THE REFRACTORIES ENGINEER

July 2016 www.ireng.org THE OFFICIAL JOURNAL OF THE INSTITUTE OF REFRACTORIES ENGINEERS

Institute of Refractories Engineers Conference and Training Day 2016

Annual Conference Wednesday 12th October

SILVER LININGS, ADDING VALUE

Programme

ArcelorMittal Dofasco – Tom Vert, Vice President Manufacturing – *What do Steelmakers really want... how refractory suppliers can add value*

British Steel / LISI – Dave Collins / Stuart Woodliffe – *Queen Anne Blast Furnace Reline*

UK Steel-EEF/ISSB – Richard White – *UK Steel Industry and its future*

Pahage – Ashley Webster, Director – topic to be confirmed

Almatis – Sebastian Klaus, Application & Market Development Engineer – *Fused & Sintered Aggregates*

Elkem – Dr Hong Peng, research Scientist – *Cement Free Castables*

Dupre Minerals – Andrew Baylay – *Perlite & Vermiculite, Sources, Quality & applications*

Kerneos – Fabien Simonin

PLACES STILL AVAILABLE See inside

Training Day Thursday 13th October

HEAT FLOW AND THERMAL EXPANSION

THE REFRACTORIES ENGINEER

The Institute of Refractories Engineers is dedicated to fostering the science, technology and skills of refractories engineering and to serving the needs of refractories engineers worldwide.

Aims: To raise the standard of ability and training in this field of science and technology. To promote and maintain the character, status and interest of members of the Institute. To disseminate information, facts, ideas, news or suggestions that may be of interest to members. To encourage the exchange of ideas and information among members to their benefit and to the benefit of the industries they serve.

The Institute is a non-profit making body and its entire income is applied solely to the promotion of these aims.

General Secretary's Report

Dear Members

We are now in the second half of the year and our Annual Conference and Training Day will soon be upon us.

We have an excellent line up of speakers the conference this year and we have had our best ever booking rate this early in the year for both the Conference and Training. We have a full two page spread in this journal with all the information you need to book. If you would like more information on booking please email me on secretary@ireng.org. But please book early as there is limited places available.

This year we will also have room for a small number of exhibition stands, please call me if you would like to discuss the opportunity to promote your company and products – and put your name in front of our guest speakers and attendees both at the Conference and Training Day.

I don't want to keep harping on about Sage Pay but it truly is a safe and secure way to pay, I am no longer able to accept your card payments by you completing the bottom of the invoice as our streamline account has now been closed. To enable us to move forward I do need your email address to enter on the sage system, I do have a fair number but there is a large number of members who have not given me contact details. You can either email me on the email address above or simply post the cover sheet from the journal back to me with your email address written on the front. I can still receive faxes if you have access to a fax machine on 0044 (0)1782 310234.

You can see in the accounts the cost of us accepting credit card payments was over £1000, the sage pay system will save the institute in the region of £800 per year, It also allows you to make the payment rather than passing over credit card details, so it is more secure.

If you have not paid your annual subs yet I am now preparing the reminders you will be given 28 days to pay, if I don't receive payment July will be your last journal and membership will be suspended.

The accounts have been signed off at the recent Executive meeting and are included in this journal for you to peruse before the AGM in October. The agenda for the AGM is also included in this journal we will be looking at the membership rates ready for us to take a vote at the AGM. I know times are hard but the price of postage and bank charges are forever increasing we no longer charge the additional £2 fee if you use your credit card to pay if you pay by bank transfer from some countries it can cost the Institute up to £7 this comes off what we have charged for your membership and is kept by the bank, this does not happen with sage pay (sorry I have said it again).

I would like to remind all branch committee members that branch funds are part of the Institutes overall assets and need to be shown in the published accounts, so I and the accountants need to have branch accounts up to the end of December as early as possible in the new year. To allow us to produce our balance sheet on time.

We keep producing our journal for members but we get very little feedback, so if you have any news, technical papers or helpful comments of how we can improve we would love to hear from you. We are looking at producing the journal in electronic form, so it can be read on tablets, this is intended to be available extra to the hard copy. But when this is fully operational you will be given the option to only have the electronic form. There is a very small cost involved but this could be less than the postage cost outside the UK.

Please enjoy the rest of the summer and any holidays that you have planned, the dark nights will be upon us all too soon.

Jayne Woodhead,
General Secretary & Treasurer
Institute of Refractories Engineers

President's Column

Hello Members and Colleagues

What an incredible few months and what a rollercoaster of a year it has been so far. It has certainly been a year of extremes so far. The successful takeover of TATA Steel Scunthorpe creating a new British Steel Limited, seemingly lots of interest from several parties for the rest of TATA Steel's British operations, acquisitions in other end user industries such as foundry both locally and internationally with news of potentially more to come later this year. I have previously commented that if just some of these had occurred by the time we get to conference it would truly be a great Silver Lining in keeping with our theme for this year conference. It's fantastic that some are already a reality. What other shocks, surprises and challenges will the rest of this year hold… we're only half way through 2016 after all (at least at the time of writing).

Hopefully here in the UK we will see steel making secured as the sale process with TATA Steel continues. Hopefully we will also see an improvement in the foundry industry. Maybe there will be further consolidation in this important sector. Hopefully we will also see a change in fortunes, so desperately needed, for our colleagues across our own industry too.

Conference this year is looking very strong and bookings are filling up well. If you are thinking of attending this year please contact Jayne Woodhead as soon as you can to ensure your place. We've had an amazing response for papers and speakers this year, truly world class. It would have been amazing to have included them all but sadly not possible. It certainly bodes well for next year's conference which we have already started to plan.

There has also been a lot of interest in the training day held at conference.

It is always well attended but this year has a lot of bookings already taken. If you want to attend the training day I suggest you contact Jayne Woodhead to book your place as soon as possible. Remember that the training day is on a separate day to conference so you can easily attend both.

Finally, after several delays, the Sheffield branch AGM has been booked and will be held in August. There are vacancies on the committee that need to be filled so if you are relatively local and are interested in helping the branch then please contact either myself, Chris Windle or simply turn up to the AGM and put yourself forward.

Similarly there maybe vacancies for the North West branch and I believe that they will also be holding an AGM later this year.

In the last edition I stated that it is important that local and national events are supported by our members and other interested parties as much as possible. We are here for you and we need your support. Get involved, go to technical meetings, go to social events, pass the journal around and please book your place at the conference and / or the training day. I cannot emphasise this enough but similarly our local branches need to help you, provide interesting content and a forum for discussions in a timely manner.

I also mentioned that advertising is an important source of revenue for the IRE journal and I'd like to repeat that if you would like to place an advert in the journal we can still organise that for you. Everyone at the Institute thanks you in advance for your continued support during these difficult times.

If you have a technical paper that you'd like us to publish for you then please let us know, we will be happy to help you get it published.

We would like to start publishing more news stories in the journal both from our industries but also related industries in the supply chain from raw material source to end user of our end user. If you know of a news story that you think will be of interest then please let us know, we will be happy to take a look at your submission or suggestion.

Amazingly, I've managed to get to the end of this column without mentioning Brexit or politics. I bet everyone is pleased about that!

Callum Arthur
President
Institute of Refractories Engineers

Sheffield Branch News

The Sheffield Branch committee is pleased to announce that the 2016 Golf Day will be held on Wednesday the 5th of October.

For further information contact:- cwindle@dsf.co.uk

An AGM is also planned for the end of August/beginning of September; a venue is being confirmed, details will be circulated and placed on the website.

Notice is hereby given that the

55th Annual General Meeting of the Institute of Refractories Engineers

will be held at 12.30 on WEDNESDAY 12th October
at Tankersley Manor, Church Lane, Tankersley Barnsley S75 3DQ UK

President Mr C Arthur will preside
By order of the General Council

AGENDA

1. To receive apologies

2. To approve the Minutes of the 54th Annual General Meeting held on 7th October 2015 at Tankersley Manor Barnsley.

3. To approve the General Council's appointment of Officers of the Institute for the year 2016/2017

President	2015/2017 Mr C Arthur
Senior Vice President	2016/2017

4a. To re-elect Members of Council.

4b. To elect any other members of Council nominated prior to the meeting date.

5. To receive a joint report from the Chairman of the Executive Committee and the General Secretary on the Management and Operations of the Institute.

6. To approve General Council's recommendation that the published audited accounts for the period ended 31st December 2015 to be accepted.

7. To approve the General Council's recommendation that the subscriptions for 2017 is as follows

Full Members	£68.00
Members under 25 undergoing training (UK based)	£25.00
Members under 25 undergoing training (overseas based)	£34.00

Full time students under 25 year on qualifying courses and residing in the UK are proposed to be admitted free of charge.

8. To appoint Short's Accountants (Sheffield) as the Institute's accountants for the financial year 2017

Any amendments to this agenda will be posted on the Institute's website www.ireng.org not later than two weeks prior to the meeting

Members who wish to record votes on any item on the Agenda and who cannot themselves be present at the Annual general Meeting may arrange with the General Secretary, or with any members of the Council, to vote on their behalf by proxy.

If it is any member's intention to vote they should furnish the General Secretary with instructions, in writing, giving full details of the item on the Agenda they are concerned with. And whom they wish to appoint as their proxy.

Any member not attending the Annual General Meeting, and not arranging such a proxy vote, will be deemed to be in favour of all resolutions, approved at the Annual General Meeting by the members there present.

DRAFT INCOME AND EXPENDITURE ACCOUNT
YEAR ENDED 31 DECEMBER 2015

	Note	£	2015 £	£	2014 £
INCOME					
Subscriptions and entrance fees			18,474		20,060
Journal advertising			48,664		45,484
E-directory			4,662		3,345
Conference fees			13,179		3,341
Training			1,655		1,976
Bank interest received			953		1,072
Branch social fund raising			17,195		9,930
			104,782		85,208
EXPENSES					
Meeting expenses		933		998	
National Dinner Dance		-		100	
Branch social events		16,142		11,503	
		17,075		12,601	
Journal					
Journal printing and distribution		39,187		40,557	
Journal e-directory		-		30	
Editorial costs		9,438		9,442	
		48,625		50,029	
Depreciation					
President's regalia		-		-	
		-		-	
Other expenses					
Telephone		458		420	
Computer expenses		793		1,590	
Printing, stationery and postage		3,345		1,112	
General Secretary and office expenses		3,970		5,189	
Insurance		1,012		1,088	
Conference and exhibition costs		14,749		4,184	
Credit card and bank charges		1,103		1,058	
General Secretary		11,566		11,144	
Branch Secretaries' honoraria		100		525	
Presidents honoraria		850		-	
Marketing costs		462		475	
Training		215		1,453	
Accountancy support fees		350		462	
Audit & accountancy fees		2,380		2,297	
Bad and doubtful debts		2,048		6,330	
Mileage		1,294		937	
Exchange rate difference		2,554		1,205	
		47,249		39,469	
			112,949		102,099
NET DEFICIT FOR THE PERIOD			(8,167)		(16,891)

DRAFT BALANCE SHEET 31 DECEMBER 2015

	Note	£	2015 £	£	2014 £
FIXED ASSETS	2		-		-
CURRENT ASSETS					
Debtors	3	13,921		16,358	
Bank deposit accounts		105,448		110,712	
Cash at bank		43,983		40,525	
		163,352		167,595	
CURRENT LIABILITIES					
Creditors	4	5,020		3,117	
NET CURRENT ASSETS			158,332		164,478
NET ASSETS			158,332		164,478
FINANCED BY:					
CAPITAL ACCOUNT					
Original balance brought forward			164,478		181,369
Net deficit for the period			(8,167)		(16,891)
			156,311		164,478

These draft financial statements were approved by Council for circulation to members pending final audited approval.

The Members of the Council acknowledge their responsibilities for:

(i) ensuring that the Institute keeps proper accounting records which comply with the Rules; and

(ii) preparing financial statements which give a true and fair view of the state of affairs of the Institute as at the end of the financial year and of its surplus for the financial year in accordance with the requirements of the Rules.

These financial statements have been prepared in accordance with the Financial Reporting Standard for Smaller Entities (effective April 2008).

The finalised audited accounts will be published in the September 2015 issue of The Refractories Engineer.

