Newsletter

# PSR Review

The Journal of Parkinson-Spencer Refractories Ltd.

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## BURNER NOZZLES

From steel to ceramic

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## COMBUSTION SYSTEM

Recent Upgrades

For any engineering company, changes to regulations and standards means the design of equipment requires ongoing scrutiny which should also drive improvements. At PSR, we see this as common practice, not only meeting the requirements of regulations but striving to stay ahead of the curve. (Continued inside)

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# WELCOME ON BOARD

The strategy for the long term continuity of PSR has always been to maintain the company as a family controlled business and this policy has ensured that the company continues to remain an independent manufacturer of specialist refractory products and glass conditioning equipment. With the time approaching for the baton to be passed from one generation to the next it was decided at the beginning of 2015 that the time was right to strengthen the board of directors, combining the energy of youth with the wisdom of experience. With that in mind we'd like to introduce you to the current line-up on the board of directors.

## DAVID PARKINSON
### MANAGING DIRECTOR

Joined the company in 1974.

Managing Director since 1985.

Chairman since 2000.

## JOHN CASWELL
### FINANCIAL DIRECTOR

Joined the company in 1999 and took over as Financial Director in 2000. Being scheduled to retire in September 2016 we'd like to thank John for keeping a steady hand on the financial tiller for the past 16 years.

## GODFREY NIELD
### COMMERCIAL DIRECTOR

Joined the company in 1973 as Shipping Clerk and has held a number of positions from Shipping Manager, Export Manager, Technical Services Coordinator through to Commercial Manager. As Commercial Director Godfrey heads up the purchasing and commercial activities and has taken on the additional responsibility for the quality management system.

## LES GASKELL
### TECHNICAL DIRECTOR

Joined the company in 1992 as Project Engineer and took over as Technical Services Manager in 2001. As Technical Director Les oversees the engineering function with responsibility for the design, development and implementation of forehearths, distributors and related glass conditioning equipment

## DAVID FERGUSON
### MANUFACTURING DIRECTOR

Joined the company in 1978 and held a number of positions in the casting, machining and production control departments. Took over as Factory Manager in 1992 and as Manufacturing Director is responsible for all the principal refractory manufacturing functions.

## JOANNE PARKINSON
### COMPANY SECRETARY

Joined the company in 2005 as Export Assistant and has worked up through management of the export, import and shipping departments. Is currently the Company Secretary and will fill the vacant board position following John Caswell's retirement.

## SIMON PARKINSON
### DIRECTOR

Joined the company in 2011 as Project Engineer and spent his first years in technical services on project installation and commissioning. Currently divides his time between overseas sales and support for technical services.

# WINDY BANK LANE LIVES UP TO ITS NAME

The road that borders the land at PSR to the East is known locally as Windy Bank Lane and, as its name suggests, has been found to be a suitable site for the recent installation of two wind turbines. Owned and operated by associate company Parwell Ltd, work on the foundations for the turbines commenced in October 2015 with the first turbine erected and in production by the end of November 2015. The second turbine was erected some three months later and was in production by the end of March 2016. Rated at 65kW, but being limited to 50kW for connection to the grid, the turbines should generate approximately two thirds of the electrical power requirements of PSR.

## BUCHER EMHART GLASS REFRACTORY LICENCE RENEWED

Our relationship with Emhart Glass started in 1970 when we took over the UK licence for the manufacture of refractory parts to Emhart designs. As well as access to the refractory drawings the licence also gave us access to the renowned refractory compositions of 311, 333 and 315. This was never an exclusive licence as it was shared with licensees in Germany, France and Japan as well as Emhart's own manufacturing plant in the USA. However recent policy changes within Emhart have resulted in other licence agreements not being renewed so that now PSR are the sole licensee alongside Emhart's own refractory manufacturing plant in Owensville, USA.

The question might be asked as to why PSR continue as licensees when other refractory manufacturers produce similar refractory parts without paying any licence fee and the answer is as follows:

1. The licence provides access to the original manufacturing drawings and tolerances. Our customers can therefore be sure that our refractory parts will integrate correctly with their Emhart feeder mechanism parts.

2. The licence provides access to all the latest Emhart metering spout designs, including the 585 metering spout design.

3. The licence avoids the need to copy refractory parts manufactured by others or to infringe any copyright or other patents held by Emhart.

