Gas Diffusers

Metal Treatment Solutions

www.capital-refractories.com

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Metal Treatment Solutions

Capital Refractories, one of the largest independent refractory companies in the UK, has been manufacturing, supplying and installing refractory materials for 50 years and operates in more than 40 countries. In 2009 the Penn Refractories castable range was incorporated into the Capital portfolio of products.

This combined product range and over 25 years of castable knowledge has enabled Capital to offer a more comprehensive range of superior refractories that are specifically designed for use in most heat application industries.

Following extensive development and investment we are able to offer to hot metal industries a complete range of gas diffusers, making technology available for improvement to metal quality and economics of operation.

Our gas diffusers can complement hot metal processes from the smallest investment foundry to the largest integrated steelworks. This technology has been proven in hundreds of sites worldwide and is patent pending.

Benefits of gas diffusers:

- Reduction in scrap rate
- Improve quality of castings
- Reduction in pinholing
- Removal of inclusions
- Reduction in gas content
- Temperature homogenization
- Distribution of alloying agents and de-oxidants

We can offer gas treatment solutions to ferrous and non-ferrous metallurgical processes. The products offered range from the permeable or natural porosity diffuser to the densecast directional or linear porosity plug. Our manufacturing facilities allow us to offer diffusers from less than 1 kg in weight to 50 kg.

The quality management at the manufacturing facility is fully accredited to ISO9001:2008.

Metal Treatment Solutions

For many years our area of specialisation has been the development, manufacture and supply of dry rammed induction furnace linings. With this knowledge, gas diffusers and associated materials suitable for integration in the furnace lining have been developed: bringing the advantages of inert gas treatment of liquid metal in the induction furnace.

We believe that each client's plant has differing characteristics and should be individually considered with respect to the perceived requirements of the user.

Therefore, a series of key questions must be asked:

- What does the client wish to achieve from gas injection? – melt homogenisation/degassing/fluxing of melt/cleanliness.
- Do they require gentle motion or vigorous stirring of the melt?
- What gas line pressure is available?
- Will gas flow be on at all times when there is liquid metal contact, or will there be significant times when the plugs will be offline?
- Will gas flow control be automated or simple, manual control?
- What purging gas(es) will be utilised?

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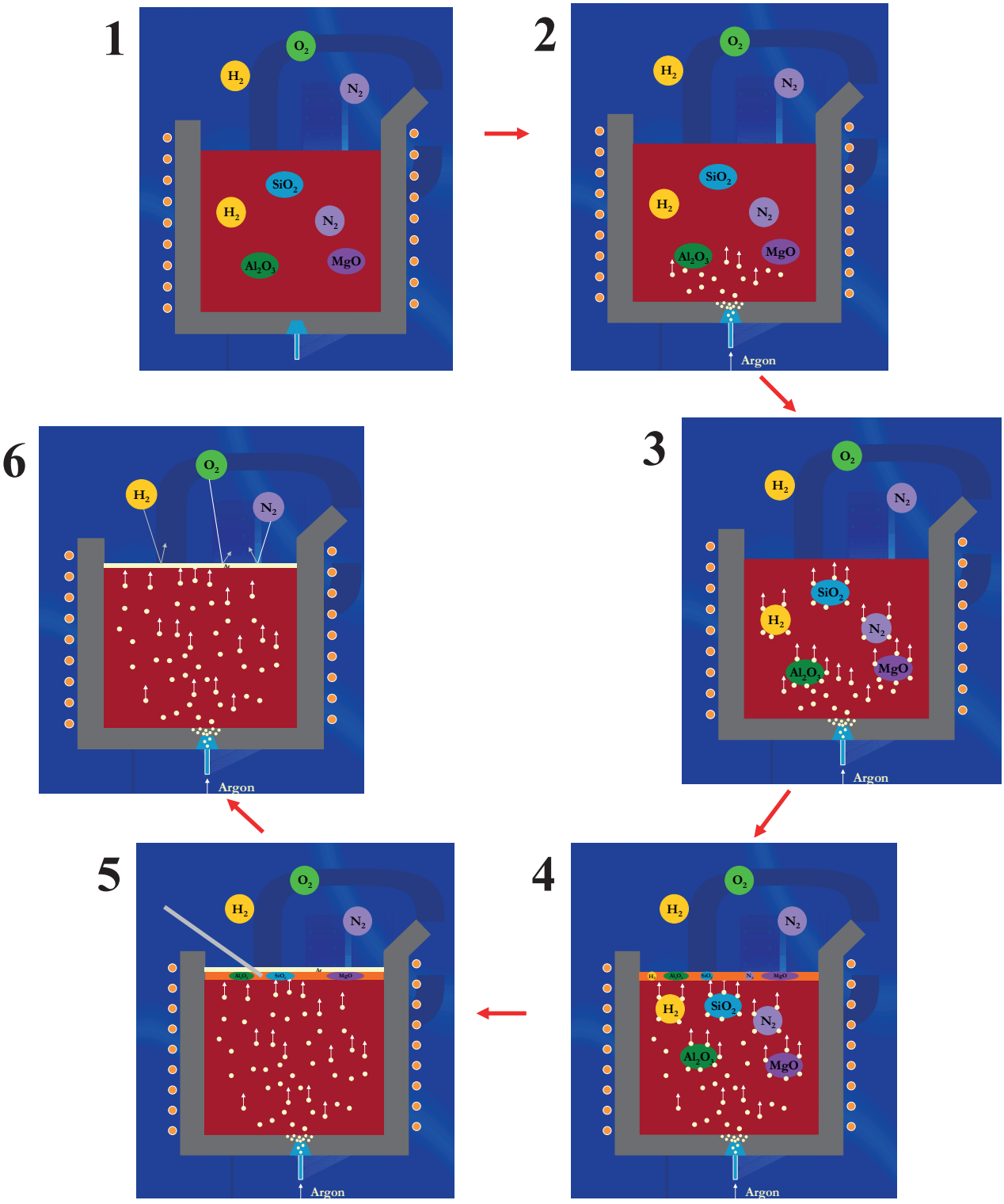
Gas Diffuser Action