P Bottomley. Chairman of the Executive Committee

NOTES TO THE FINANCIAL STATEMENTS
FOR THE YEAR ENDED 31 DECEMBER 2015

1. Accounting policies

Basis of accounting

The financial statements have been prepared under the historical cost convention, and in accordance with the Financial Reporting Standard for Smaller Entities (effective April 2008).

Cash flow statement

In the opinion of the Council the Institute qualifies as a small entity and accordingly a cash flow statement is not required.

Income

The subscription and entrance fees income represents the amounts due from members for the period after adjusting for subscriptions in advance.
The journal advertising income represents the amounts due for the period for services provided, exclusive of Value Added Tax.
All other income represents amounts due for the period for services provided.

Depreciation
Depreciation is calculated so as to write off the cost of an asset, less its estimated residual value, over the useful economic life of that asset as follows:
Presidents regalia - 5% straight line basis

Stocks
Stocks are valued at the lower of cost and net realisable value, after making due allowance for obsolete and slow moving items.

UK Branches
All income, expenses, assets and liabilities for the UK branches for the year ended 31 December 2015 and year ended 31 December 2014 are recognised in full within the financial statements.

Australia Branch
All income, expenses, assets and liabilities for the Australian branch for the years ended 31 December 2015 and 2014 are recognised in full within the financial statements after being translated at the appropriate exchange rate

South Africa Branch
The net contribution paid to the UK is recognised as income. No assets or liabilities of the branch are shown within the financial statements.

2. Tangible fixed assets

	President's regalia
	£
Cost	
At 31 December 2014 and 31 December 2015	788
Depreciation	
At 31 December 2014 and 31 December 2015	788
Net book value	
At 31 December 2014 and 31 December 2015	-

3. Debtors

	2015	2014
	£	£
Trade Debtors		
Advertising debtors	9,322	11,566
Subscriptions overdue	1,507	439
Buyers Guide debtors	1,135	1,134
Conference fees debtors	44	1,648
	12,008	14,787
Provision against bad and doubtful debts	-	-
	12,008	14,787
Other debtors	1,913	1,571
	13,921	16,358

4. Creditors: Amounts falling due within one year

	2015	2014
	£	£
Creditors and accrued charges	5,020	3,117

5. Contributions in the event of a winding up
Every member of the Institute undertakes to contribute to the assets of the Institute in the event of its being wound up. This applies while he is a member or within one year afterwards for payment of the debts and liabilities of the Institute contracted before he ceases to be a member and of the costs, charges and expenses of winding up and for the adjustment of rights of the contribution amongst themselves such amount as may be required not exceeding one year's annual subscription.

6. Taxation
The Institute's mutual income (subscriptions and conference fees) is not chargeable to corporation tax.
No tax charge arose on the remaining income in the year and as at 31 December 2015 corporation tax losses carried forward totalled £118,227.

BRANCH INCOME AND EXPENDITURE ACCOUNTS 2015

	Main Institute	NW Branch	Sheffield	Stoke	Australia	Cons.Adj	Total
	£	£	£	£	£	£	£
INCOME							
Subscriptions and entrance fees	18,205				2,969	(2,700)	18,474
Journal advertising	48,664						48,664
E-directory	4,662						4,662
Conference fees	2,150				11,029		13,179
Training	1,655						1,655
Bank interest received	93				860		953
Branch social fund raising	5,638	9,270	1,228	1,059			17,195
Total Income	81,067	9,270	1,228	1,059	14,858	(2,700)	104,782
EXPENSES							
Meeting expenses	757		176				933
National Dinner Dance							-
Branch social events	5,474	8,819	1,103	746			16,142
Journal							
Journal printing and distribution	39,187						39,187
Journal E-Directory	-						-
Editorial costs	9,438						9,438
Other expenses							
Telephone	458						458
Computer expenses	793						793
Printing, stationery and postage	3,276			69			3,345
General Secretary and office expenses				60	3,910		3,970
Insurance	577				435		1,012
Payments/Grants to branches					2,700	(2,700)	-
Conference and exhibition costs	2,719				12,030		14,749
Credit card and bank charges	1,103						1,103
General Secretary	11,566						11,566
Presidents honoraria	850						850
Branch Secretaries' honoraria	100						100
Marketing costs	462						462
Training	215						215
Accountancy support fees	350						350
Audit & accountancy fees	2,100				280		2,380
Bad and doubtful debts	2,048						2,048
Mileage	1,294						1,294
Exchange rate difference	-				2,554		2,554
Total Expenses	82,767	8,819	1,279	875	21,909	(2,700)	112,949
NET SURPLUS/ (DEFICIT) FOR THE PERIOD	(1,700)	451	(51)	184	(7,051)	-	(8,167)

Institute of Refractories Engineers Conference and Training Day 2016

Venue: Tankersley Manor, Church Lane, Tankersley, Barnsley, South Yorkshire S75 3DQ. Tel: 01226 744 700

Annual Conference Wednesday 12th October

SILVER LININGS, ADDING VALUE

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ArcelorMittal Dofasco – Tom Vert, Vice President Manufacturing – *What do Steelmakers really want... how refractory suppliers can add value*

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Elkem – Dr Hong Peng, research Scientist – *Cement Free Castables*

Dupre Minerals – Andrew Baylay – *Perlite & Vermiculite, Sources, Quality & applications*

Kerneos – Fabien Simonin

Conference Day Member £95.00
Conference Day Non Member £115.00
Conference Dinner including VAT £32.00
Training Day Member £70.00
Training Day Non Member £95.00
1 Night Bed & Breakfast £84.00

Additional nights accommodation can be booked at £84.00 per night.

To make bookings please contact Jayne Woodhead on secretary@ireng.org or telephone 01782 310234.

Places are limited so please book early.

Institute of Refractories Engineers Conference and Training Day 2016

Training Day Thursday 13th October

HEAT FLOW AND THERMAL EXPANSION

Refractory materials are used to provide containment for high temperature processes. An understanding of how heat flows through a refractory lining and the thermal expansion of the refractory lining is critical to safe and effective design and operation of process plant.

This course will provide a working knowledge of the calculation of thermal gradients and thermal expansion allowances and is aimed at personnel who design linings and select and specify materials of construction. No knowledge of refractory materials is required.

Course content

- **Introduction**
- **What is Thermal Conductivity and Thermal Expansion**
- **Thermal Gradient Calculation and Heat Transfer**
- **Thermal Expansion Calculation and Allowance**
- **Application of Thermal Calculations**

The course will be made up of lecture and small group problem solving sessions which will reinforce the key points.

Conference and Training Day Booking Form

Name..... Company .....

Tel..... Fax..... Email.....

Postal Address.....

.....

Conference Fees Members ..... ☐ £95.00

Wednesday 12/10/15 Non Members..... ☐ £115.00

(Includes lunch) Student/Retired..... ☐ £50.00

Conference Dinner All Welcome ..... ☐ £32.00

Wednesday 12/10/15 7-00 for 7-30pm

(Including wine)

Training Day

Thursday 13/10/14 Members ..... ☐ £70.00

(Includes lunch and refreshments) Non Members..... ☐ £95.00

1 Night Bed & Breakfast ..... ☐ £84.00

Total Payable .....

I enclose a cheque payable to

INSTITUTE OF REFRACTORIES ENGINEERS ☐

Visa/Mastercard/Switch/Delta ☐

(delete as necessary)

Please tick

Card No .....

Expiry Date .....

Valid From .....

Issue No.....

Security Code .....

Signature.....

Places are limited

To reserve a place please contact the IRE General Secretary - email secretary@ireng.org or send the attached form to **Mrs J. Woodhead, General Secretary & Treasurer, The Institute of Refractories Engineers, 575 Trentham Road, Blurton, Stoke-on-Trent, Staffs ST3 3BN. Tel/fax 0044 (0) 1782 310234**

Magnezit Group develops cooperation with EVRAZ Consolidated West-Siberian Metallurgical Plant (EVRAZ ZSMK)

Magnezit Group has won a number of tenders for delivery of refractories to EVRAZ Consolidated West-Siberian Metallurgical Plant (EVRAZ ZSMK). The companies will continue cooperation in several areas: tests of combined linings for steel teeming ladles and oxygen converters, tests of trial batches of materials of various purpose; imports substitution; repairs of working linings and development of new designs of thermal vessels linings.

In particular, on the site where EVRAZ ZSMK produces construction rolled metal, tests of Magnezit Group's products are being continued and new tests are planned. Specialists are waiting for results of tests of combined lining of 350-tons steel teeming ladles. These tests were started in March 2016. The working lining of thermal vessel is made of bricks delivered from the plant Liaoning Dalmond Refractories, which is a Chinese production site of Magnezit Group. Refractories produced at Satka production site are used for slag lines and for maintenance. Pilot tests of monolithic covers for ladle-furnaces continue as well. These large-size shapes weighing nearly two tons were manufactured at the Department of Innovative Products. They showed themselves to good advantage last year during trial tests.

One more new direction of cooperation is connected with deliveries of trial materials for blast-furnace shop. We are planning to test tapping and trough masses produced at the Chinese production site of Magnezit Group. Magnesia fluxes manufactured in Satka should be mentioned in particular. During recent years they have become indispensable assistants as far as it concerns improvement of vessels service life. In particular, they are successfully used for reduction of wear rate of the main areas of magnesia-carbon lining in converters. This year Magnezit Group will deliver to EVRAZ ZSMK 75 thousand tons of fluxes amounting to nearly 80% of the plant's annual consumption, – representatives of Magnezit Group in Novokuznetsk informed.

Volumes of deliveries to the second production site of EVRAZ ZSMK (where rolled metal for railways is produced) are also impressive. During this year Magnezit will supply about 70% of working lining complete sets for 130-tons steel teeming ladles. Such sets were successfully tested last year. About 80% of the annually required volumes of repair and maintenance complete sets of refractories for ladles slag lines are also shipped from Magnezit Group.

Tests of Satka refractories in working lining of 100-tons electric arc steel-making furnace were carried out successfully as well. In order to prove again the obtained results two more complete sets of lining will be delivered. And again if we speak about volumes it should be pointed out that Magnezit employees provide for half of the annual requirements: in total four such complete sets are required every year, – representatives of the Group in Novokuznetsk underlined.

At present the program of perspective cooperation in the main fields of development of ZSMK rail production site was agreed upon. In particular specialists of Magnezit Group will develop a new design of electric-arc steel-making furnace lining (EAF). The purpose of the new project is reduction of costs per unit during maintenance of lining and increase of the vessel service life.

The following technological proposals will be developed within the framework of the program: application of nozzle fillers for steel teeming ladles and EAFs; application of corundum concretes and of a novel type of Magnezit Group product – all-ceramic plates for sliding gates of magnesia-chrome-spinel composition. This work is carried out by specialists of the Directorate of Engineering Developments.

At present the process of preparation of the technical and budgetary offer for production and delivery of a complete set of refractories for steel casting is being completed. This set of refractories is intended for a continuous casting machine. The shapes will be produced in China.

Planned trial tests of refractories intended for all the above mentioned projects were successfully carried out.

First custom-built steel foundry commissioned since 1980's to bolster UK steel casting innovation

The first custom-built steel foundry to be commissioned in the UK since the early 1980's has been unveiled at AMRC Castings, part of the University of Sheffield's Advanced Manufacturing Research Centre (AMRC) with Boeing.

The new facility consists of two Inductotherm air melting induction furnaces, with a combined 2.8 tonne melt capacity, able to produce cast parts with a finished weight of up to 1300kg.

The £600,000 investment into the new foundry by the AMRC will allow the AMRC Castings group to conduct innovative research and product development projects in collaboration with its industrial partners for the benefit of industry sectors in which castings are, or could be used in the future.

The organisation develops new castings technologies and provides design and manufacturing consultancy services for aerospace and other high-value manufacturing sectors.

The opening of the new facility is a significant event for the UK foundry sector, said AMRC Castings' Ryan Longden: "Keeping the UK at the forefront of steel castings technology is the only way to ensure the capability survives. It's our aim to support steel foundries at home in the UK and around the world and castings users wanting to push the boundaries of current castings processes."

The new advanced steels casting facility is fully operational and being used to contribute to a collaborative project for the energy sector.

"Using the new facility alongside our MEGAshell® Process allows us to put our technical expertise to full use and conduct pioneering research for the energy sector into producing cast steel components that are more cost and time effective to manufacture," added Ryan.