BUCHER emhart glass

Lajos Giczi (right) and David Parkinson shake hands on the new agreement at the Emhart offices in Cham.

# CORD DISPERSAL SYSTEM GOES FROM STRENGTH TO STRENGTH

The PSR Cord Dispersal System was first introduced in 2002. Since then it has developed into one of PSR's great success stories.

In the 2012 issue of PSR Review, we reported an accelerating trend in the supply of our stirrer systems, with 81 systems having being supplied. We are pleased to report that this figure has doubled over the last four years. Over 160 systems have now been sold, with 26 systems being sold in 2015 alone.

"Cat scratch" cord is a defect found on the surface of glass containers which resembles a scratch caused by a cat's claws running down the surface of the container. The cord consists of a glass enriched in alumina and/ or zirconia which, due to it's higher viscosity than that of the glass product, tends to settle out on the bottom of forehearths and distributors. This enriched glass then travels along the bottom of the forehearth and is drawn into the spout and on to the surface of the gob, appearing as a line or series of lines on the surface of the article being manufactured. It is now generally accepted that the source of this material is the exudation upon initial furnace heat up, and corrosion during subsequent operation, of glassy phase material from the fused cast AZS refractories in the melting end of the furnace.

## MEXICAN FACTORY WITH CDS INSTALLED ON ALL 13 LINES

We were first approached in 2004 by a client in Mexico for a solution to their "cat scratch" cord problem and the first stirrer system was supplied in 2005. The client had very strict quality requirements, dictated by their customers, particularly with regard to the "cat scratch" cord defect. This meant that a solution to the problem was potentially extremely valuable, not just through the increased production possible but also through avoiding the potential loss of lucrative contracts.

Following the success of that first system a further two were ordered and supplied in 2006. In the four years between 2010 and 2014 a further three systems were installed. Over these years the systems were transferred from forehearth to forehearth as problems with production were encountered. However, the "cat scratch" defect returns after a period of time without operating stirrers and can then take a period of time to be eliminated again once the stirrers are re-introduced. It is therefore best policy to run the stirrer systems continuously to ensure a continuing quality of production. Therefore, in 2015 the client took the decision to complete the factory with the installation of Cord Dispersal Systems on their final seven forehearths. Now, with Cord Dispersal Systems installed on all 13 of their production lines across three furnaces, the factory is our biggest single customer for this equipment.

Two PSR Cord Dispersal Systems installed on a tandem forehearth in Mexico

# 160 SYSTEMS SOLD WORLDWIDE, 26 OF THESE IN 2015

## GLASS MANUFACTURERS USE TWO COMMON METHODS TO TRY TO COUNTERACT CAT SCRATCH CORD:

**1** The first comprises a special drain block located in the base of the channel, near the front of the forehearth. This is used to drain off the bottom glass, where the "cat scratch" material is expected to reside, thereby removing this material from the finished glass article. However, there are several disadvantages to this method. It is very wasteful of glass, as often several tonnes of glass are removed from the forehearth every day, reducing the maximum possible forehearth load and reducing the energy efficiency and pack to melt ratio of the forehearth and furnace.

The drain must be run continuously as, if it is shut down, the special drain block actually acts as a sump in the forehearth where the viscous "cat scratch" material can build up. This is, therefore, a cause of the problem. It is very often found to be ineffective at removing the cord from the glass and we have installed several stirrer systems on forehearths which already had ineffective drain systems installed. In each case the stirrer system solved the "cat scratch" cord problem and the drain was shut off, eliminating the wasted glass being removed from the forehearth.

**2** The other method of addressing this problem is the installation of a stirrer system in the forehearth to disperse the "cat scratch" cord material into the body of the glass so that it no longer appears as a defect in the finished article. This is the method originally promoted by PSR as a solution to the problem. Since then other suppliers have moved away from the drain systems towards the more successful stirrer system. However, most do not have the experience or expertise to employ this method correctly, through correct design and configuration of the systems, and none back up their supply with a full money back guarantee.

PSR offers a money back guarantee which stipulates that if the client is not happy with the results of the system, we will remove it and return the cost of the equipment to them. We are proud to say that with more than 160 systems supplied to date, we have not yet been asked to act upon our guarantee.