The following diagrams demonstrate the processes occurring in the melt as a gas diffuser operates:



Types of Gas Diffusers

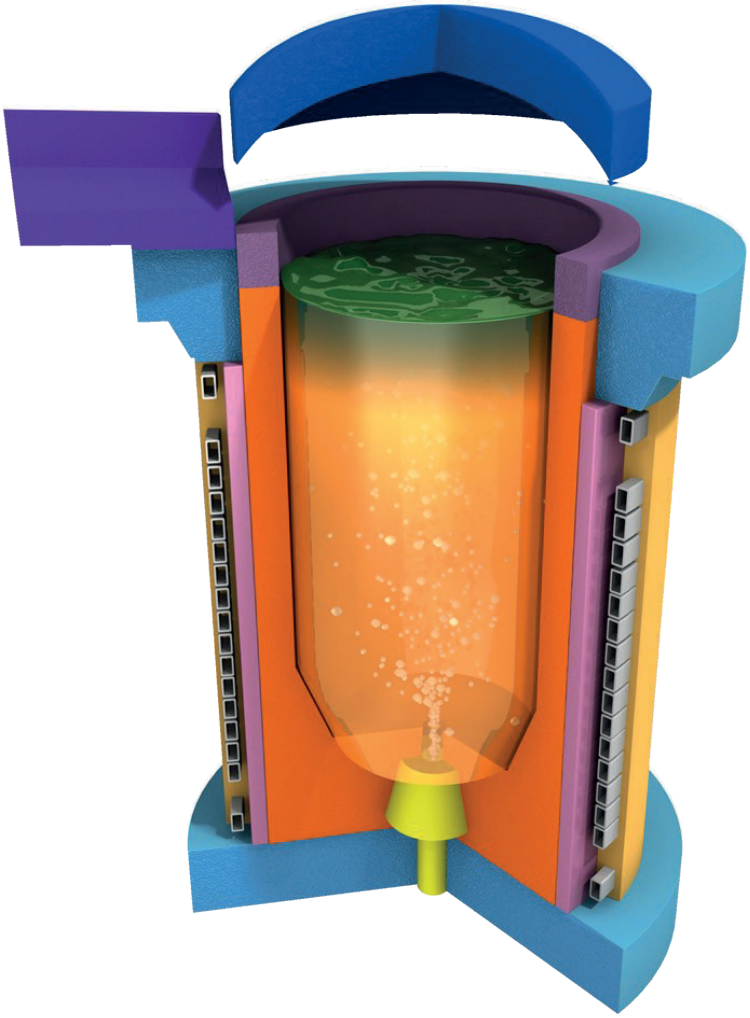
Permeable or Natural Porosity

This is a general purpose plug consisting of a hydraulically pressed and high temperature refractory shape whose granulometry has been designed to optimise gas flow with resistance to metal penetration. Available in permeable magnesite or permeable high alumina, this diffuser is suitable for a wide variety of applications across a spectrum of metals and alloys, from aluminium to stainless steels and can be operated in ladles from only a few kilos to many tonnes. A permeable alumina ceramic has been developed for use in the induction furnace. A permeable diffuser can also be used for aluminium. Its chemistry is modified to impart non-wetting characteristics and so it can be used in multiples within melting and holding furnaces.

Directional or Linear Porosity

Where high volume rates of gas are required or in extreme temperatures and slag conditions (such as in steel plant applications), the appropriate choice is the directional diffuser. This is a dense precast product with a specified geometric arrangement of gas outlet holes - these being capillaries, slots or segments. The cross-sectional area of the gas passageways is constant from top to bottom of the diffuser. When there is no flow of gas through the diffuser and it is in contact with the melt, there can be ingress of metal into the channels (only a few millimetres) but this has to be expelled before gas flow can recommence. Generally, there is a requirement of 10-12 bar pressure to start a directional diffuser in this state. As soon as flow is established, pressure can be reduced to 2-3 bar to maintain the purge flow.

Gas Diffusers in the Induction Furnace



A significant development has been the gas diffuser designed for installation within the base lining of the induction furnace.