The MEGAshell® Process is a novel ceramic shell moulding and casting process that provides improved dimensional accuracy and superior surface quality compared to traditional sand-moulded castings.

Combined with the new advanced steels casting facility, AMRC Castings is the only UK organisation able to produce a ceramic shell big enough for such research projects, producing specialist cast components from material grade duplex 4A steel in a one-piece ceramic mould.

The new foundry facility will also enable the advance of research into the composition of materials. Development programmes such as these will provide a knowledge bank of process and materials data, leading to the development of new material grades and optimised material chemistries for advanced castings.

"The new AMRC Castings advanced steels casting facility allows us to develop and demonstrate innovative new castings techniques, further enhancing the integrity and improving the material properties of castings.

"This kind of research will help the AMRC build up the technical knowledge and expertise needed to keep UK castings technology and manufacturers competitive within global markets," added Ryan.

Health and safety accreditations provide vital vetting step for approval at ACCS

Family owned business, ACCS Ltd, based in Stoke-on-Trent, UK, is principally involved in the corrosion protection sector, specialising in providing industrial chemical linings to the Oil & Gas, Petrochemical and Chemical industries. ACCS Ltd's most recent clients have included major players such as Rolls Royce, Westinghouse, Saudi Aramco, Petrofac, BP and Ineos.

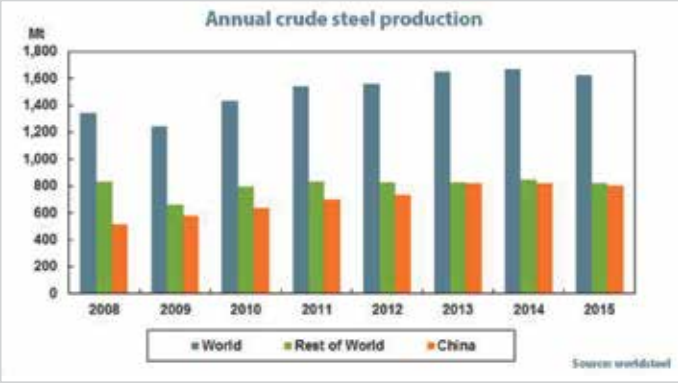
After many years of installing chemically protective linings to their customers, whilst maintaining high levels of health and safety standards, ACCS Ltd have now obtained 'top safety status' as a contractor by becoming accredited with both CHAS and Safecontractor, two third party health and safety schemes. By gaining accreditation ACCS Ltd have shown they are fully compliant with current regulations and standards, and provides a vital vetting step for approval by new clients.

In addition to the health and safety accreditations, ACCS Ltd has also achieved Constructionline accreditation – providing an important pre-qualification status for jobs both in the public and private sector. Constructionline provides an online database, which denotes members who have demonstrated efficiency, time and cost saving, and best practice at the heart of their organisation.

"By becoming accredited by both CHAS and Safecontractor, two well-known health and safety accreditation schemes, ACCS Ltd show to our customers and future clients that alongside high quality service and products, we strive to maintain the highest levels of safe working environments, procedures and policy. Adding this to our Constructionline membership, which allows new clients to independently verify our competency, reinforces our position as a leading designer, manufacturer, supplier and installer of corrosion resistant linings in the Market."

World crude steel output decreases by 2.8% in 2015

World crude steel production reached 1,622.8 million tonnes (Mt) for the year 2015, down by -2.8% compared to 2014. Crude steel production decreased in all regions except Oceania in 2015.



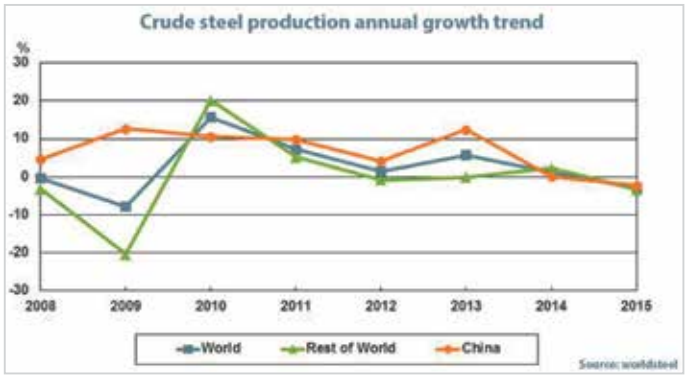
Annual production for Asia was 1,113.8 Mt of crude steel in 2015, a decrease of -2.3% compared to 2014. China's crude steel production in 2015 reached 803.8 Mt, down by -2.3% on 2014. China's share of world crude steel production increased from 49.3% in 2014 to 49.5% in 2015. Japan produced 105.2 Mt in 2015, down by -5.0% compared to 2014. India's crude steel production for 2015 was 89.6 Mt, up by 2.6% on 2014. South Korea produced 69.7 Mt of crude steel in 2015, a decrease of -2.6% compared to 2014.

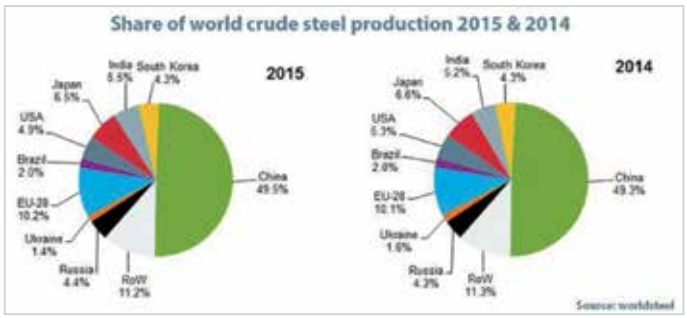
In 2015, the EU (28) produced 166.2 Mt of crude steel, a decrease of -1.8% compared to 2014. Germany produced 42.7 Mt of crude steel in 2015, down by -0.6% over 2014. Italy produced 22.0 Mt in 2015, a decrease of -7.1% over 2014. France's crude steel production in 2015 was 15.0 Mt, down by -7.2%. Spain produced 14.9 Mt of crude steel in 2015, an increase of 4.4% compared to 2014.

Crude steel production for 2015 in North America was 110.7 Mt, a decrease of -8.6% compared to 2014. The US produced 78.9 Mt of crude steel, down by -10.5% on 2014.

The CIS showed a decrease of -4.3% in 2015, producing 101.5 Mt of crude steel. Russia* produced 71.1 Mt of crude steel, down by -0.5% on 2014 and Ukraine* recorded a decrease of -15.6% with a year-end figure of 22.9 Mt.

Annual crude steel production for South America was 43.9 Mt in 2015, a decrease of -2.5% on 2014. Brazil produced 33.2 Mt in 2015, down by -1.9% compared to 2014.





Top 10 steel-producing countries

Rank	Country	2015 (Mt)	2014 (Mt)	%2015/2014
1	China	803.8	822.8	-2.3
2	Japan	105.2	110.7	-5.0
3	India	89.6	87.3	2.6
4	United States	78.9	88.2	-10.5
5	Russia (a)	71.1	71.5	-0.5
6	South Korea	69.7	71.5	-2.6
7	Germany	42.7	42.9	-0.6
8	Brazil	33.2	33.9	-1.9
9	Turkey	31.5	34.0	-7.4
10	Ukraine (a)	22.9	27.2	-15.6

Source: worldsteel

In December 2015, world crude steel production for the 66 countries reporting to the World Steel Association (worldsteel) was 126.7 Mt, a decrease of -5.7% compared to December 2014. The crude steel capacity utilisation ratio of the 66 countries in December 2015 was 64.6%. This is -4.9 percentage points lower than December 2014. The average capacity utilisation in 2015 was 69.7% compared to 73.4% in 2014.

Sweet taste of success

Left to right comedian Katherine Ryan who hosted the awards, Katy Moss receiving her award and Andrea Holland from BMW

Katy Moss of Trent Refractories, was recently nominated for the award for First Woman of Engineering and Manufacturing.

The First Women Awards is the UK's leading programme for senior-level business women and professionals created by Real Business and supported by the CBI (Confederation of British Industry).

Since conception in 2005, the awards have grown in influence and impact and enjoy the support of many of the UK's leading firms, industry bodies and inspirational business leaders.

The awards ceremony was held on Wednesday 22nd of June at the Lancaster Hotel in London and we are proud to announce that Katy won the prestigious award. Sponsored by BMW they offered an i8 for a few days as the prize.

The finalists in her category were exceptionally high calibre and it was a hard fought award, receiving more nominations in that category than the others.

When asked what winning the award meant to her Katy said "Wow, I never expected to win this, just to be nominated and shortlisted was an amazing experience but it has made me reflect on the last five years and I feel proud and honoured, it is nice to be recognized by others" Adding "it was also nice to be able to have my 12 year old daughter at the event as I hope seeing and meeting such strong inspirational women gives her drive and belief in herself to forge her own future".

Katy started her career working for HSBC bank under their management trainee scheme and following the birth of her daughter up-skilled herself by studying Accountancy, she went on to become a Business Manager for 11 schools before undertaking her role at Trent.

Katy took over Trent Refractories when her father passed away mid-way negotiating the sale of his business. Without any knowledge of the refractory products or running a manufacturing company, Katy became the firms Managing Director, with a mission to secure the jobs of her employees and run the company on behalf of the family. She has worked tirelessly to provide a stable future for the company, improving employees' opportunities and is trying to grow the business in a challenging market.

Katy said "It was a tough time for our family and I had a near vertical learning curve whilst also juggling my other career initially, being only 29 at the time it was difficult bringing people on board".

This award is more poignant this week as Thursday was National Women in Engineering Day.

Trent Refractories supplies the major players in the Steel Industry, especially in the Sheffield, Rotherham, Scunthorpe area. Refractories are essentially heat resistant materials which line furnaces designed to go to very high temperatures.

This award is important in the refractory industry as out of 134 UK companies, less than a handful have female MD's. More importantly there are far less of these companies who actually produce refractory materials themselves.

Katy has a fresh approach which has enabled the company to move forward "I try to engage with people on all levels and make them feel part of the bigger picture, helping them realise they can affect the outcome of everything they do. Integrity, honesty and openness are important to me".

Given the result of the EU referendum, I asked Katy what she thought the outcome was for the Steel Industry overall. "I think we need to accept the result and get to work on securing our future as an independent country, focusing on the right negotiation's that are going to help us be competitive and fuel our exports." Adding "Britain has a history steeped in Steelmaking and can produce exceptional products which cannot be rivalled anywhere in terms of quality".

Katy's focus is to continue to build a business which echoes her values and supports British manufacturing "we have done an excellent job with locally produced food and British meat but we need to try and think about everything we buy and make ethical and consider decisions that secure the future of our country".

IPS Ceramics Expands UK Team

Having just established a subsidiary in the USA, IPS Ceramics has now announced two new appointments at its UK headquarters. Alan Keenan comes in as Sales Manager and Adam Wright has joined as Business Development Manager.

Alan Keenan has many years' experience in the ceramic industry, most recently with Wade Ceramics. He joined Wade in 1994 as a sales administrator and business manager and was factory manager at this leading British ceramic manufacturer during the past four years. Alan's role will be UK based, with some responsibilities also in Europe.

"Alan brings with him a good mix of experience in key areas," commented Sales Director, Phil Green. "He has over 25 years of sales experience but has also been responsible for manufacturing – running a production team, optimising systems and minimising losses and reworking. These are all critical skills when it comes to understanding our customers' needs and meeting their expectations, which will be central to his role at IPS."

"I'm excited about the challenges presented by my new role with IPS Ceramics," said Alan. "I look forward to working with the whole team to maximise all the sales opportunities that exist for our diverse range of refractories and technical ceramics."

Adam Wright will be working as part of the sales and commercial team and will seek to continue the success that IPS has had in branching into new areas with a broadening product portfolio. Adam has worked in a sales environment for the past eight years, most recently dealing with property investments.

"This is a very positive step for me," said Adam. "I have always wanted to go into the ceramic industry, where my father has spent his entire career. I am very much looking forward to making the most of my enthusiasm and ambition to take IPS Ceramics to new levels."

"With these new appointments we've achieved a balance of youth and experience," concluded Phil Green. "We believe we can achieve much more, both here in the UK and abroad, where we have just returned from highly successful exhibitions in the USA and Germany. It's been a really positive start all round in 2016."

www.ipsceramics.com

Insulating castable refractories – specification best practice for furnace and kiln applications

Industrial furnaces and kilns rely on high temperature insulation materials to optimize production yield and minimize energy costs, which can rise rapidly if excessive heat escapes from the point of operation.