## REMOVING COLOUR STREAKS:

Our system has also been proven to remove colour streaks from the glass, particularly colour streaks originating from the furnace.

One customer in the Middle East reported a particular problem with residual green colour streaks appearing in flint glass for several weeks following conversion of the furnace from green to flint glass. We first supplied a system to this factory in 2014 and the installation was carried out during a furnace colour change from green glass to flint glass. Once the colour change was complete and the correct flint colour was obtained, the remaining colour streaks and cat scratch cord were quickly removed from the manufactured articles by the effect of the stirrers. In addition, the thermal homogeneity values were recorded before and after the installation. These were found to be 96% before installation of the stirrers and 99% after installation of the stirrers, indicating a 3% thermal homogeneity increase as a result of the operation of the stirrers. Following this successful installation, a second system was installed in 2015 on an adjacent forehearth with similar results.

This repeat business is very typical for our Cord Dispersal System sales. We have many customers who have installed multiple systems, four of whom have 10 systems or more across multiple furnaces and/or factories. This is a clear indication of the results and savings that are regularly achieved by these systems.

## GLASS MANUFACTURER IN SLOVENIA INSTALLS THREE SYSTEMS IN SIX MONTHS.

In 2015 we were approached by a Slovenian glassmaker to provide a solution to their "cat scratch" cord problem. The forehearth was 26 inches wide and had a drain system installed in the third channel block from the front of the forehearth. The drain was ineffective at removing the "cat scratch" from the glass and was wasting up to two tonnes of glass per day. We supplied the stirrer system in June 2015 and it was installed and commissioned in July 2015 under the supervision of our engineers.

The stirrer system was quickly proven to be effective and solved the client's "cat scratch" cord problem. As a result of this success we were then asked to supply two more systems on two different forehearths. These were installed in December 2015 and February 2016.


PSR Cord Dispersal System during installation in Ukraine

# BURNER NOZZLES FROM STEEL TO CERAMIC

Stable and efficient combustion within the forehearth and distributor is essential to ensure that consistent operation and efficient glass production is maintained. Here we describe the importance of the burner nozzle in this process and how converting from stainless steel to ceramic burner nozzles can achieve greatly improved results.

## BURNER NOZZLES

The burner nozzle is the point of interaction between the forehearth or distributor and the combustion system. The air/gas mixture supplied by the combustion system flows through the burner nozzle into the forehearth or distributor zone where it burns in the combustion chamber above the glass (See Fig 1).

The burner nozzle diameters are normally specified based on the forehearth or distributor width. The burner nozzle diameters would typically range between 4.0mm and 9.0mm in increments of 0.5mm. The burner nozzle diameter is sized to provide sufficient heat input in order to maintain the required glass temperature at the specified forehearth or distributor section minimum load condition as well as adequate temperatures under no load conditions when no glass is flowing.

The burner pipe and nozzle assembly is designed to seal against both the inside face and the outside face of the refractory burner block to ensure that all combustion takes place within the forehearth and to prevent any excess air in-leakage around the burner nozzle which would weaken the air/gas mixture, reduce the flame temperature, increase the flue losses and thereby reduce the combustion efficiency. (See Fig 1).

The burner nozzle is traditionally manufactured from a stainless steel material. This allows the nozzle to withstand the temperatures within the burner block. However, the burner nozzle is cooled by the flow of the air/gas mixture through the inside of the nozzle and the high thermal conductivity of the stainless steel means that the heat at the tip of the nozzle from the forehearth atmosphere is quickly transferred along the steel nozzle away from the nozzle tip. This results in a relatively low surface temperature at the tip of the burner nozzle providing a cold surface on which volatile materials from the glass, such as soda vapour, can condense. These volatile materials are carried to the burner nozzle from the forehearth combustion chamber atmosphere by the action of re-circulating gases around the burner flame (See Fig1). Over time these condensates gradually build up on the surface of the burner nozzle causing it to reduce in diameter and, in the absence of proper preventative maintenance, it can eventually become completely blocked.