Operation of the diffuser in this environment brings the advantages and benefits of gas purging, as detailed elsewhere in this publication, to the induction furnace.

Significant improvements in melt homogenisation, with respect to temperature and composition, have been observed by many users. The former leading to improvement in lining wear characteristics, the latter in casting quality. Reduction in melt gas content, nitrogen and hydrogen, has also been reported thus permitting greater use of foundry returns in the furnace charge.

The diffuser has been designed specifically to be compatible with our range of dry rammed linings and can be operated continuously or intermittently. It has been designed to last the life of the lining.

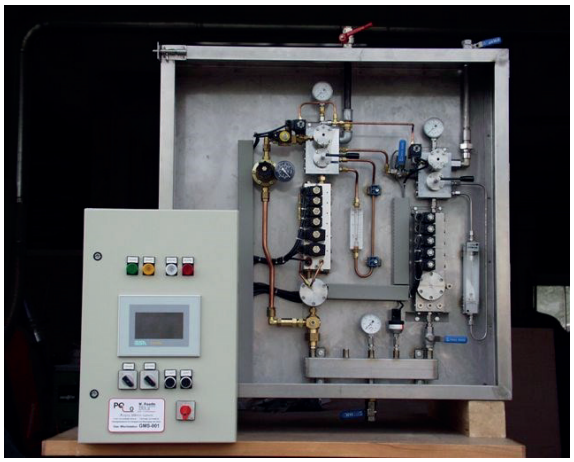
For optimum performance Coral GDR has been developed to be installed immediately above the gas diffuser. This facilitates enhanced gas flow even in high slag environments.

It is recommended to keep a positive pressure of gas whenever molten metal is present.

Flow Control Systems

For the safe and effective operation of any gas diffuser, we ***thoroughly recommend*** that a flow control system is installed to regulate and control the pressure and flow of gas delivered from the source to the diffuser.

This system should be installed and operated in line with our written instructions. The first installation should be supervised by our experts, and used with a Capital lining.



For more permanent arrangements, we can arrange for touch screen panels to be installed which can be linked to a plc system.

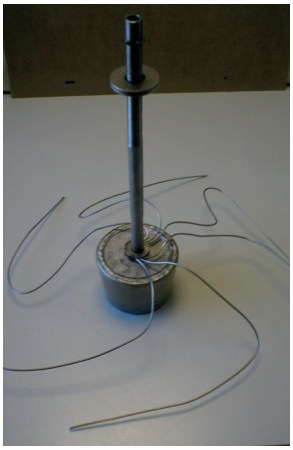
A flow control system attached to a bottle

We are able to offer customers a simple flow regulator or needle valve which will limit the discharge of gas to a predetermined flow rate. The valve acts as a pressure reducer. Flow can be indicated by either a float in a glass tube, or a dial.