Insulating castable refractory materials are key to this energy-saving process due to their inherent low heat conductivity as well as advantages derived from ease of placement and structural strength. However, with so many local, national and global manufacturers delivering to market a myriad of material technologies and products, accurate specification is a highly challenging task.

Lance Caspersen, from Morgan Advanced Materials, one of the world's leading producers of Insulating Firebricks (IFBs) and lightweight castable refractories under the K® IFB and Kaolite® insulating castable brand names, examines the key considerations for specifying castable refractory insulation systems, offering advice on achieving the best value solutions which minimise energy consumption, optimize outputs and meet the needs of both the installer and end user.

Customer requirements for ever higher performance products, and installer needs for easy to apply materials, drive the leading refractory manufacturers worldwide to continue to invest heavily in the research and development of next-generation industrial insulation materials. The aim is to bring to market castable products which combine optimum insulation performance with other important attributes, such as strength, operator safety and ease of installation.

Specifying insulating castable refractory systems has become a real challenge, with those containing alternative, high-performance core monolithic ingredients, such as crushed IFBs, now an increasingly popular specification staple for complex high-temperature applications. That said, the use of conventional raw materials such as perlite, an amorphous volcanic glass, and vermiculite, a hydrous phyllosilicate mineral, remains prevalent in many sectors. Despite crushed IFB containing insulating castable mixes outperforming conventional material choices in both application precision and product performance, habitual specification behaviour is preventing customers in certain industries from moving in favour of better alternatives. As with any change in specification, education is key to enable decision-makers to select a product which is best suited to each individual application in accordance with environmental factors, application considerations, desired outcome and, of course, cost.

With advances in materials technology set to continue, and product variety expected to increase even further, specification best practice will become continually more challenging to apply. With that in mind, it is vital for specifiers to obtain and uphold a detailed understanding of the key products, their technical capabilities, application processes and how each one can facilitate or hinder key drivers including installation, lifetime cost and energy efficiency.

Understanding the ingredients of each castable mix

On the face of it all insulating castable refractories look the same, comprising a mixture of aggregates, cement and additives, such as clay and fillers. When mixed with water, they will form a slurry suitable for application via casting, gunning, ramming, pouring or plastering, and in some compositions, pumping and shot-creting. It is important to realize that all castable refractories can be different, and therefore should not be commoditised. By learning the difference between each castable type, specifiers, contractors and installers can select and install a product which is better matched to their application, delivering improved energy and output performance, increased lifespan and associated cost efficiencies as a result.

The best way to facilitate an ongoing learning curve is by partnering with an established and knowledgeable manufacturer that can not only encourage best practice throughout the specification process, but will also assist specifiers and procurement teams in making the right purchasing decision on a site-by-site basis, in accordance with customer requirements.

The difference between working closely with a manufacturer and seeking a commodity castable refractory solution is simple. A highly experienced

Insulating castables found as primary and back-up linings in many Industrial and Energy applications

Perlite, 0.5 lbs

and well-established manufacturer has refractory products to suit even the most complex insulation challenge, balancing properties such as density, strength and thermal conductivity; something which is particularly useful when specifying for an environment which is particularly harsh or requires a specific method of application.

It is also important to understand that while raw materials in insulating castables vary, there are three main 'core' aggregate raw materials on the market, used to form a variety of insulating castable refractory products. Before we go any further, it is important to assess these key ingredients.

Perlite

Perlite is a completely natural siliceous volcanic mineral, formed by the sudden cooling and solidification of volcanic ash, which traps crystalline water into its masses. Used widely in construction, as well as agriculture for the aeration of soil, perlite is mined throughout the US, Greece, China and Italy.

World reserves of perlite are estimated at 700 million tonnes, with around 1.5 million tonnes being mined and processed each year. Characterized by its ability to expand to up to 20 times its original size when rapidly heated to 1,472°F and 1,742°F (800°C and 950°C), Perlite is essentially a mass of minuscule glass bubbles which give it the insulating properties for which it is known.

Vermiculite

Vermiculite is a hydrous phyllosilicate mineral which occurs naturally as an alteration product when certain types of rocks form next to each other. When heated to around 572°F, exfoliation occurs and vermiculite expands to approximately 30 times its original size. There are large commercial vermiculite mines in Russia, South Africa, China and Brazil, producing material for a variety of industries. For insulation purposes in certain mixes, vermiculite and perlite can withstand temperatures of up to 2,000°F and 2,100°F (1,093°C and 1,149°C), respectively before excessive shrinkage occurs.

Crushed Insulating Firebricks

Used as an alternative core raw material for making insulating castable refractories, typical cast process crushed IFB offers superior heat-resistance capabilities of up to 2,800°F (1,538°C). Having already been fired to a high temperature during the brick manufacturing process, crushed IFB is a pre-shrunk aggregate which, when mixed to make a castable refractory, contracts very little during high temperature use.

With the inherent structural strength capacity of an insulating fire brick and a density of 34PCF (545kg/m^3) compared to perlite's 8PCF (128kg/m^3), monolithic castable mixes which use crushed IFB as the core material will not only perform extremely well in high temperatures, but can also be formulated specifically to offer increased strength and thermal insulation performance in harsh furnace and kiln environments.

While there are a number of manufacturers worldwide that promote Insulating Fire Bricks, there are very few which crush special cast produced IFBs for use in monolithic castable refractories, making Morgan Advanced Materials the leading innovator in this area of materials technology.

Key specification criteria

With a clearer understanding of the three main core raw materials in insulating castables, the next question is: which base aggregate to choose? There are a number of key criteria which would be considered best practice in specifying insulating castable refractories. These include the method and complexity of application, the quality and cost of the product and the environment in which the product is expected to perform. Get these three elements right and the product specified, assuming it has been correctly installed, should deliver optimum furnace or kiln performance and improved energy efficiency over a longer lifespan. Here we look at the three variables in more detail.

Application consistency

Taking an industrial or commercial furnace or kiln out of operation is inconvenient and incredibly expensive, so specifying an insulating castable refractory which is quick and efficient to apply, while providing long reliable service, is of great benefit to the end user.

There are two main concerns when selecting a product that will facilitate a predictable and efficient application; ease of use generally by casting or gunning and product loss usually via rebound or material compaction.

Insulating castable products which are deemed easy to install are consistent in production and can be applied under a wide variety of conditions. Cast process crushed IFB based castables have a consistent density and particle size enabling tight control on water addition resulting in a smooth castable with good flow characteristics. They also lend themselves to installation by gunning and by pumping since a more porous aggregate will tend to clog the hoses.

It is this application downfall which has seen many specifiers and contractors to move in favour of castable materials using raw material technologies such as crushed IFB, so that material costs can be more accurately controlled prior to application.

The other key consideration here is 'rebound', which is the name used

Vermiulite, 0.5 lbs

Insulating Firebrick, crushed, 0.5 lbs

during installation to describe the situation when gunned material falls off the walls or ceiling onto the floor. Waste caused by rebound is usually the aggregate, which is why leading manufactures like Morgan have engineered specific formulations to minimize rebound to as low as 10% while providing greater consistency of the installed product.

Finally, material compaction is when the gunned castable mixture compacts when being installed on the wall due to the force of application, requiring additional material in order to deliver the desired thickness. Despite its beneficial lightweight characteristics, perlite-based castable products are known to compact up to 20% when gunned, which can make what is, at first glance a cost-effective material, a more expensive overall installation. Meanwhile, IFB-based insulating castables suffer very little, if any, on the wall gunned compaction since the hard fired raw material does not easily break down during the application process.

Thanks to the uniform and reliable manufacturing methods used in creating crushed IFB insulating castable refractories, installers can also benefit from simplified and consistent application processes.

Monolithic refractories with a core of crushed IFB mix into a smooth, homogenous 'ball in hand' consistency, compared with other insulating castables which are typically grainy and less cohesive. The consistency of IFB mixes allow for more precise control during application, requiring less air or water adjustments and potential surging during the gunning process.

The quality vs cost argument

The quality vs cost argument is an age-old specification problem, especially when working with large companies with an in-house procurement team tasked with identifying cost savings.

Tackling this issue in accordance with best practice means engaging with both the technical and purchasing teams to aid a process of understanding. Put simply, by encouraging an appreciation of the benefits which a better quality product can offer in the long run, when compared with a lesser quality material with a more attractive perceived initial cost, specifiers can guide other decision-makers within the purchasing chain to opt for a refractory which not only delivers enhanced performance and product reliability, but a more sustainable whole life cost too.

It can even be said that an application which only requires a low to moderate level of thermal insulation could reap the benefits of 'over-specifying' on quality in order to enjoy better whole life costs and minimize the risk of costly kiln failure. A good example of this would be the purchase of a $1,100/metric ton castable material rather than a $1,000/metric ton alternative, which might potentially deliver more reliable product service life, as well as added performance, insulation and speed of installation benefits which come with a better quality product. One has to look at the total cost: the price of the material, the installation production rate, the density on the wall, the installed material performance and service life.

Gunning application for a furnace roof

Specifying on a project-by-project basis

It is not uncommon for specifiers to have preferred manufacturers or suppliers for materials or building products whom they use on a regular basis. For some materials though, including insulating castable refractories, this approach is not always conducive to best practice.

Commercial and industrial furnaces and kilns can be subject to a variety of different application-specific factors and there may be a number of operational variables at play too, which will shape the specification requirement. The key here is to really get to know the environment you are specifying for, so that you can recommend a product that will provide adequate insulation, performance and lifespan.

The simplest example of having to specify on a project-by-project basis is that of operating temperature. While all furnaces rely on intense heat, there can still be a significant difference in temperature between one environment and the next. As not all monolithic refractories offer thermal resistance to the same level, a furnace or kiln which operates at 2,000°F, for example, could be insulated with a perlite, vermiculite or crushed IFB based refractory, but an alternative environment reaching much higher temperatures would rule out perlite and vermiculite mixes completely.

The formulation of the mix will change depending on the temperature requirements of each project, with more cement and a denser aggregate providing increased strength, and less cement but a better insulating aggregate being most suitable for higher temperature operations. This is true for a number of environments within the ceramics sector, such as the manufacture of small ceramic spheres for LNG fracking, which requires a high-strength castable capable of performing in extremely high temperatures.

An established manufacturing partner will be able to assist in specifying the right mix for the job, providing guidance on best practice and how to accommodate the change in formation with appropriate application methods.

Other important considerations here are the presence of contaminants in the operator's process, which will require a purer castable refractory, as well as the issue of 'thermal cycling', which describes the scenario where a furnace or kiln is heated then cooled frequently during operation. This constant change in temperature may cause cracking in a lower strength castable while an insulating castable mix formulated with a pre-shrunk core material, like IFB aggregate, would be more suitable.

Changing the specification habits of a lifetime

Many areas of the supply chain can be resistant to change, especially in environments where planned downtime or furnace failure is extremely costly. It is this resistance as well as a focus on simple material price that is slowing the shift towards better materials technologies in some sectors, despite the obvious benefits.

When considering best practice, the unfortunate truth is that the very nature of specification can bring about habitual behaviors, which can eventually lead to sub-optimal product choices if decision-makers do not keep up to speed with technological advances and market changes. However, it is crucial to remember that improved castable refractory materials offer enhanced performance, better insulation and ultimately, energy and costs savings over the life of the product – so they should be embraced as early as possible.

Drilling Furnace Walls & Refractories- a Practical Guide

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Abstract: Bricks, monolithic refractories, cooling elements and structural steel are used to construct a furnace. Additionally, small bore holes are also a common feature in the walls of a metallurgical furnace. Holes are needed to mount instruments, or to sample molten materials, or for manual measurements. Drilling furnace walls is difficult because it is specialised and requires appropriate planning and equipment. Commercially available drilling equipment was not generally designed for use on hot refractory. This paper briefly discusses some types of small bore holes required for successful furnace operation, and makes practical suggestions to help overcome the limitations of readily available drilling equipment during the installation of instruments, sample points and condition monitoring equipment.

Keywords: i.e. refractories, drilling.

