Borates for glass technology and the vitreous industries

The global industrial minerals supplier of choice
Vitreous Enamel Supplies and Services

We Supply:

- Curran Fishscale Test Powder
- Frits and ‘Ready to Use’ Enamels for Sheet Steel and Cast Iron
- Enamel Powders for Electrostatic Application
- Small sizes of Steel for sample panels etc.
- Consultancy and Training
- Technical Service and Advice
- Certified Auditor for ISO 9001
- Approved Auditor for EEA

Chris Taylor is a Fellow of the IVE with over 35 years enamelling experience and is a lecturer for the IVE Basic Approach Course.

Technical Data received by M. & C.T. Ltd. in the course of consultancy work is and always will be treated as confidential.
Speed, sustainability, innovation, product quality and complete care for the environment.

Our clear view of the future.
THE VITREOUS ENAMELLER

ANNUAL SUBSCRIPTIONS

Members Gratis
Non Members
UK & EU £52.00
Non EU £60.00 ($117.69)

Official Journal of THE INSTITUTE OF VITREOUS ENAMELLERS

VOLUME 59 NUMBER 4 WINTER 2008

1 Editorial 163
2 Institute News 165
3 Events Calendar 166
4 Business News 169
5 Standard News 171
6 Health, Safety & Environment 173
7 Chemically Resistant Enamel 178
8 Silicate Enamels for Stainless Steels 186
9 Obituary 196

Published quarterly by:
The Institute of Vitreous Enamellers
39 Sweetbriar Way, Heath Hayes, Cannock, Staffs, WS12 2US, ENGLAND.

Tel No: 01543 450596
Fax No: 08700 941237
E-mail: info@ive.org.uk
Web: www.ive.org.uk

The Institute is not responsible for the opinions and statements appearing in The Journal

© IVE
Masters of range cooking

Vitreous Enamelled cast iron range cookers and cookware

AGA RAYBURN

www.agarayburn.co.uk

For further information and details please contact your local Aga showroom direct on 08457 125 207
EDITORIAL – AUTUMN 2008

Well, Well, It was a while ago when I said I would write this edition’s editorial. I have spent the last few days thinking how I could be positive in this current climate, and bring news to all that could cheer them up. It comes as no surprise that I can’t!!

So on a morning that Royal Bank of Scotland announces the biggest loss in corporate history, between £24 and £28 Billion, the gloom just gets worse.

I don’t understand how any company is allowed to trade at this amount of debt. I certainly don’t understand how a bank, who I thought were responsible for educating individuals and business alike, how to control there finances, are allowed to do this. How many of our business ventures are watched monitored and controlled by our Bank Managers? Most of them is the answer. Doesn’t exactly give us confidence does it.

I am a huge football fan. I believe that in Germany, football clubs are not allowed to trade at a loss, this is against league rules. They still compete at the highest levels in club football, the Champion’s League, but you don’t hear of them going into liquidation, like many low league English clubs. Surely this is a model that needs to be copied. Why should successful companies be trading against companies who can run at huge losses and bring down all around them. In this case the banks have brought down all around them, but are being protected to continue to trade by governments across the world. To add insult, the banks have said they need a 10% increase in pay, to compensate for the bonus they no longer get. What about all the people who are losing Jobs and on short time working???

Anyhow, let’s have a look a little closer home, what about our sector, Manufacturing. Well I was surprised to learn that only 15% of the UK workforce now works in manufacturing. All of the mass produced items have headed east, to use cheap labour. In the current climate, more manufacturing jobs are being lost. There appears to be little government support for these jobs, but the government continues to push money into the banks, to ensure their survival. While I think it is wrong for the government to try to support industry, like the car industry, I find it hard to understand why they support the banking system.
I am told that the manufacturing that is still in the UK is innovative, specialised, hi-tech. This is the way our government want manufacture to be. So where does this leave the traditional industry that is still left in the UK. Well I think traditional industry will cling onto a few niche markets, but will continue to move east. I used to think that a lot of our skill base would follow and we would find ourselves working around the world. While this may be the case for the specialised few, it certainly will not be true for the masses. If you take a look at China, they recently reported that 20 million people were returning to work after the Chinese New Year, to find that their companies had no orders; it is indeed a worldwide recession. It is also worth noting that each year 6 million students pour out of universities in China and into the job markets, armed with a degree and looking for work. Not going to be that many opportunities for UK residents working abroad.