For safety reasons, the source of gas (be it mains or a bottle) is remote from the furnace. The flow meter and valve can be situated near to the furnace. This allows for the user to have full control over the system and can operate the flow control system based on requirements and observations.

Fixtures and Fittings

All gas diffusers for the induction furnace are available with an integral earth leakage electrode as an option. This should be clearly specified when the order is placed. The gas diffuser (with or without the earth leakage electrode), will be supplied with a mounting kit of attachment nuts and washers to enable the gas diffuser to be secured to the furnace base where the gas feed pipe exits the furnace base.



A gas diffuser with an earth leakage electrode

The following additional kits are available to purchase through Capital:

Induction Furnace Gas Diffuser Flow Meter System Installation kit (U.S.A.):

- 33 foot (10 metre) long, ⅜ B.S.P. Hose, partially covered with 3 metres of heat resistant thermo-jacket sleeving (to protect the hose at the plug end).
- 1 x 0-15L.P.M. Flow metre, with all the required fittings to terminate to a U.S.A. Argon cylinder at ⅜ N.P.T.

Induction Furnace Gas Diffuser Flow Meter System Installation Kit (U.K.):

- 10 metre long, ⅜ B.S.P. Hose, partially covered with 3 metres of heat resistant thermo-jacket sleeving (to protect the hose at the plug end).
- 1 x 0-15L.P.M. Flow metre, with all the required fittings to terminate to a U.K. Argon cylinder at ⅜ B.S.P.

⅜ B.S.P. Diffuser Mounting Kit:

- One insulation washer, one stainless steel washer and one locknut, to hold the plug firmly against the furnace base.

Two brass locknuts and two brass washers to form an earth spider connection.

One female socket and one male coupler to give the final hose connection point.

Additional components:

0-15 L.P.M. Argon flow metre with 3/8 B.S.P. inlet and outlet connections.

3/8B.S.P. to 3/8N.P.T. stainless steel adaptor.

Replacement/spare 10 metre long hose.

Please note: full selection, operation, installation and trial instructions are available from your sales contact.

Purging Gases

Argon is the gas selected in most ferrous and non-ferrous applications.

Argon comes in a variety of grades but for the vast majority of applications, welding grade argon is the economic choice. This gas (generally offered for MIG and TIG welding processes) is not pure argon but is a mixture of argon (generally 95%) and carbon dioxide (5%).

The most expensive grades of argon available are not necessarily for gas purging purposes (e.g. for medical or spectrometer use).

Nitrogen may be used in aluminium applications but is generally considered a deleterious gas in most other applications.

Connecting the gas diffuser to a gas supply

A frequently asked question to Capital is:

"*What becomes of the argon after it passes through the melt, and are there health risks associated with its use?*"

Argon is a tasteless, odourless, non toxic gas that is denser than air and only becomes a hazard to health if it is discharged in a confined space where it may displace air and thereby act as an asphyxiant. There is an onus on the customer to be aware of confined spaces in the vicinity of the furnace and the gas system and to put in place any necessary precautions and monitoring.

Argon does however readily disperse into the atmosphere and the argon which has passed through a melt into the atmosphere will become a negligible addition.

Early trials at a major producer of nickel alloys, required the production of risk assessments to consider the effect of a build up of argon.

Argon displaced after passage through the melt as well as from leakage of the connecting hose or feed pipe, and from the respective pits in which each furnace is located was measured.

Oxygen depletion monitors were installed in each pit, set to produce an audible alarm should the atmospheric oxygen content fall below 18%.

It is now over 2 years since the installation of Capital's gas diffusers, there have been no recorded instances of the alarms being triggered.

Details of such types of oxygen depletion monitors may be found on the Council of Gas Detection & Environmental Monitoring website www.cogdem.org.co.uk.