1. Introduction

An obvious question must be, 'why would it be necessary to drill holes in furnace walls and refractories'? There is of course more than one answer. Some of the reasons why a hole is required might include: to insert a bar inside the furnace from the outside to measure the depth of molten product contained within the furnace; to insert a temperature probe into the refractory or the furnace gas space to measure temperature; to insert an instrument to sample gas; or to insert a device to sample product. Holes in furnace walls and refractories are required over a range of different sizes depending on their purpose.

Drilling a hole in hot furnace refractory is difficult for a number of reasons. How do you keep a drill cool without using water? Do you want to use water to cool a drill? Hydration is an obvious concern if water is used on MgO-based refractory materials. [MgO + H2O → Mg(OH)2]

Readily available drilling equipment is typically designed for applications in masonry and construction trades and not specifically intended for use with furnace refractory, either hot or cold. What are the limitations of readily available equipment, and what types of this equipment and drilling consumables have been successfully used in refractory applications?

Drilling refractory is of course easier when there is easy access to the refractory. How do you make a hole in the furnace shell or structure to expose the refractory if none exists already? What are the considerations when doing this on a hot furnace compared to a cold furnace?

This paper will discuss some of the different approaches used for drilling holes ranging in size from 8 mm to 100 mm and larger in diameter, in both hot and cold furnaces.

2. Equipment for drilling furnace external walls (steel)

Mostly holes are placed in furnace walls or sections during the construction period either in situ, or in a workshop according to the design documents. This is relatively easy to do when the furnace is cold, access scaffolding is plentiful, and specialised machining equipment is available. Traditionally the equipment used for drilling thick steel sections is a rotor broach in conjunction with a magnetic based drill similar to the one shown in Figure 1.

Figure 1: Magnetic Base Drilling Unit –[1]

A manufacturer of a magnetic based drilling equipment recommended to the author that their machines not be used in situations where the ambient temperature exceeded 80 degrees Celsius due to concerns of damage to the insulation of electrical components. The surface temperature of a steel furnace wall which was going to potentially be in contact with the magnetic base was measured at 200 degrees Celsius. This temperature was also considered inappropriate by the manufacturer for the use of the magnetic base drill.

On occasion there may be a requirement to cut the steel wall of a hot furnace. If the correct equipment or know how is unavailable, expedient

decisions may be taken to use alternative methods to make the hole, similar to the example shown in Figure This approach of thermal cutting is not recommended as the oxidised residue from the thermal cutting process burns into the back of the brick making it very difficult to drill. It also leaves ragged edges around the perimeter of the hole that may act as stress concentrators and initiate a fatigue crack of the shell during future cycles of thermal stress.

Figure 2: Example of Thermal Cutting on Hot Furnace

The smooth surface of a circular machined hole is preferable to thermal cutting. Drilling of hot steel furnace walls has been successfully achieved by combining a rotor broach with a diamond coring tool using a specialised Morse Taper adaptor and a water swivel operating with compressed air as the cooling medium.

3. Equipment for drilling refractory

Investigation of commercially available drilling equipment, consumables and techniques utilised in concrete cutting, stone masonry and refractory installation was undertaken together with discussions with tradespersons and potential suppliers. When this information was combined with the author's own knowledge and experience it enabled a better understanding of the limitations and an improved approach was developed.

To successfully drill holes in refractory, diamond coring tools, similar to the example shown in Figure 3, have been successfully utilised. A drilling stand should always be used as part of the rig to provide smooth feed control, additional support and to prevent uncontrolled movement when prevent injury to operators in the event that the large diameter drills should grab or jam during the drilling process. Use of a drill stand also allows for much easier adjustments during alignment of the drill rig.

Due to the brittle nature of refractory there is a potential to damage bricks by hammering, so percussive drilling is generally not recommended. It is never employed on furnaces the author is involved with. The only exception to this would be the use of a percussive drilling machine to break through solidified clay/slag mixes that may be placed to seal existing holes in the furnace wall.

Figure 3: Diamond Coring tool with Drill stand- [2]

Selection of appropriate drill consumables is also important to ensure the drill bits purchased are compatible with the drilling/coring unit selected. Some equipment manufacturers utilise proprietary drill bit connections in attempts to monopolise after-market sales of drilling consumables. Such manufacturers tend to be very inflexible with any changes to their standard product range. The author has found it advantageous to fabricate a range of suitable adaptors that allow drill rigs and drill bits to continue being used interchangeably

Work was done with an Australian supplier over many years to provide flexibility of component supply, and the use of improved materials to manufacture drill bits for drilling refractory. An example of the improved materials was the introduction of high temperature brazing alloys to guard against detachment of diamond tips on small diameter pin drills at temperatures "higher than normal". Laser-welded segments were also chosen to improve productivity on the larger diameter core bits. Lengths of drills have been customised to suit different applications.

Type of Hole	Purpose	Furnace Conditions During Drilling Process
8 mm (blind hole) for Heat up Thermocouples	To provide accurate temperature of refractory during initial heat up	Cold
8 mm (blind hole) for Embedded Thermocouples	Condition monitoring of refractory during the life of the furnace	Hot – Drilled when furnace is on-line
40 mm (perforation) for sheathed thermocouple	To monitor internal furnace temperature	Cold – Before heat up
>40 mm (perforation) for Tap Holes	To remove product from Furnaces	Cold – Before heat up
>40 mm (perforation) for Dip Bars – Other types of access ports	Measuring liquid depth inside the vessel	Cold – Before heat up (Possible to do later, but difficulty increases)

Table 1: Types of Holes required in Furnace Refractory & when they are installed

The overall length of the drill is important. Long pin drills for example are prone to excessive flexing when they are loaded, because the pin drill body diameter is small it is weak, and it cannot tolerate being flexed while under load. Flexing causes the drill to wobble and wobbly pin drills are likely to collapse without warning. The author has observed many failures of pin drills when this was ignored by the operator. When a pin drill fails under these conditions there is potential for entanglement, injury and damage to equipment. It is important to always start drilling small diameter holes with a short drill which is less prone to flexing. After starting the hole and drilling in a sufficient distance the drilled passage provides good security against flexing of the longer length drills. For safety reasons always ensure longer drills are inserted into the pre-drilled holes before switching on the drilling motor. Another limitation on the drill length that can be used in an application is the amount of travel possible with the drill stand being used.

4. Hot & cold refractory drilling – when are they required?

Table 1 lists a variety of applications for small-bore holes and the corresponding installation conditions that may be necessary.

5. Installing heat up thermocouples

One of the major difficulties of heating up a furnace is the ability of operators to know and accurately control the temperature of the refractory. Some contractor companies that provide heat up services have been observed to use thermocouples inserted in various locations of the furnace gas space. In the author's experience this provides no real certainty of temperature in refractory linings when compared to being able to measure the interior temperature of bricks.

Wire thermocouples may be co-installed with the refractory lining. For some years the author installed, as a routine task, many 3 mm wire thermocouples with great care into the brick work of new furnaces. An example of this is shown in Figure 4. The main weakness of this method was the fragility of the thermocouple. Additional time was also required to cut grooves in bricks to accommodate the thermocouple wires.

During initial heating of refractory the working brick lining undergoes some movement relative to the furnace shell. The movement of the working lining was sufficient to disturb, crush and in some cases shear 3 mm thermocouples passing through the furnace wall. This caused many failures and created situations where vessels were being heated up with unreliable temperature monitoring.

Figure 4: Original method of installing Thermocouple

For these reasons an improved approach was developed for heat up thermocouple installation. Two main changes were made to overcome the problems experienced with the premature failure of the 3 mm thermocouple wires. Firstly the diameter of the thermocouple was increased to 6 mm to make them stronger; secondly where the thermocouples had to penetrate both a backing and working lining, a 40 mm diameter hole was placed in the backing lining to allow the thermocouple to move freely with the working lining, independent of any movement of the backing lining. (Refer to Figure 5, below). As part of this development the practice of cutting grooves in bricks to accommodate thermocouples was abandoned in favour of drilling blind holes into the bricks with a pin drill from the outside of the vessel. The drilling of blind holes from outside the vessel means the installation of heat up thermocouples is able to take place in parallel with the refractory installation.

The new method of installation has vastly improved the performance and longevity of the heat up thermocouples. Some heat up thermocouples installed using the new method have remained working for several years following the initial heat up period.

A typical refractory heat up thermocouple arrangement is shown in Figure 5.

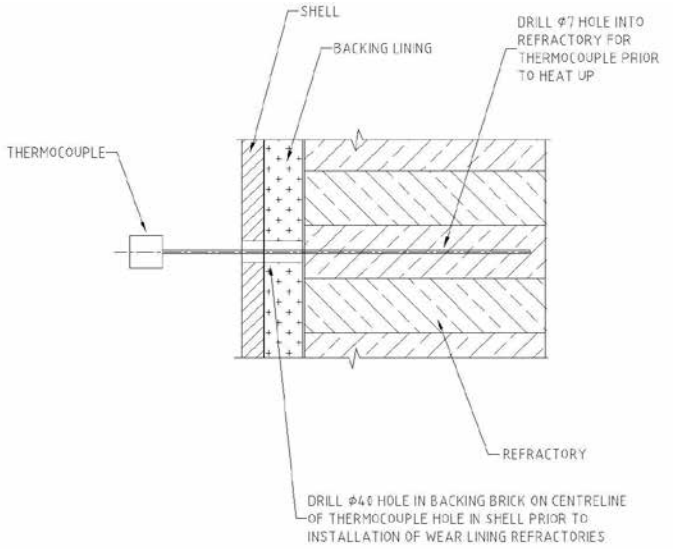


Figure 5: Heat up Thermocouple Placement – Improved Method

6. Installing embedded thermocouples for condition monitoring

Refractory monitoring thermocouples are installed in blind holes that are drilled into the refractory from the outside of the furnace. The holes for these thermocouples are drilled when the furnace lining has reached its steady-state temperature and there is no longer a significant risk of relative movement between brick layers that may adversely affect the integrity of the thermocouples.

The positioning and interpretation of the information provided by thermocouples are important for achieving accurate condition-monitoring, and are not covered in this work. A lengthy treatment of the subject is included in a patent [3] by Edwards & Tuppurainen.

To survive contact with the hot refractory, drill bits can be successfully cooled by compressed air. Water has also been used, but at flow rates so low that not more than a very small trickle of water is seen to escape from the hole. Such small flows of water have proved insufficient to keep the hole cleared of drilling residue. By comparison, the use of compressed air for drill bit cooling allows the hole to be kept clear and simultaneously eliminates the possibility of brick hydration and/or the possibility of a steam explosion. Compressed air coolant is therefore favoured over water, but

Figure 6: Evidence of multiple attempts to drill a Thermocouple hole in Refractory

necessitates the use of respiratory protection (RPE) to protect the operator against exposure to dust.

Hot drilling is not a fast process. Drilling rates of 5.0 – 10 mm/minute are quite common. It must be remembered that 8 mm pin drill bits are very fragile and the temptation to increase the load on the drill bit must be resisted. Figure 6 shows evidence of the need to follow strict procedures to prevent uncontrolled movement or overloading of pin drill bits. A diamond drill tip sheared off and stuck deep in a hole cannot always be easily removed.

7. Anchoring requirements for a refractory drilling rig

As described previously the coring unit should only be operated in conjunction with a drill stand in order to maintain good control and alignment of the drill bit. Anchoring of the drilling rig to the furnace shell is therefore required and the author has experimented with various methods to achieve this. One early anchoring method involved the preparation and welding of flat plates to furnace walls to match the curved steel shell with the flat base of the drill stand. The drill stand was then attached to the plate with multiple fasteners. This method was time consuming to set up, difficult to adjust if the hole needed to be re-located, and there was a reluctance to leave the plates in position afterwards, due to its interference with the mechanical and thermal properties of the furnace shell. The repeated process of preparing and welding flat mounting plates to the furnace shell was burdensome and needed to be done each time the refractory lining was changed.

To improve the ease with which the coring unit could be mounted, a simplified anchoring arrangement was developed. A standard connection or joining nut as shown in Figure 7(a), was welded to the steel furnace wall, and the fine thread of the proprietary stud bar shown in Figure 7(b) was screwed firmly into the nut to provide a strong anchor point. Once the base of the drill stand had been slid over the anchored bar, the proprietary speed nut could be quickly tightened to hold the coring unit in the correct position. The current mounting arrangement is shown schematically in Figure 8.

