- **Burner throats.**
- **Hog Fuel boiler walls and around cleanout doors.**
- **Ash flumes.**
- **Refractory baffles.**
- **Lime Kiln hoods.**

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- **Stacks and ducts subject to corrosion.**

Useful Applications of Furnascote

Patching and Plugging Weak spots in Hot Furnaces, Without Stopping

Users of Furnascote NONVIT have reported excellent results in keeping furnaces in operation when a stoppage for urgent repair would have caused chaos in production.

If a brick has fallen out of a wall or roof of a furnace, leaving a gaping hole, or a chunk had spalled off a monolithic wall, this could leave a weak spot in the structure, with the danger of collapse of the wall or roof. This sometimes occurs when a job is in hand for a shipping order and the stopping and cooling of the furnace for urgent repair could result in cancellation of an export order, and losing a client. The Works Manager must then make a vital decision, to stop the furnace and do a major repair, or try to patch the furnace quickly and continue production. Should this situation repeat itself the remedy can be provided by the use of NONVIT, Zircon-Rich refractory, in the following way:

If the weak spot can be located by visual means, and is accessible inside the furnace on the roof, walls, corners, or hearth, consists of a gaping hole, about the size of a brick which may have fallen out. or have disintegrated, this hole can be filled and strengthened with NONVIT, after the furnace has been stopped without any wait for cooling.

NONVIT powder is mixed with sufficient fresh water to just make a bond to form a stiff clay. Place a ball of this clay on a steel lance, which has a supporting cap on which the NONVIT is placed, and thrust into the hole, applying manual force for 3 minutes. The moisture in the clay disperses rapidly, without blowing, and the NONVIT fills the hole and attaches itself to the surface and remains secure thereafter. This repair gives strength to the weak spot and prevents the collapse of the furnace. It is best to add 10% extra NONVIT to the quantity calculated to fill the hole, in order that the repair is "proud" above the surface.

The best results are obtained at 800°C to 1000°C (1472°F to 1382°F) although the method can be used at higher temperatures if it is impossible to cool down to 1000°C. Suggestions as to where instant spot repairs can be made with NONVIT, are ladles, receivers, soaking pits, annealing furnaces, aluminium and non-ferrous crucibles, boiler furnaces, converters, heat exchange units, ships boiler plants etc., etc. Precautions must be taken by the operators when handling this type of repair, such as the provision of suitable protective clothing and goggles.

Increasing the Working Life of Carbon Crucibles

In small and large scale production of ferrous and non-ferrous metals, carbon crucibles are used, and are fired by gas, oil and electricity. These crucibles are attacked by metals, wear out and break after a number of melts. Being expensive, it would be desirable to increase their working life to get better returns. We have always considered that a coating of Zirconium as a barrier coat at high temperatures could achieve this aim. Zirconium is incompatible with carbon and will not adhere.

After many years of experiments we found a way to stick a blended Zirconium such as NONVIT to carbon crucibles. This has been achieved by mixing 5% by volume Sodium Silicate in the water used to convert NONVIT to a thick paste. Apply 2 to 3 brush coats of the paste to the inside wall of the crucible, the wall should be wire-brushed beforehand, and left to dry in a warm atmosphere for a couple of days to "set off". The first heating of the crucible should be slower than normal, but. subsequent melts can be conducted as normal. A one millimetre coating (1/32") has been found to double the life of a crucible and increase the number of melts, and improve the quality of castings. Once the first coating has been accomplished, subsequent coatings of NONVIT build up excellent protection of the crucible.

Special Note on Surface Preparation

Where dense quality fire bricks and castables display glossy surfaces, and past experience has shown that flaking does occur after firing, we advise as follows:

Apply a revolving abrasive wheel of the Norton Crystalon type to the face of the bricks or castables for a few seconds to scratch the skin and "de-scale" the surface. Wet the "de-scaled" bricks with fresh water to reduce dust from rising. Then apply brush coatings of Furnascote in the normal way, allow to dry before firing. This treatment will increase the adhesion of Furnascote to give superb results on glassy, dense, fire bricks.

For Further information, please don't hesitate in contacting us.

Save Energy With Furnascote

Increase Output From Your Fuel Ration

Conservation of Energy

Furnascote NONVIT (Zircon rich) refractory was designed originally after World War II, when fuel oil and coal, were in short supply, to obtain the maximum output of energy from rationed supplies of fuel to industry. Rationing of fuel oil was more severe than it is today. The interest in conservation of fuel oil fell into decline after the 1960's, as crude oil was so abundant, that many users regarded low price fuel oil as a commodity which would last forever, at a give away price.