Gas Diffusers for Aluminium

Treatment of aluminium by inert gases of liquid metal has seen a quantum leap in terms of product quality by homogenisation of the melt prior to casting with respect to temperature and chemistry. A further attraction is the low installation costs and inexpensive consumables compared with, for example, the top lance process. Due to the low melt density, fluidity at relatively low temperatures and the grain 'wetting' characteristics of aluminium, pressed and fired corundum (Al_2O_3) has emerged as the material choice for the porous plug application in the aluminium furnace.

Benefits of gas diffusers:

- ***Reduced scrap rate***
- ***Improved melt homogeneity***
- ***Cost-effective over time compared with Rotary Systems***
- ***Low maintenance***
- ***Environmentally friendly compared with other systems***
- ***Improved melt rate in melting furnaces***

Plug materials

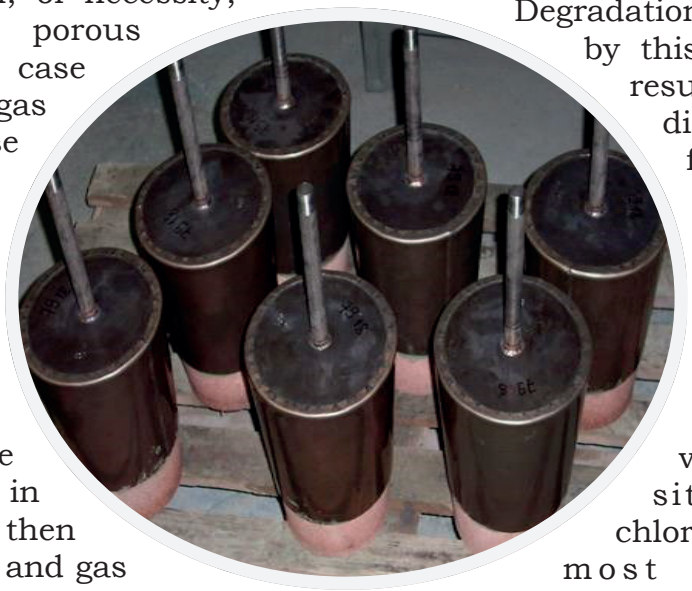
The permeable core of the plug, through which the purging gas passes, is a balance of compromises. There has to be sufficient permeability to allow passage of the gas under pressure (sufficient pressure to overcome the aluminostatic head pressure at the exit face of the plug) into the melt, yet be sufficiently dense to prevent ingress of the liquid aluminium into the porous material, ultimately leading to blockage of the plug. This is achieved by designing the granulometry of the batch from which the porous brick is to be pressed to enable the fully fired plug to have the above-mentioned characteristics. To enhance the non-wetting capabilities of the permeable media certain additives are introduced during batching of the raw materials which, upon firing, form a microscopic layer around the alumina grain. This coating modifies the wetting angle so that when it is in contact with the liquid aluminium adhesion cannot take place.

Installation of gas diffusers in an aluminium melting furnace.

Gas Diffusers for Aluminium

We can offer two variations of the Caperdiff 94ALR, where the mean pore diameter is 55 microns and a standard version of 90 microns. For most applications the former is preferred as it produces finer bubbles that bring a greater surface area into contact with the liquid being purged. The latter, more open structured plug, is particularly effective where high volume flow rates are required or denser gases (e.g. chlorine) are used.

The question of "what purging gases will be utilised?" is particularly important when selecting the plug: not just the refractory component but the metal case which, of necessity, surrounds the porous core. The metal case ensures that the gas can only diffuse through the brick and exit via the designated exit face.



Where argon or nitrogen is to be used and lining temperatures are relatively low (i.e. in an in-line box), then all the metal case and gas feed pipe work can be in mild steel. Where the plugs are installed into a vessel hearth and the lining is well insulated (i.e. high working temperature), then it is recommended that grade 310 stainless steel be used for the casing as, over a prolonged period, oxidation of mild steel could take place.

An increasing number of secondary melting operations are now adopting chlorine as a fluxing gas, this being particularly effective in removing magnesium from the melt. Additionally, introduction of chlorine to a bath by means of gas diffusers is more efficient and environmentally acceptable than fluxing with salts or lances/wands.

It is imperative that at the outset the potential user should be aware that if chlorine is to be used then the gas diffuser has to be designed specifically for that purpose. It has been found that at elevated temperatures the chlorine gas will attack and quickly corrode mild steel and even stainless steel albeit at a slower rate.