(a)

(b)

Figure 7: Anchoring system for Coring rig: (a) Joining nut, (b) Proprietary components

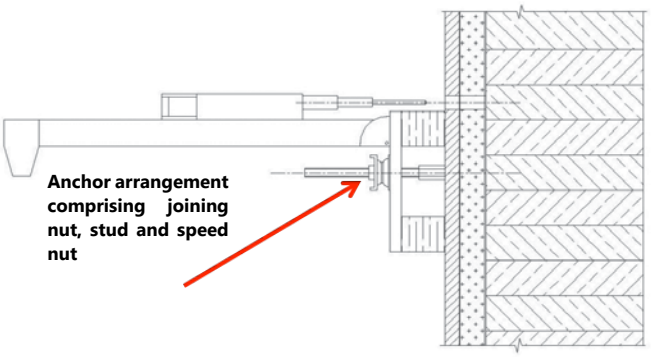


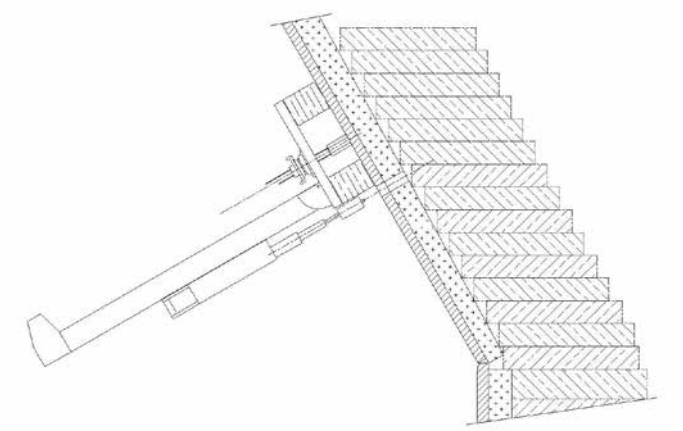
Figure 8: Coring rig Anchoring system on a vertical wall

Differing set ups of drilling units are required to suit different furnace geometries. The set up shown in Figure 8 is probably the simplest. The furnace shell is vertical and the bricks are laid in horizontal courses. It is easy to align and insert a thermocouple within a single brick.

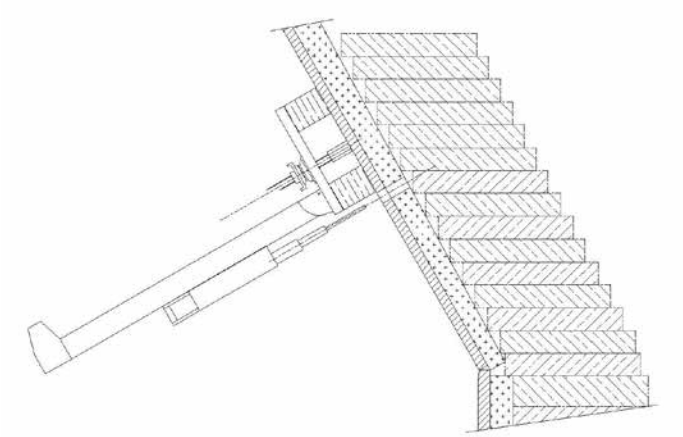
Drilling steel and refractory on a sloping section is more difficult. To successfully engage the rotor broach it is necessary to have full contact between the rotor broach pilot, broach cutting teeth, and the surface being cut. The easiest way to orient the drilling rig with the furnace to accomplish this is shown in Figure 9 (a). Unfortunately the hole resulting from this approach does not allow the drill bit to follow a course parallel to the bedding plane of the brick course, as can be seen in the view shown in Figure 9(b).

Drilling the shell as per the example in Figure 9(a) and then tilting the drill stand to align the drill with the brick course, means that the two holes have different centerlines. In practice this allows a hole to be drilled, but there is

a poor alignment of the hole in the shell with the hole in the backing lining. This is illustrated in Figure 10. If there is relative movement of the shell and backing lining, the thermocouple will be sheared.



(a)



(b)

Figure 9: Drilling steel and refractory on sloping section

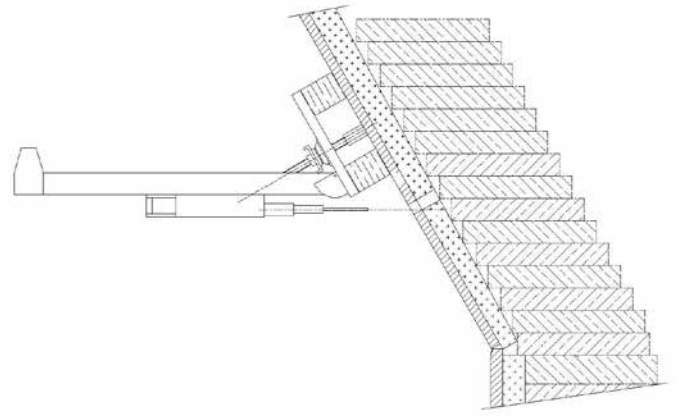


Figure 10: Misalignment of drilled hole and brickwork

To fully overcome this problem it is necessary to use a fabricated wedge block or guide to provide an area of full contact for the broach. A suitable arrangement for drilling on sloped sections is shown in Figure 11.

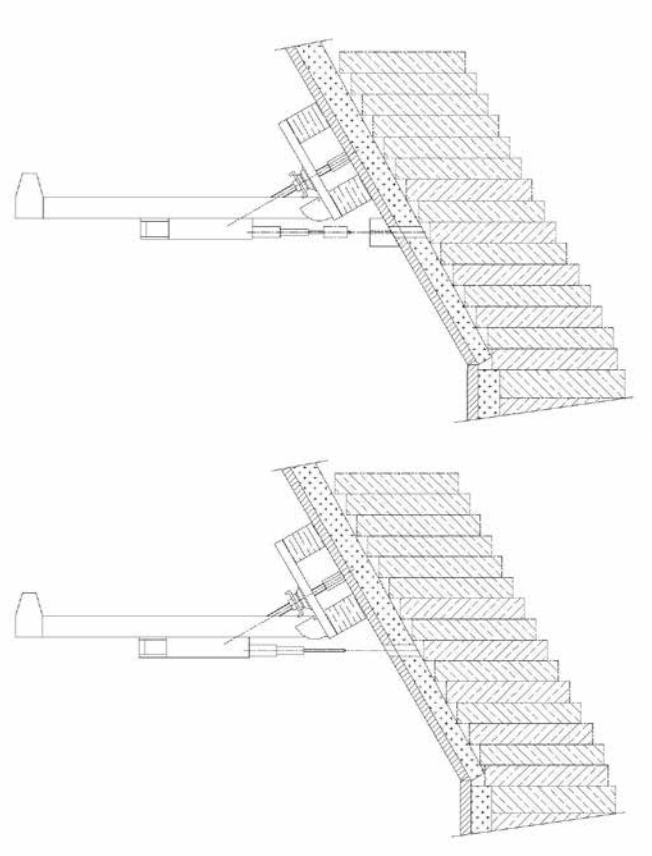


Figure 11: Suitable arrangement for successful drilling on sloping sections

8. Conclusions

Drilling of both steel and refractory walls of furnaces is possible and it has been safely achieved in both hot and cold conditions. Holes ranging in diameter from 8 – 100 mm and up to 550 mm deep have been drilled in many furnace walls worldwide.

Acknowledgements

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Improvement in Tundish Lid Life by Utilising the Tools and Principles of Total Quality Control

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[2]Refractory Installations, BlueScope Limited, Port Kembla,
[3]Steelmaking Maintenance, BlueScope Limited, Port Kembla,
[4]Slab Handling and Tundish Area, BlueScope Limited, Port Kembla.

Tundish lids are used for a number of reasons at BlueScope Limited, Port Kembla. First and foremost they must provide a safe working platform for the caster floor operators who have to work on the lid covering the molten metal bath for a number of activities. This requirement provides some key parameters for design and performance in that the lid thickness is restricted, external steel stiffeners cannot be used and if excess bowing occurs the lid is removed as it becomes a trip hazard. Other requirements of the tundish lid include being a seal to allow effective preheating of the tundish and a protective cover at times such as start up when splashing can occur. There had been a number of attempts at improving the life of tundish lids but in 2012 it was again identified as an area that was costing significant amounts of money with low and variable performance. At this time restructuring meant there were personnel changes in the cross functional working group that had the responsibility of this application. It was deemed by this new group that the problem is best addressed using the basic principles of Total Quality Control. First and foremost this included better control through measurement and continual improvement through a systematic approach. The team approach ensured there was involvement of a number of stakeholders and the improved performance has been a major benefit to the plant. This paper explains how these basic principles were used to gain a significant improvement in tundish lid life.

Keywords: i.e. refractories, thermal stress, tundish lids, Total Quality Control.

1. Introduction

People are often exposed to a number of training courses throughout their career. Some of the practices learnt at these courses are adopted and sometimes they are forgotten if not practiced after the course. During the late 1980's, a training course that was frequently given at what was then known as Rod and Bar Products Division at Newcastle, was a course on TQC or Total Quality Control concepts.[1] This training was based on four basic ideas that Deming and Juran promoted and these were:

- Satisfy your customers
- Continually improve through a systematic approach
- Control through measurement
- Involve everybody in the improvement

In 2012 variable and low values of tundish lid life was highlighted as a significant cost issue for BlueScope's Port Kembla steel plant. Tundish lids are used for a number of reasons. First and foremost they must provide a safe working platform for the caster floor operators who have to work on the lid covering the molten metal bath for a number of activities. This requirement provides some key parameters for design and performance in that the lid thickness is restricted, external steel stiffeners cannot be used and if excess bowing occurs the lid is removed as it becomes a trip hazard. Other requirements of the tundish lid include being a seal to allow effective preheating of the tundish and a protective cover at times such as start up when splashing can occur.

Some previous Finite Element Analysis modelling had indicated that bowing could be expected in tundish lids during casting[2] and although some changes had been made in response to this modelling work the gains promised from initial results had not been achieved over the long term. Therefore work was commenced to improve the life of the tundish lids and the methods used to improve the life and the outcomes are explained in this paper.

2. Experimental program and results

2.1 Baseline Data

The cross functional team responsible for managing the life of tundish lids decided to utilise the basic concepts of TQC to manage the improvement process. The first steps were to:

- Ensure all lids are made as per drawing
- Start collecting data on tundish lid baseline performance

It should be noted that at this time the tundish lid fleet consisted of two main designs. These were:

- 700 series lid with a single component refractory layer and nominally 125mm internal steel ribs
- 800 series lids with a 2 component refractory layer and 50mm high billet shaped internal ribs

The tools used for measuring the baseline performance included run charts recording the number of casting sequences completed by each lid and pareto analysis for the reason for removing the tundish lid. This baseline data is shown in figures 1 to 3.