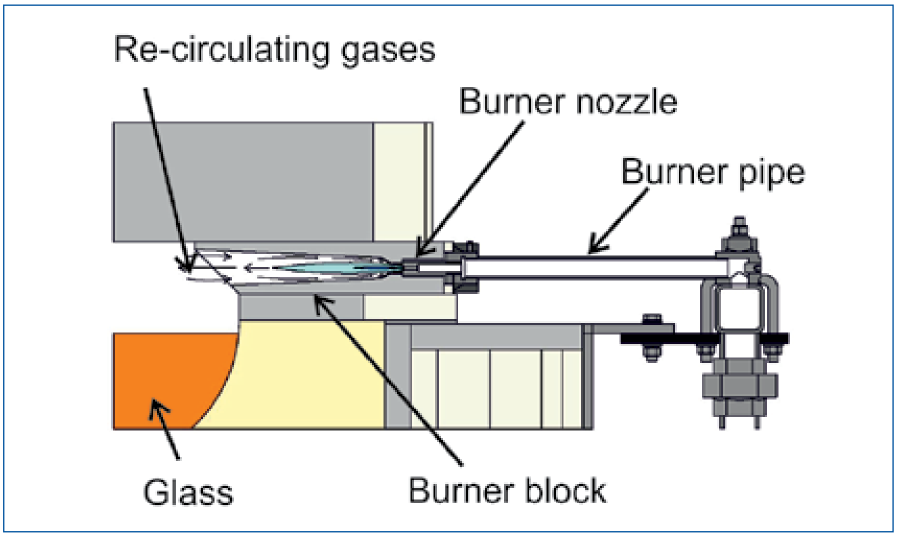


FIG 1: Forehearth Burner And Refractory Burner Block Assembly.

Figure 2 shows the condition of burners removed from a forehearth by PSR engineers in which problems were being experienced in achieving adequate operating temperatures for correct glass production. The burners were reported to be clean. This forehearth operates at low tonnages and high temperatures and it was stated that the burners were cleaned out in-situ every twelve months. In this case, following removal, it was determined that the last scheduled burner cleaning had not been carried out and the burners had not been cleaned for more than 18 months resulting in the operating problems. Following replacement of the burners with spare burners, originally supplied as part of a recommended spare parts package with the forehearths to assist with regular maintenance, the combustion system performance was returned to its original, as commissioned, state.

This progressive reduction in the burner nozzle diameter will, with any pre-mixed combustion system, eventually result in a change in the air/gas ratio unless corrected. The air/gas ratio will become gas lean with the excess air reducing the flame temperature, increasing the flue losses and thereby reducing the combustion efficiency. This will initially result in an increase in fuel consumption to achieve the same operating temperatures. However, if this deterioration is allowed to continue further without the proper burner maintenance then the reduction in burner nozzle diameter will reduce the firing capacity and eventually result in an inability to adequately control or achieve the required forehearth operating temperatures. As it is also only the flow of the air/gas mixture through the burner nozzles that keeps them cool, complete blockage of the burner nozzles can result in overheating of the burner nozzles and backfiring of the air/gas mixture in the burner manifolds and pipe work resulting in damage to the pipe work and combustion equipment if left uncorrected.

The degree of condensate build up and the frequency of burner nozzle maintenance required will depend on a


FIG 2: Burners with stainless steel nozzles after removal from a forehearth experiencing temperature control problems. Many nozzles are fully or partially blocked by the build up of condensates having not been correctly cleaned out for 18 months or more.


FIG. 3: Burners with 5.5mm ceramic nozzles removed from the frit addition section of a colourant forehearth after six months' operation. The nozzles are relatively free of any condensate build up.

number of interrelated factors including glass composition, glass colour, burner nozzle size and operating temperatures.

Coloured glasses such as amber and green will generally produce more condensates than white flint glass and the burner nozzles will require more regular maintenance. Larger diameter burner nozzles used on wider forehearths and distributors are less likely to block up than smaller diameter nozzles and therefore require less maintenance.

Forehearths operating at high temperatures and low tonnages will result in greater evolution of the volatile materials from the glass which will then be present in greater concentration in the forehearth atmosphere and more readily available to condense on any cooler surfaces.

Forehearths operating at lower glass temperatures and higher tonnages will have a lower concentration of volatiles in the forehearth atmosphere but will have cooler surfaces on which the volatile materials can condense.