So, finally, what about Vitreous Enamelling, well it has already happened, most of the high volume manufacture has gone east. This is putting specialist products under pressure for price and forcing down the selling price of those who are still producing in this country. As UK manufacturers come under pressure from the cheaper price structure, less vitreous enamel is produced within the UK and manufacturing and Vitreous Enamel alike continue to decline. I see no sign of the overall use of Vitreous Enamel increasing within the UK; it can only continue to move to cheaper manufacturing countries. Vitreous Enamel is too small an industry, if only 15% of us work in manufacture, certainly well below 0.5% work in Vitreous Enamel.

So the gloom goes on. What is our future? Well I am no Economist, certainly not a politician, but unless there is a focus on increasing manufacture within this country, then the future remains bleak. People say that we will come out of this recession of course we will, but manufacture will continue to decline until there is leadership within this country who want it to prosper.

I wish all of you success over the coming months, it is certainly going to be a very tough year to survive, but let’s hope better times will soon be on the horizon. For those of us who fail to emerge there will be many life changes. Unless you are a bank of course, where you will be rescued and things will remain the same, possibly with a pay increase or at least a bonus payment.

MARK NUTTING
Kingfisher Enamelling
IVE Council Member
CANCELLATION OF THE BASICS APPROACH COURSE 20\textsuperscript{TH} OF APRIL 2009

It is with regret that the Institute has to announce the cancellation of this year’s Basics Approach Course for Vitreous Enamelling, which was due to commence on the 20\textsuperscript{th} of April 2009.

Insufficient interest in this year’s course has made it unviable. The Institute would like to apologise for any inconvenience caused as a result of the cancellation.

IVE MEMBERS ZONE

The Member’s Zone of the IVE website is now live. To access the Zone, click on the link on the left-hand side of the homepage and then select ‘IVE and VEA Members Zone.’ The Member’s Zone is only available to IVE members. Please contact the IVE for access codes.

NEW MEMBER

We would like to welcome the following New Member:

\textbf{Nicala Ind. Co (PVT)}

16km Karaj-Qazvin Freeway
Kamalshahr
IRAN

\textit{Representative: Davoud Pira}

The company profile for Nicala Ind. Co (PVT) can be found on the IVE website: http://www.ive.org.uk/map/companies/nicala.htm#profile
03 March 2009 - 05 March 2009
4th Indian Ceramics 2009
Venue: Ahmedabad, INDIA
Contact: Kevin Hudson, Exhibition Director
Tel: +44 (0)7967 278321
Email: kevin@gattacaltd.com
www.indian-ceramics.com/4th_indian_ceramics.html

10 March 2009 - 13 March 2009
BLECH Russia’09 (Exhibition for Sheetmetal Working)
Venue: St Petersburgh, RUSSIA
Contact: Susanne Bauberger, Event Director
Tel: +44 (0)1727 814400
Email: info@blechevents.com
Web:www.blechrussia.com/english/

18 March 2009 - 21 March 2009
China Kitchen Furniture and Appliance Fair 2009
Venue: Guangzhou, CHINA
Contact: Ms. Evangeline Ho
Tel :+ 65 6500 6719
Email:e.ho@koelnmesse.com.sg
www.koelnmesse.cn/fair/New_CKFA_E/index.asp

10 May 2009 - 17 May 2009
International Consumer Goods and Technologies Fair 2009
Venue: Plovdiv, Bulgaria
Web:www.fair.bg/en/events/spring09.htm
E-mail: exhibitions@fair.bg

31 March 2009 - 2 April 2009
European Coatings Show 2009
Venue: Nurnberg, GERMANY
Contact: Ulla Kallert, Project Manager
Tel: +49 (0) 9 11.86 06-81 28
www.european-coatings-show.com/en/default.ashx
Email:isabell.dauer@nuernbergmesse.de
THE VITREOUS ENAMELLER