Degradation of the plug case by this process will result in loss in directionality of gas flow into the melt, tracking of the gas into the surrounding lining and even leakage of gas through the furnace shell – a very dangerous situation when chlorine is involved. In most applications involving chlorine as a purging gas, the temperature of gas feed pipe which passes through the furnace shell is sufficiently low to permit a stainless grade to be utilised.

In an aluminium furnace plugs can last the life of the hearth if reasonably looked after. Where chlorine is used, there will be deterioration but lives of 18 months to 2 years have been achieved even with heavy chlorine usage.

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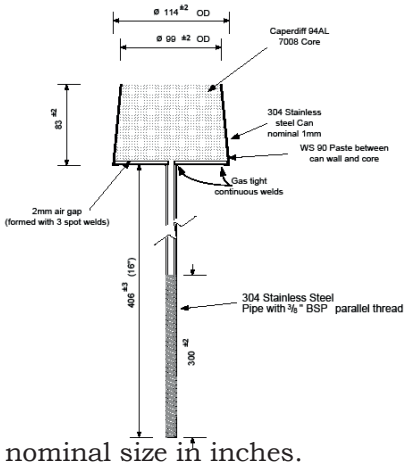
Crucible Gas Diffuser

Gas Diffusers for Induction Furnaces

Gas Diffuser Model		Lining Thickness	
Name*	Drawing No.	/ mm	/ "
MINI	7204	< 75	< 3
IF 1.5	7220	< 75	< 3
IF 2	7205	75 - 100	3 - 4
IF 3	7206	100 - 150	4 - 6
IF 4	7207	150 - 200	6 - 8
IF 6	7217	200 - 250	8 - 10
IF 8	7228	> 250	> 10



* The name: IF refers to induction furnace and the number is the nominal size in inches.

Duplex Gas Diffusers for Induction Furnaces

Gas Diffuser Model		Lining Thickness	
Name	Drawing No.	/ mm	/ "
DP 2	7235	75 - 100	3 -4
DP 3	7236	100 - 150	4 - 6
DP 4	7237	150 - 200	6 - 8

Aluminium Furnace Gas Diffusers

Gas Diffuser Model	Specification			
Drawing No.	Diameter / mm	Height / mm	Pipe / mm	Can
7240	158	279	355	Stainless Steel
7119	158	279	371	Inconel
7229	158	282	Socket	Stainless Steel
7232 (Assembly)	229	340	45	Stainless Steel
7264	229	340	185	Short Can
7164 (Assembly)	229	340	465	Stainless Steel
7127	229	340	685	Inconel

Miscellaneous Gas Diffusers

Gas Diffuser Model	Specification			
Drawing No.	Diameter / mm	Height / mm	Pipe / mm	Type
7532	46	64	37	Directional
7114	46	64	37	Permeable
7219	48	130	38	Permeable

Selection

Ladle gas diffusers

Model	Specification			
Drawing No.	Diameter / mm	Height / mm	Pipe / mm	Type
7129	95	104	50	Permeable
7162	106	165	190	Permeable
7121	100	206	110	Permeable
7123	100	206	120	Permeable
7196	100	206	150	Permeable
7113	97	206	370	Permeable
7264	110	140	110	Permeable
7110	110	151	38	Permeable
7254	110	160	75	Permeable
7120	110	151	90	Permeable
7125	182	120	52	Permeable
7241	182	120	200	Permeable
7501	61	257	120	Directional
7528	137	380	50	Directional
7519	138	155	38	Directional

Crucible Gas Diffuser

Capital Refractories has now incorporated their gas diffuser technology into a pressed crucible. The resultant metallurgical treatment crucible is a multi-use, isostatically pressed one piece refractory vessel with an integral gas supply device.

The granulometry of the crucibles walls and base is such that gas can easily travel through it. This allows the gas to enter the metal not just from the base but also the side walls. The outer wall of the crucible is usually coated with an inorganic sealant to inhibit loss of gas through the external surface.

Gas consumption has been proven to be substantially reduced when compared with surface gas blanket techniques.