Colourant forehearths in which the colourant material is added to white flint glass as a relatively low melting point frit are particularly volatile and the condensates from these materials readily build up on the relatively cold areas of a colourant forehearth such as the exhaust dampers, peepholes and burner nozzles and are very corrosive.

## BURNER MAINTENANCE

In order to maintain efficient combustion conditions inside the forehearth or distributor, the burners must be regularly cleaned to maintain the correct burner nozzle diameter and thereby the correct air/gas ratio. This could be done in-situ by removing the plug from the rear of the burner and using a rod with a drill of the correct burner nozzle diameter to ream out the burner nozzle without removing the burner from the burner manifold. However, this method is not recommended by PSR as it results in the condensate materials formed on the burner nozzle being pushed into the glass, and does not guarantee that the face of the burner nozzle and the opening in the refractory burner block is clean.

PSR recommend that the complete burners be replaced during job changes or other machine stoppages and the burners removed be thoroughly cleaned by grit blasting and drilling out in the workshop so that they are completely clean and ready for the next scheduled burner replacement. Spare burners of each forehearth or distributor section type are normally included in our recommended spares package to allow this method of burner maintenance.

However carried out, burner maintenance is a time and labour consuming process which must be correctly documented and controlled to prevent operating problems and between the scheduled burner cleaning the combustion system efficiency is continuously, gradually reducing from the optimum value. In our experience this essential maintenance is, in many cases, not carried out as often as required resulting in diminished forehearth operation.

## CERAMIC BURNER NOZZLES

The solution to this problem, to eliminate the build up of condensates and subsequent blockage of the burner nozzles without the need to regularly change and clean the burners, is to use a ceramic material for the burner nozzle instead of stainless steel. Due to the lower thermal conductivity of the ceramic material compared with stainless steel, the heat at the ceramic burner nozzle tip is not conducted along the nozzle away from the nozzle tip as quickly as with a stainless steel nozzle. The ceramic nozzle tip therefore operates at a higher temperature greatly reducing or eliminating the tendency for any volatile materials from the glass to condense and build up on the ceramic nozzle surface. This prevents the reduction and eventual blockage of the burner nozzle, thereby continuously maintaining the air/gas ratio and combustion efficiency whilst reducing or eliminating the need for burner maintenance. Other normal combustion system maintenance, such as regularly replacing combustion air fan filter media, still needs to be carried out to prevent foreign materials such as dust entering the combustion system and potentially blocking the burner nozzles.

## PSR CERAMIC BURNER NOZZLES

The PSR ceramic burner nozzles are manufactured from a 95% dense alumina. It is an exceptionally strong material, to the extent that it is not practical to drill out the ceramic nozzles to the required diameters. They are typically manufactured in diameters at 0.5mm increments from 4.0mm up to 9.0mm and each different diameter must be cast using it's own specific mould.

This inherent strength of the material is important to ensure that the nozzles can withstand the rigours of day to day operation in a glass factory. Under both cold and hot conditions these nozzles must be extremely durable to withstand heavy loads such as from workers inadvertently standing on the burners and burner manifolds to access components on the forehearth superstructure.

The nozzles were designed to function in exactly the same way as the stainless steel burner nozzles which preceded them. Having exactly the same exterior nozzle diameter and nozzle length from the burner nozzle holder to the tip of the nozzle ensures that the nozzle seals against the inside face of the burner block and the burner nozzle holder seals against the outside face of the burner block in the same way that a stainless steel nozzle does. The use of the ceramic burner nozzles will ensure that the combustion system efficiency set during commissioning can be continuously maintained.

The PSR ceramic burners have now been installed in glass factories producing a variety of glass colours under various different operating conditions. They have been installed on a colourant forehearth frit addition section where the presence of volatile materials from the addition of the frit material would ordinarily result in the need to regularly maintain the burners to ensure that operating conditions are maintained.

Fig. 3 shows a row of these burners which were removed from a colourant forehearth frit addition section after six months operation. The burners were removed following cool down of the forehearth for a furnace rebuild.