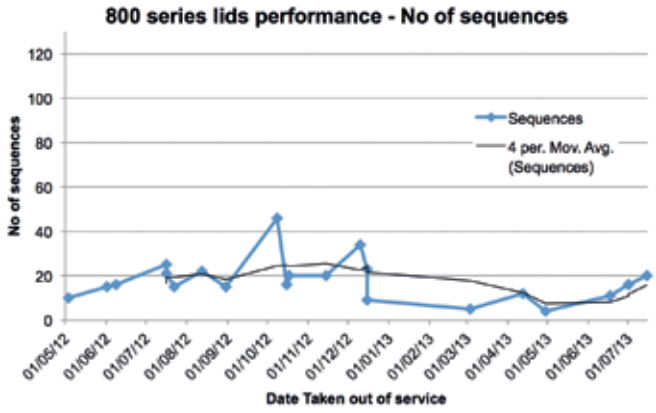


Figure 1: Run chart showing the baseline life for 800 series tundish lids

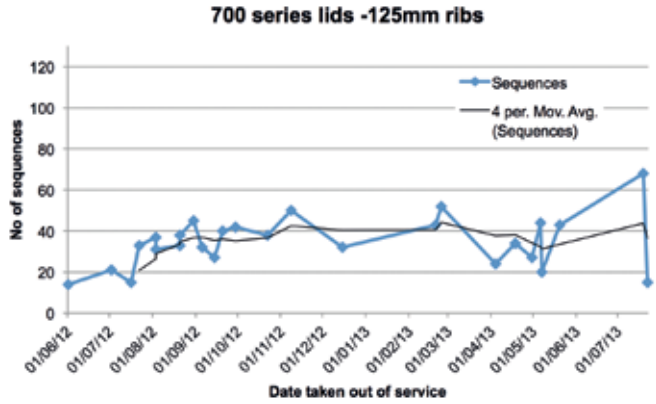


Figure 2: Run chart showing the baseline life for 700 series tundish lids with 125mm steel ribs

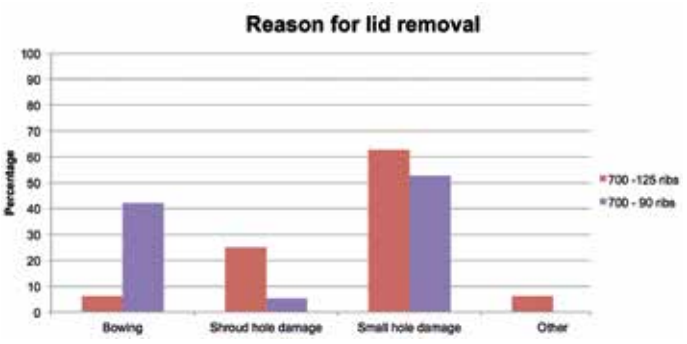


Figure 3: Pareto analysis comparing the reasons for lid removal for 800 series and 700 series (125mm ribs)

2.1 First Improvement Cycle

Having collected the baseline performance data it was then relatively easy to utilise the Plan-Do-Check-Act cycle to select and test potential improvement activities. For 800 series lids where bowing was the major cause of premature lid removal it was proposed that heat stress relieving the steel shell before relining with the standard castable would remove the bowing memory in the steel shell. The performance of a trial 800 series lid before and after the heat treatment process is shown in figure 4.

For the 700 series lids with 125mm steel ribs, figure 3 indicates that loss of refractory from around the small holes in the lid was the major cause of removal. Observations made on the plant indicated that the higher steel rib was contributing to the loss of castable in this region as shown in Photograph 3. Therefore it was proposed that the first improvement activity for 700 series lids was to reduce the steel rib height to 90mm. The performance of these 700 series lids is shown in figure 5 and the pareto analysis comparing the reasons for removal with 700 series lids with 125mm ribs is shown in figures 6 and 7.

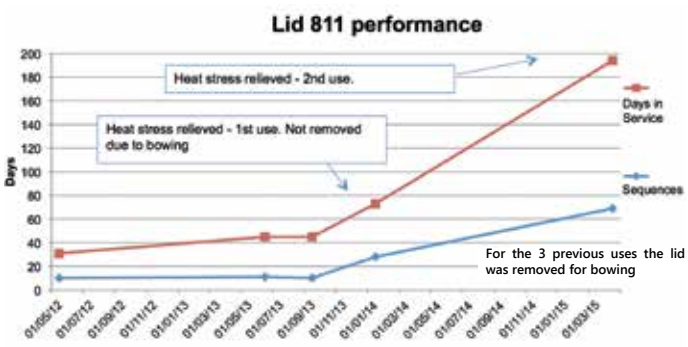


Figure 4: Comparison of the life of an 800 series lid before and after heat treatment

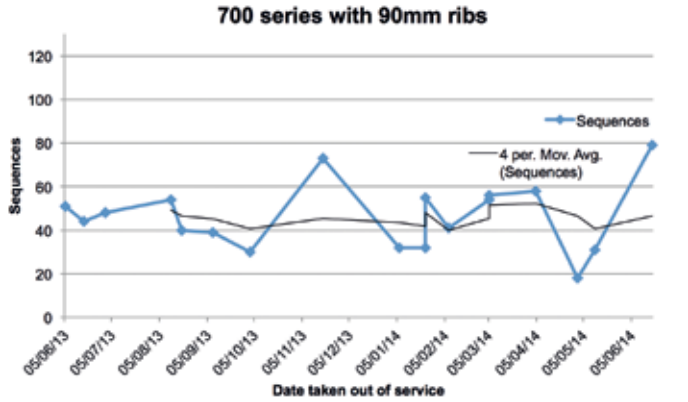


Figure 5: Run chart showing the life for 700 series tundish lids with 90mm steel ribs

Figure 6: Pareto analysis comparing the reasons for lid removal for 700 series (125mm ribs) and 700 series (90mm ribs)

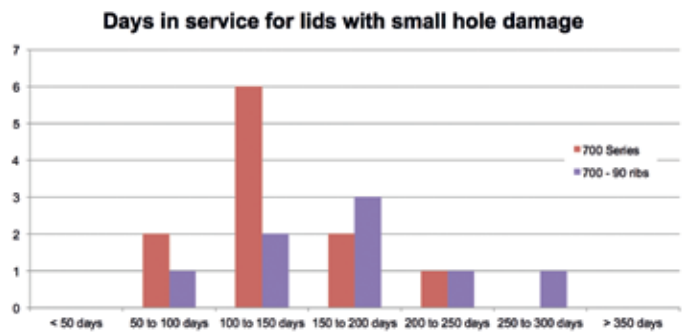


Figure 7: Comparison of the life achieved for 700 series lids removed for refactory loss around the small hole

2.2 Second Improvement Cycle

Since it had been noted that a number of lids continued to be removed due to loss of refractory around either the larger shroud hole or the smaller inspection holes, it was decided that a higher quality stainless steel fibre reinforced castable should be trialled. Key refractory lining properties defined to gain improvements in this application were minimal high temperature shrinkage and a high thermal shock resistance even after being fired to high temperatures.

To determine the high temperature length change characteristics of the new material two tests were conducted. These were the measurement of permanent dimensional change as defined in Australian Standard AS1774.13[3] and the measurement of linear length changes as defined in Australian Standard AS1774.11[4] using an Orton dilatometer. The thermal shock resistance was determined as defined in Australian Standard AS1774.24[5] on samples that had been pre-fired to 1000°C and 1400°C. The results of this testing are shown in table 1 and figure 8.

Property	90% alumina castable with 6% SSF	Previous standard material
Weigh and measure Bulk Density (g/cc)	2.92	2.33
Permanent linear change – 1000°C fired (%)	0.0	-
Permanent linear change – 1400°C fired (%)	0.8	-
Modulus of rupture – 1000°C fired (MPa)	14.8	23.5
Modulus of rupture – 1400°C fired (MPa)	9.6	-
Retained Strength Index – 1000°C fired (%)	105	103
Retained Strength Index – 1400°C fired (%)	99	-
HMOR @ – 1000°C (MPa)	9.6	-
HMOR @ – 1400°C (MPa)	1.3	-

Table 1: Comparison of the properties of the new stainless steel fibre reinforced castable and the previous standard hot face castable

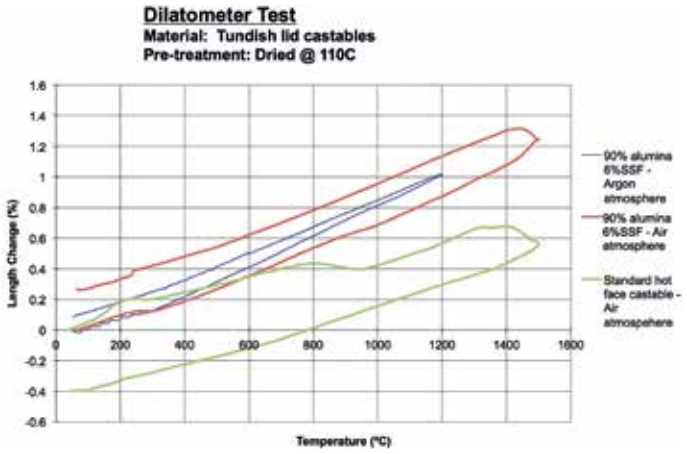


Figure 8: Comparison of the linear length change with temperature for the new stainless steel fibre reinforced castable and the previous standard hot face castable.

It was decided to initially trial the more expensive stainless steel fibre reinforced castable at the end of the tundish lid around the larger shroud hole only. The performance of the lid with this design is shown in the run chart in figure 9, whilst the analysis for the types of failures and the life for different types of failure are shown figures 10 to 12.

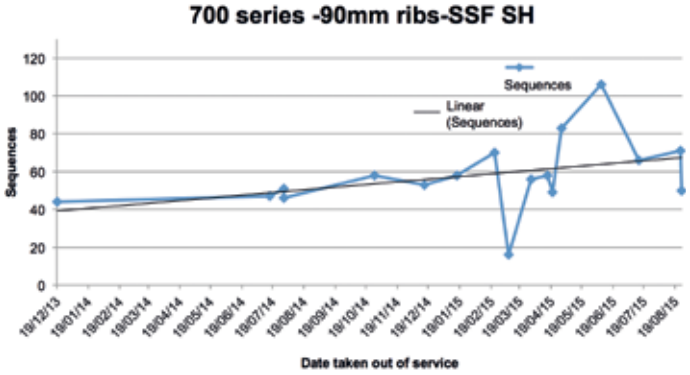


Figure 9: Run chart showing the life for 700 series tundish lids with 90mm steel ribs and stainless steel fibre re-inforced castable around the shroud hole

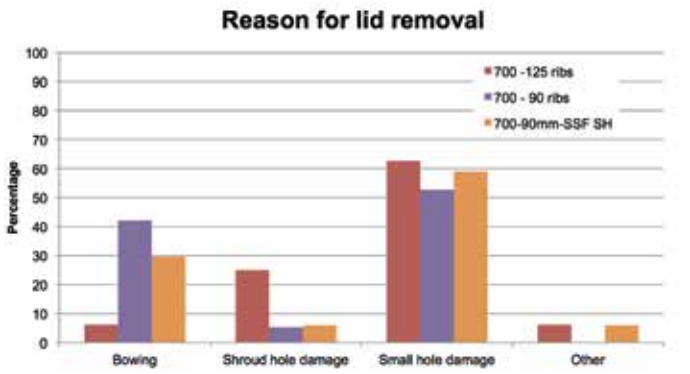


Figure 10: Pareto analysis comparing the reasons for lid removal for three different designs 700 series tundish lids

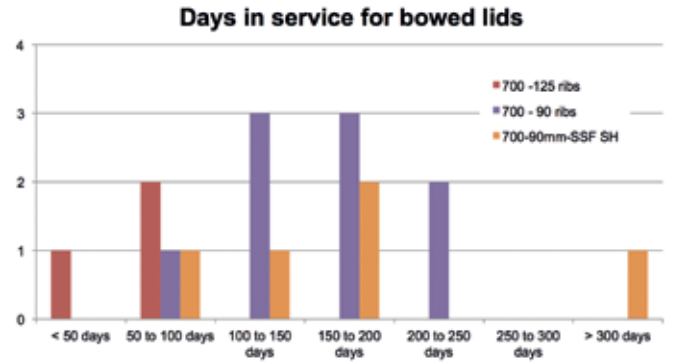


Figure 11: Comparison of the life achieved for 3 designs of 700 series lids removed for bowing