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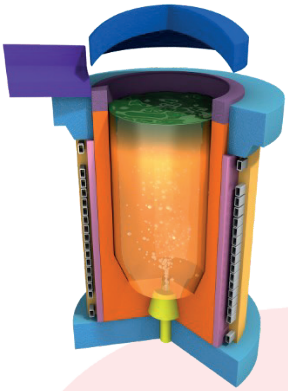
Products and Applications

Product Name	Principle Raw Materials	Chemical Analysis / %							
		SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	Cr_2O_3	P_2O_5	BaO
Caperdiff 90ALR	Alumina-chrome	2.4	0.1	94	0.2	-	1.4	1.3	-
Caperdiff 94AL	Alumina	2.6	0.1	94	0.05	-	-	2.9	-
Caprax AS DP	Alumina Magnesia Spinel	0.1	0.1	93	1.5	4.2	-	-	-

Values presented are the average results of quality control testing carried out over a period of time and so do not constitute a guarantee or specification. Maximum service temperatures are for guidance and not guaranteed.

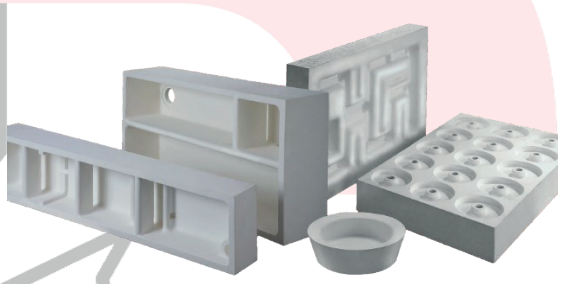
	BD / kg m^{-3}	AP / %	CCS / MPa	Applications
	3160	17.7	120	Pressed and fired high strength permeable chrome-enriched alumina diffuser for both ferrous and non ferrous applications.
	2850	21.0	100	Pressed and fired permeable alumina diffuser for both ferrous and non-ferrous application. A high strength product where mechanical damage (cleaning) may be an issue, together with a low pore size to give a finely dispersed bubble swarm. Recommended for induction furnace application
	3120	16.6	55	Directional or channel porosity diffuser for application in steel ladles where there is an aggressive slag environment.

Capital Group Overview



Capital specialise in the supply of refractory linings and associated products to metal melting, foundry and cement industries around the world. Capital manufactures a wide range of dry vibration rammable products for lining coreless induction furnaces, vacuum coreless induction furnaces and channel induction furnaces for the melting of steel and high temperature alloys, iron, copper, bronze, aluminium and masteralloys. Capital also supply magnesia and magnesia-chrome bricks for furnace linings.

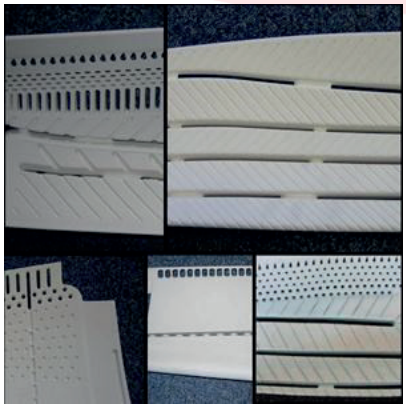
The dry vibration induction furnace rammables are supplemented by a wide range of topping, ramming and patching refractories and other refractory products. We also supply a wide range of shaped products and runner systems for molten metal control.



Capital supply the patented Unibore/ Multicast stopper and nozzle bottom-pour system for ladles and auto-pour which improves metal flow and quality as well as offering a quick change nozzle for improved cleanliness or to easily change nozzle diameters.

Capital also manufacture a wide range of crucibles manufactured by vibro-casting or isostatically pressing. Crucibles are available in a range of alumina, chrome-alumina, magnesia, zircon, zirconia and mullite.

Capital supplies a range of ancillary products including mica slip plane products, coil screeds, earth leakage electrodes, vibratory installation equipment, furnace and ladle formers, ceramic fibre shapes, holloware, ladle opening technology, sampling and temperature measuring equipment.



Capital Injected Ceramics, a subsidiary of Capital, manufactures injection moulded ceramic cores. CIC has proven its capability by producing some of the largest and most complex blades and vanes for IGT and aerospace. In addition, CIC supplies a wide range of cores to the medical, hardware, construction and automotive casting industries. CIC is accredited to AS9100 Aerospace standard for core production — believed to be the only independent company with that status.

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