One particular project on which the benefits of ceramic nozzles over stainless steel nozzles was of particular importance, consisted of a forehearth and distributor for production of electrical insulators for overhead power lines. The extreme thermal toughening process which the glass insulators are subjected to means that the quality requirements for the glass are extremely high, particularly with respect to foreign particles in the glass. Even microscopic inclusions in the glass can cause the insulators to shatter when undergoing this toughening process. Therefore, any places where materials could build up and then enter the glass, such as the condensates on a burner nozzle, are of serious concern. The low forehearth operating temperatures of 1050°C to 1080°C at the spout entrance position also provided conditions under which the build up of condensates would be of additional concern. This was also the fist time that the ceramic burner nozzles had been installed on a forehearth and distributor cold during a furnace rebuild and warmed-up to operating temperatures. When the burners are installed cold and heated up with the forehearth and distributor, the nozzles are subjected to additional stresses due to the expansion and movement of the burner blocks and the re-setting of the burner manifolds to re-align the burners with the burner blocks. No breakage of the ceramic burner nozzles occurred and no other problems were experienced and they have currently been in operation for 14 months without any problems.

The ceramic burner nozzles have now been adopted as our standard supply with all new forehearth and distributor installations.

## CONVERSION FROM STAINLESS STEEL TO CERAMIC

The PSR ceramic burner nozzles are not only an addition to our new forehearth and distributor packages as standard, they can also be installed on existing PSR MR-5000 combustion systems as well as other forehearth systems. Upgrading to PSR ceramic burner nozzles from steel burner nozzles previously supplied by PSR requires replacement of the burner nozzle holder including additional internal sealing gaskets and washers for the ceramic nozzle and the steel burner nozzle with the equivalent ceramic burner nozzle. The overall length of the burner pipe remains the same and the burner casting and burner pipe can be reused. The conversion would normally be carried out by converting spare burners supplied by PSR in a recommended spares package for regular maintenance from steel to ceramic burner nozzles, installing them during a scheduled burner replacement and then continuing the process with the burners removed until all the forehearth burners have been converted.

To upgrade to PSR ceramic burner nozzles from steel burner nozzles on a different forehearth and distributor combustion system would require the information detailed in the drawing in Fig. 5.

Using this information, PSR can determine whether our standard ceramic burner nozzles are compatible with the customer's existing burner configuration.

Additionally PSR can determine whether the ceramic nozzles and nozzle adapters are compatible with the existing burner pipe in which case they can be supplied as an upgrade kit to be installed using the existing burner pipe. If they are not compatible with the existing burner pipe then they can be supplied as a complete burner assembly. To reduce time during conversion from steel to ceramic burner nozzles we would recommend that spare burners be converted from steel to ceramic nozzles if available or spare burners be supplied with ceramic nozzles for complete combustion zones. Once these spare burners are installed and commissioned on these complete combustion zones, the burners removed can be converted from steel to ceramic nozzles and are then available for installation on subsequent combustion zones to be converted.

FIG. 4: PSR burner upgrade kit consisting of ceramic burner nozzle, burner nozzle holder and washers.

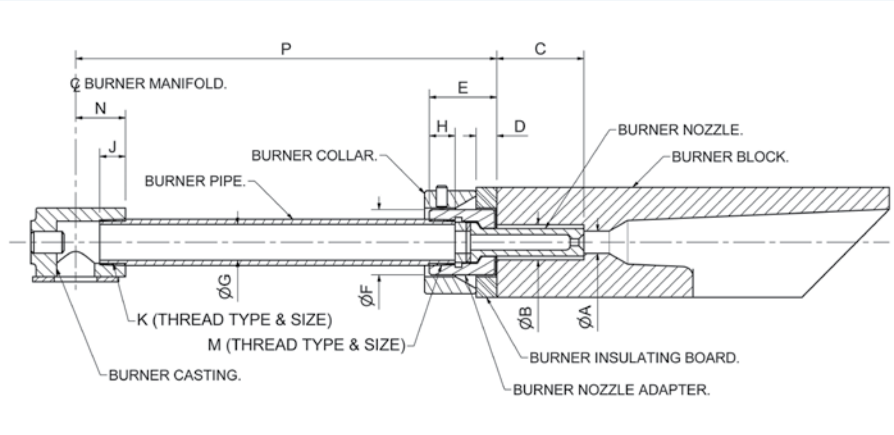


FIG 5: Details required to determine compatibility of PSR ceramic burner nozzles.