How Furnascote can Conserve Energy

After much research work following the war a suitable formula was produced with FURNASCOTE which was capable of sealing the inside of furnaces, facing the flames, hot gas'es, or electric elements, and thus stopping the ingress of cold air, and the escape of valuable heat through cracks, present in the firebricks, monolithic, or castable walls, ceilings or hearths. The Government investigation specialists dealing with fuel conservation, revealed that cracked firebricks could lose into atmosphere, and waste AS as much as a third of the energy available in the fuel, whether it be solid or oil.

Application of Furnascote

NONVIT, with its very high concentration of zirconium, resists many forms of vicious chemical attack at elevated temperatures using thin coatings up to 3mm thick, from ambient temperature as high as 1910°C (3470°F) and a 3mm film of NONVIT offers as good protection and insulation, as a 5". (127mm) firebrick. So, small quantities are involved. It forms a superb gas-tight seal on the furnace walls through which hot gas cannot leak out. Thus, a maximum output of energy can be obtained. Wear and tear on the surface, is very slow and a 3mm coat will last many years. We have found that when annual inspection and maintenance of furnaces are carried out, usually annually, that a quick wash of 1mm NONVIT over the original layer, increases efficiency.

How Furnascote is Supplied

NONVIT is supplied as a dry powder sealed in tropic proof drums of 50 kilos, and will last indefinately in arctic or tropic areas. The dry powder is mixed with fresh water to make up a suitable consistency to form a slurry (for spraying or brushing), a paste for trowelling; and a cement for filling in large cracks and spalls.

Any Average Bricklayer Can Apply NONVIT Rapidly and Efficiently

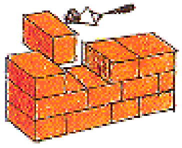
Precautions in First Application

The only precaution necessary is that, when the first repair on old furnaces, or application on new furnaces, is made, that the first firing be made slowly. **After drying the damp NONVIT for at least 24 hours, then a slow rise of 50°C per hour to reach operating temperatures.** Once operating temperature is reached there is no problem. The furnace can be stopped, cooled or heated irregularly, as can happen where thermostatically controlled fuel supply is used, such as where surges of peak demand occur in power stations NONVIT is found to be superb in reducing damage to heating units, caused by Thermal Shock.

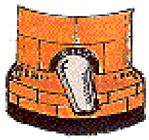
Following are some of the applications that FURNASCOTE-NONVIT is recommended for use in where fuel oil and solid fuels are employed in furnaces (NONVIT is particularly recommended in applications against Thermal Shock):

- Air Force, Army and Navy
- Atomic Energy Plants
- Aircraft Factories
- Bakeries
- Breweries
- Cable Factories
- Cargo Ships
- Ceramic
- Chemical Works
- Coal Mines
- Confectionery Works
- County Councils
- Dairies
- Domestic Furnaces
- Drydocks
- Electric Furnaces
- Food Factories
- Foundries
- Glass Works
- Hospitals
- Hotels
- Hydro Electric Systems
- Laundries
- Meat Packing Plants
- Metal Casters
- Motor Car Factories
- Municipal Authorities
- Non-Ferrous Smelters
- Oil Refineries
- Passenger Lines
- Pottery
- Power Generating Stations
- Railways
- Rubber Factories
- Schools
- Ship Repairers
- Smelting Works
- Steel and Iron Works
- Tankers

Delay in receiving supplies of NONVIT can mean losses of thousands of dollars to ship owners. These delays can be caused by industrial strikes, fogs, heavy weather, transport, hold-ups everywhere.

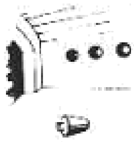


For bonding expensize firebricks use FURNASCOTE-NONVIT

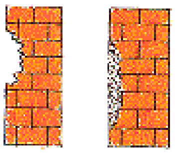


Stop spouts and channels slagging, with HIGLAZE

Inside walls and lips of receivers will last longer with NONVIT



Castables, brick walls, jet burner areas, are protected by using NONVIT



Broken firebricks can be re-inforced with Furnascote NONVIT

Supplied as a dry powder Mix into a cement with fresh water.