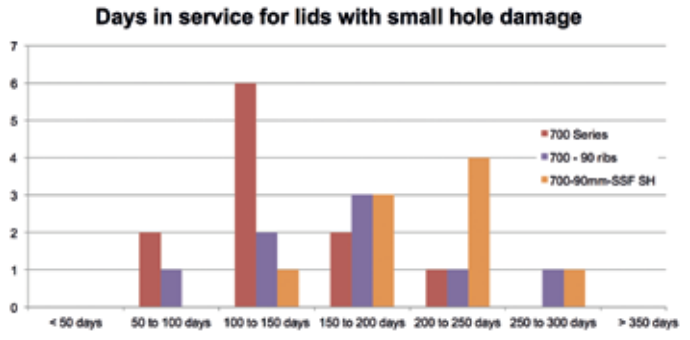
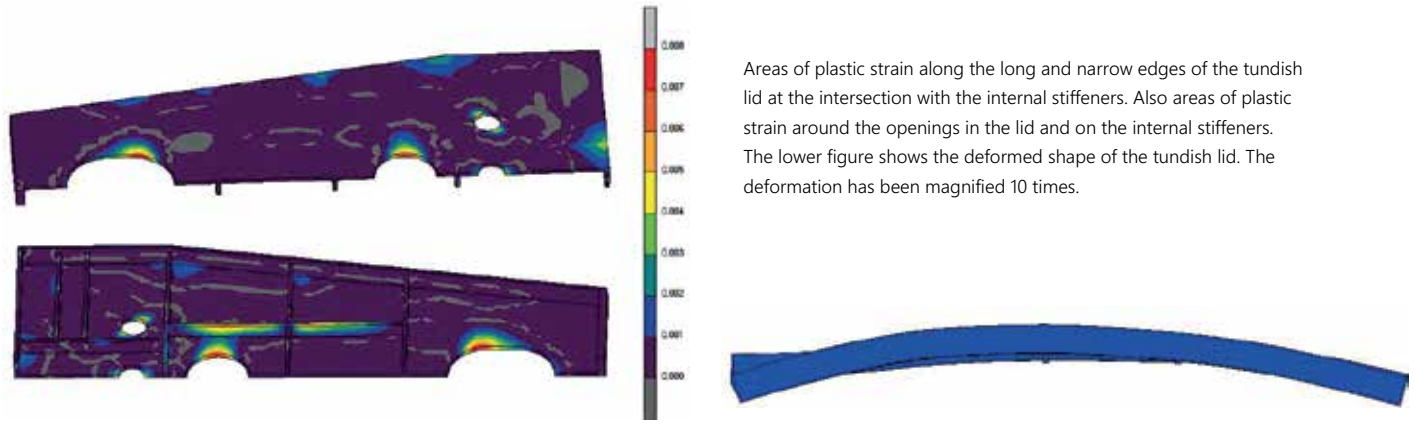


Figure 12: Comparison of the life achieved for 3 designs of 700 series lids removed for refractory loss around the small hole



Areas of plastic strain along the long and narrow edges of the tundish lid at the intersection with the internal stiffeners. Also areas of plastic strain around the openings in the lid and on the internal stiffeners. The lower figure shows the deformed shape of the tundish lid. The deformation has been magnified 10 times.

Figure 13: Thermal modelling indicating plastic deformation of a 700 series lid can be expected during casting.[2]

3. Discussion

Some previous finite element analysis had shown that tundish lids made to the 700 series design could be expected to bow in service as shown in figure 13. Examples of the bowed tundish lids are shown in photograph 1 and this also includes an image showing how a lid can become a trip hazard if the bowing is excessive. Thermal imaging had shown that the hottest locations were around the shroud and small inspection holes on the tundish lid especially during preheat (Figure 14) and one of the design changes introduced was to recess the steel shell away from the opening to reduce the amount of flame impingement on to the shell. An example of this recessed steel shell is shown in photograph 2.

A trip hazard develops if the bowing is excessive

Photograph 1: Examples of bowing in tundish lids

Photograph 2: An example of a recessed steel shell around the shroud hole

Although some design changes had been proposed through the finite element analysis and some initial trials looked encouraging, continuous measurement of performance had not been implemented. Therefore when it was noted that the tundish lids were being frequently removed from service there was limited data to understand the issue. Therefore it was decided to utilise some of the basic principles of Total Quality Control to address this issue.

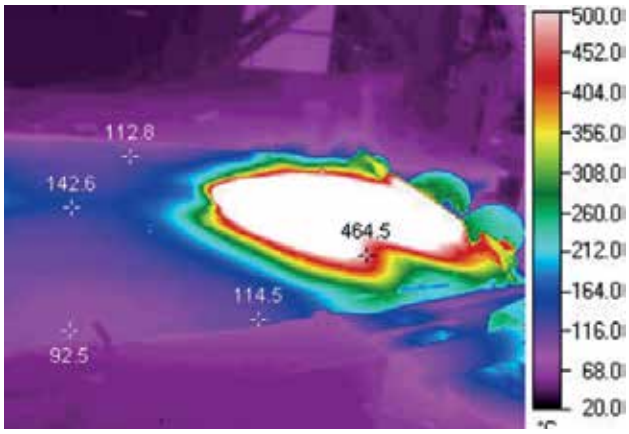


Figure 14: Thermal imaging showing the high temperatures around the shroud hole during preheat

The basic principles proposed of Deming and Juran and promoted in the Rod and Bar training course were:

- Satisfy your customers
- Continually improve through a systematic approach
- Control through measurement
- Involve everybody in the improvement

The initial work to ensure the steel shells were made to drawing and the

Photograph 3: Damage around the small inspection holes promoted by 125mm high steel ribs

collection and analysis of baseline performance data shown in figures 1 to 3 was an essential step to start the improvement process. The information in figures 1 to 3 clearly showed that the average life and the primary reason for removal of the two lid designs were different. The process then moved to conduct a number of Plan-Do-Check-Act cycles targeting the specific issues for each design.

Due to the high rate of bowing contributing to the low lives of the 800 series lids, it was proposed that a bowing memory had developed in the steel shell and so it was proposed this should be removed by putting a shell through a heat stress relief process. Figure 4 indicates this has some potential to provide better performance but due to the improved performance of 700 series lids this trial was stopped. The information is now available to consider and possibly utilise if there is a reduction in tundish lid performance due to bowing in the future.

It was observed as shown in photograph 3, that the shallow coverage of the castable over the 125mm steel ribs was a contributing factor in the loss of castable from around the small inspection holes in the 700 series lid. Therefore the proposal was made to reduce the rib height in this design to 90mm. Figures 5 to 7 illustrate there was an improvement in the average life of lids with this new rib height and even though approximately the same percentage of lids were being removed due to loss of castable in this area, the average number of days before this type of failure occurred had increased.

It was known from thermal imaging such as that shown in figure 14 that there was significant potential for flame impingement of the steel shell during preheat. Earlier design changes included recessing the steel shell around the holes that are used for burner access as shown in photograph 2. However it was often noted that the castable used as a barrier in this area cracked and fell out thus exposing the steel shell to more flame. It was proposed that the use of a castable that remained in place longer would provide more protection during preheat.

Some of the key material properties identified for this region were low shrinkage at high temperatures, good thermal shock resistance and a stainless steel fibre addition to reduce the risk of pieces falling out due to cracking. It was proposed that the stainless steel fibre addition should be at a level that provides the necessary crack resistance but is not excessive so that it becomes a weakness as it is oxidised in contact with the flame. The property test results in figure 8 and table 1 indicate that the material selected had improved properties in comparison to the current standard material.

Initially this improved castable was used only at the larger shroud hole end of the lid with the remainder being cast in the lower cost standard material. Photograph 4 provides a comparison of the level of cracking in the new castable and the previous standard material. The new castable is far less prone to cracking and thus has greater potential to remain in place around the lid holes. It is proposed that this retention of castable especially around the shroud hole has contributed the increase in life for lids being removed for bowing as shown in figure 11. This has contributed to the average life for lids to continue to increase.

Some other changes to anchor patterns and the recess of the steel shell around the small holes were also made at this time in the 700 series lid design to improve the protection of the steel shell by the castable. These changes have also contributed to the apparent improvement in life for lids being removed due to damage around the small holes.

Since figure 10 indicates a large percentage of lids are still being removed due to loss of castable from the small holes, the next stage of improvement will be to extend the higher quality stainless steel fibre addition castable over the entire lid and to monitor the performance. Hence starting another Plan-Do-Check-Act cycle to continue to build on the significant increase in life already achieved as shown in figure 15.

Photograph 4: A comparison of the cracking of the new castable (left) and old castable (right) in the same lid

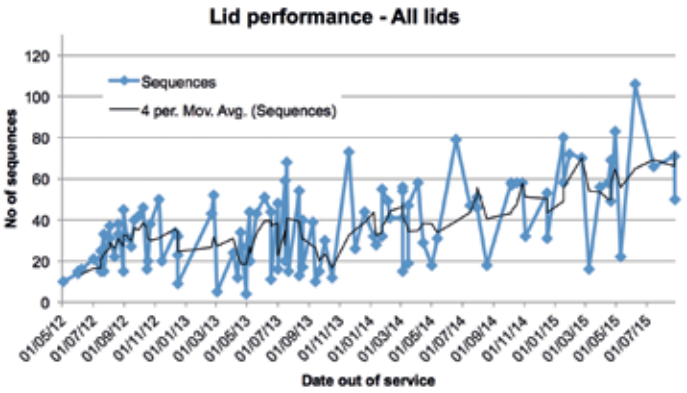


Figure 15: Run chart showing the life for tundish lids from the project start to the present time

4. Conclusion

All the key concepts of the Total Quality Control methodology were used in this improvement project. All participants in the cross functional team contributed to this improvement program. A systematic approach was used. This included utilising finite element analysis modelling, temperature measurement technology and laboratory testing to provide extra data to be used as inputs into discussion. The other key tools used included run charts and pareto analysis to establish the base data and then to monitor the performance through a number of Plan-Do-Check-Act cycles. Even though the performance has improved, monitoring is continuing which ensures the new expected performance is maintained and will also be used for further Plan-Do-Check-Act cycles. The overall improvement in lid life with the resulting cost saving and other advantages such as increased safety due to less transport and manual handling has of course been very satisfying for the key customer.

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Email: sales@dsf.co.uk

ALUMINA FIBRE PAPER 1600°C

Calderys UK Ltd
5-8 Ashfield Way, Whitehall Estate, Whitehall Road, Leeds LS12 5JB.
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Website: www.calderys.com

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Email: paul.bottomley@kerneos.com
Website: www.kerneos.com

CEMENT (AIR SETTING)

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Unit 8, Norfolk Business Park, Foley Street, Sheffield S4 7YW.
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Fax: (0114) 276 7438.

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CERAMIC FIBRE (VACUUM FORMED)

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Website: www.unifrax.com

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Faith Works, Clubmill Road, Sheffield S6 2FH.
Tel: 0114 232 4155.
Website: www.chapmanbrack.co.uk

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Website: www.dysontc.com

DEMOLITIONS

Gnat (UK) Ltd
5 Jackson Close, Olympic Way, Gallowfields, Richmond, North Yorks DL10 4FD.
Tel: 01748 826046. Fax: 01748 826056.

DIAMOND PRODUCTS

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East Goscote Ind Est, East Goscote
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Robert Lickley Refractories Ltd
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DY1 2UF.
Tel: (01902) 880123. Fax: (01902) 880019.

DOLOMITE BRICKS

Magnesita Refractories Ltd
8 Clock Court, 1 Campbell Way, Dinnington,
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Email: info@magnesita.com
Website: www.magnesita.com

DRY VIBRATION RAMMABLE REFRACTORIES

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S43 4AB, UK
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Fax: +44 (0) 1246 819573
Email: info@capital-refractories.com
Website: www.capital-refractories.com

DRYING AND CURING OF PRE-CAST REFRACTORY BLOCKS UP TO 1250°C (IN HOUSE)

Thermal Hire Ltd
Unit 12, Pagefield Industrial Estate,
Miry Lane, Wigan, Lancashire WN6 7LA.
Tel: +44 (0)1942 620062.
Fax: +44 (0)1942 620156.
Email: sales@thermalhire.com
Website: www.thermalhire.com

DRYING AND CURING OF REFRACTORIES (ON SITE)

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Miry Lane, Wigan, Lancashire WN6 7LA.
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Fax: +44 (0)1942 620156.
Email: sales@thermalhire.com
Website: www.thermalhire.com

ENDOSCOPIC AND THERMOGRAPHIC SURVEY

Chapman Brack Contractors Ltd
Faith Works, Clubmill Road, Sheffield
S6 2FH.
Tel: 0114 232 4155.
Website: www.chapmanbrack.co.uk

FIREBRICKS AND FIRECLAYS

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Baslow Road, Totley, Sheffield S17 3BL.
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Website: www.fcs-ltd.com

Gnat (UK) Ltd
5 Jackson Close, Olympic Way, Gallowfields,
Richmond, North Yorks DL10 4FD.
Tel: 01748 826046. Fax: 01748 826056.

Gunform International Ltd
33 Carsthorne Road, Carr Lane Industrial
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Fax: (0151) 632 6444.
Email: info@gunform.com
Website: www.gunform.com

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Vulcan Refractories Ltd
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Email: info@therseruk.com
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Gunform (Equipment Supplies) Ltd
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Email: info@gunform.com
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Croker Mixers - Winget Ltd
PO Box 41, Edgefold Industrial Estate, Plodder Lane, Bolton, Lancashire BL4 OLS.
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