# 50 YEARS' SERVICE

ON 1ST AUGUST HE PASSED A PERSONAL MILESTONE OF 50 YEARS' SERVICE WITH PSR

For potmaker Richard Wilkinson 2016 was a remarkable year, not only because he reached his retirement age of 65 but also because on 1st August he passed a personal milestone of 50 years' service with PSR.

We thank him for his service with the company and for his commitment to ensuring the quality and reliability of every pot that passed through his department.

At one time he had both his father, Peter, and his brother, Anthony, working alongside him, but even after he has left the Wilkinson legacy will live on with his son Matthew heading up the mould department and his nephew Edward working alongside Mathew.

# GLASSHOUSE POTMAKING TO END IN 2016

The demise of the glasshouse pot as a means of melting glass has long been predicted but remarkably it continues to be used in small quantities in certain specialist areas of the hand-made glass industry.

At the peak of our output for glasshouse pots some 30-40 years ago, we manufactured up to 1800 pots per year and we operated two clay mines to provide the unique siliceous local glasshouse potclay that was used so successfully for the melting of lead crystal glass.

Over the following years the changing market for crystal glassware and the increased use of continuous melting furnaces took its toll on demand for pots and by 2015 our annual output had fallen to less than 50 pots per year. With the imminent retirement of our potmaker Richard Wilkinson in 2016 we therefore decided that the time was right to cease manufacture of pots and in August 2015 we announced that we would take no more orders for pots after December 2015.


Seven-Zone Combustion Skid Unit Installed On Site

# COMBUSTION SYSTEM UPGRADES

For any engineering company, changes to regulations and standards means the design of equipment requires on going scrutiny which should also drive improvements. At PSR, we see this as common practice, not only meeting the requirements of regulations but striving to stay ahead of the curve. This is particularly the case for our combustion system where, as with any system that involves combustible gases, safety is of paramount importance. Additionally, minimising production losses in the event of a problem is also very important for glass manufacturers whose equipment and processes have to operate on a continuous 24 hour basis for 10 years or more. We continuously review all our systems but particularly our combustion system, acting quickly to implement any changes that will improve the system. As a worldwide supplier, if regulations from different regions of the world stipulate that our system needs to meet certain criteria then we often look to implement the upgrades across the board where applicable to become our standard. It is not since an article in our PSR Review 2010/2011 that we have provided an update on our MR-5000 Combustion System so we thought the time appropriate to further detail these and other relatively recent upgrades.

## MIXTURE PRESSURE AND SAFETY HEAD MONITORING.

All MR-5000 Combustion systems include mixture pressure and safety head monitoring as standard in addition to the normal main gas safety shut-off system. This system includes safety heads incorporating a micro-switch installed in the mixture pipe work upstream from the burner manifolds on each side of each combustion zone, a low mixture pressure switch and a high mixture pressure switch installed in each individual mixer outlet and a solenoid shut-off valve in the gas supply inlet to each individual mixer. These components are all electrically connected to a mixture pressure and safety head monitoring control panel mounted on the combustion skid unit. The shut-off valve and pressure switches are pre-wired to the control panel on the combustion unit. The safety head switches must be wired from the safety heads mounted in the mixture pipe work to the control panel. Safety heads are installed to provide relief of the shock wave pressure caused by a backfire, temporarily opening to relieve the pressure and stopping the back fire and then immediately closing to re-seal the pipe work. This prevents damage to equipment upstream. Whilst the safety heads are very effective at relieving the pressure caused by the backfire they do not correct the cause of the back fire which must then be determined and corrected. European regulations state that indication and alarming is required when a safety head has operated. In the event of a backfire the safety head switch operates and indication and alarming is provided on the control panel and an additional alarm output signal is also provided for remote indication in a central supervisory temperature control system. In addition the gas supply to the individual combustion zone is shut-off. This allows the cause of the problem to be investigated safely whilst reducing the effect the problem would have on production if the main gas safety shut-off valves were closed shutting off the gas supply to the entire forehearth. The micro-switch in the safety head is a latching switch which must be re-set with a pushbutton switch on the safety head following examination of the condition of the safety head to ensure that it has closed and is sealing.

One primary cause of backfiring is the manifold mixture pressure being lower than the pressure inside the forehearth which then allows hot gases from the forehearth atmosphere to flow back into the burner nozzles igniting the mixture. Three safe guards against this occurring are already in place with the combustion actuator being calibrated to provide a minimum manifold mixture pressure of 1 inch (2·5 mbar) at the minimum control output position, the closed position limit switch inside the combustion actuator being set to provide a minimum manifold mixture pressure of 0·75 inches water gauge (1·875 millibar) and the physical stop on the mixer screw carrier being set to provide an absolute minimum manifold mixture pressure of 0·5 inches water gauge (1·25 millibar) during commissioning. However, a minimum mixture pressure switch is also installed in the mixture outlet of each mixer and set at typically 0·4 inches


Mixture Pressure And Safety Head Monitoring Control Panel Mounted On A Combustion Skid Unit.

water gauge (1 millibar) to operate and shut-off the gas supply to the mixer with the solenoid valve if the manifold mixture pressure falls below 0·5 inches water gauge (1·25 millibar) further preventing a backfire from occurring. The cause of the low manifold mixture pressure would still then require investigation and could be due to a leak in the mixture pipe work or burners or incorrect setting of the mixer minimum physical stop screw.

The normal maximum manifold mixture pressure at maximum firing for each combustion zone is 20 inches water gauge (50 millibar). A maximum manifold mixture pressure switch is also installed in the mixture outlet of each mixer and set at typically 28 inches water gauge (70 millibar). In the event that the manifold mixture pressure exceeds this value the pressure switch operates to shut-off the gas supply to the mixer with the solenoid valve. The cause of the high manifold mixture pressure would then require investigation and could be due to a downstream valve in the mixture pipework having been inadvertently closed, blockage of the mixture pipework or burners or failure of the safety head to operate and relieve the pressure from the shock wave during a backfire.

Normally one common alarm is used from the mixture pressure and safety head monitoring control panel to the main temperature control panel and individual indication of alarm conditions for each combustion zone are provided on the mixture pressure and safety head monitoring control panel and individual pressure switches.

As a further enhancement to this system, individual zone alarms are available from the mixture pressure and safety head monitoring panel to the main temperature control panel to indicate that the gas has been shut-off to the particular zone due to an incorrect mixture pressure or operation of the safety heads in that zone. If normal temperature control continued under these circumstances then, as the temperature would fall due to the loss of gas supply, the control system would proceed to open the combustion actuator, possibly eventually to maximum, to increase the zone firing in an attempt to increase the zone temperature to set point. However, as only combustion air would be passing through the mixer this would actually result in a further, possibly more rapid, reduction in temperature. Under these circumstances the alarm signal from the mixture pressure and safety head monitoring panel for the individual combustion zone can be used to automatically put the particular control zone into manual with minimum firing and minimum combustion air to help to conserve the zone temperature until the problem can be corrected and the gas supply to the zone re-established.

Another cause of backfiring is blockage of the burner nozzles due to inadequate maintenance. This has recently been addressed by the introduction of ceramic burner nozzles which are much less likely to become blocked and require much less maintenance.

## LEAK DETECTORS.

Leak detectors are valve proving systems that have been used by PSR for many years in the main gas safety shut-off systems as a start-up check to ensure that the main gas safety shut-off valves have completely shut-off and sealed before they can be re-opened. European regulations stipulate that automatic shut-off valves controlling capacities greater than 1,200 kW shall be equipped with a valve proving system. Although the majority of the combustion units supplied by PSR are below this capacity, we equip all our safety systems with a leak detector unit as standard.

## DUTY AND STAND-BY COMBUSTION AIR FANS AND MAIN GAS SAFETY SHUT-OFF SYSTEMS.

Each forehearth and its associated Distributor or Alcove Section supplying it has duty and stand-by combustion air fans and gas safety shut-off systems installed as standard. These provide back up in the event of a combustion air fan or gas safety shut-off system component failure or for routine maintenance and testing. The advantage of this configuration is that a component failure on one system would only temporarily affect one production line on an installation with a distributor and several forehearths.

Gas Safety Shut-Off System Pipe Train With Leak Detector.


Seven-Zone Combustion Skid Unit During Assembly And Testing At PSR

# PSR OVERSEAS AGENTS & REPRESENTATIVES

**BULGARIA AND SERBIA**
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