19 April 2009 - 21 April 2009
CRU’s 15 World Steel Conference
Venue: Vienna, AUSTRIA
Contact: Glenn Cooney, Senior Marketing Manager
Tel: +44 20 7903 2056
Email:glen.cooney@crugroup.com
Web:www.crugroup.com/Events/CRUEvents/WorldSteel/Pages/worldsteel.aspx

30 April 2009 - 10 May 2009
Kitchen, Bathroom and Electrical Household Appliances (Paris Trade Fair)
Venue: Paris, FRANCE
Conact: Immeuble le Wilson
Tel: +33 (0)1 49 68 51 00
Email:info@comexposium.com
Web:www.foiredeparis.fr/index.php?id=5457&L=3

28 April 2009 - 29 April 2009
Far East Steel Conference
Venue: Beijing, CHINA
www.metalbulletin.com/events/Details/Intro.aspx?
EventID=812

04 May 2009 - 07 May 2009
AISTech 2009: The Iron & Steel Technology Conference and Exposition
Venue: St. Louis , USA
Contact:Bill Albaugh
Tel: (724) 776-6040
Email:balbaugh@aist.org
Web:www.aist.org/

12 May 2009 - 13 May 2009
Measurement and Testing of Coatings
Venue: Birmingham, UK
Contact: Janet Saraty, Events Manager
Tel: + 44 (0)20 8487 0811
Email: conference@pra-world.com
Web: www.pra-world.com/conferences/measurementandtesting/
23 May 2009 - 28 May 2009  
World Tunnelling Congress and  
35th ITA General Assembly  
Venue: Budapest, HUNGARY  
Tel: +36 1 214 7701  
Email: chairman@wtc2009.org  
Web: www.wtc2009.org/00entry.htm

24 May 2009 - 26 May 2009  
40th Steelmaking Seminar - International  
Venue: Sao Paulo, BRAZIL  
Contact: Margareth Nunes  
Tel: +55 11 5534 4333  
Email: margareth.nunes@abmbrasil.com.br  

--ooOoo--
BRIC MANUFACTURERS FEELING THE PINCH

The impact of the global slowdown is also becoming increasingly evident in emerging economies – including the manufacturing powerhouse of the BRIC (Brazil, Russia, India, China) economies. Accountants and business advisers BDO Stoy Hayward say that while the UK’s GDP growth is expected to fall 1.2 percentage points in 2009, Brazil’s is tipped to fall by 4.6 percentage points, Russia by 4.3, India by 2.7 and China by 1.8 percentage points. Head of manufacturing at BDO Tom Lawton, says: “At the start of the financial crisis in the West, many commentators thought that the large emerging economies such as China and India would be able to de-couple from the recession and continue to grow at similar levels to recent years. This has not proved to be the case and the BRIC economies have been severely hit by the recession, particularly in some of the key manufacturing regions.” Citing the example of Guangdong, a rich southern province of China close to Hong Kong and a major manufacturing base for electronic products, toys, textiles and plastics, BDO China expert Katherine Liu points out that growth in exports from the region have slowed dramatically from 22% in 2007 to less than 6% in 2008. However, China has big plans for manufacturing in Guangdong, Liu says. “The Pearl River delta area of the province looks likely to be turned into a technological hub with the Chinese National Development and Reform Commission releasing plans this month for the region to become a significant innovation centre by 2020.” BDO observes that the investment by China in this region is impressive: Around 100 state laboratories for engineering innovation and research and development will be established in next three years and the goal is that by 2012 there will be three to five industrial clusters powered by high-technology that will generate more than $14.60 billion in industrial output in total. By 2012, R&D expenditure will account for 2.5 per cent of the region’s annual GDP, and the proposal sets out plans to improve intellectual property rights protection and make finance more accessible for companies occupied in technological development. “China is here to stay as one of the world’s great manufacturing centres. It still offers the UK’s manufacturers great advantages in terms of a large and relatively well skilled labour force and is a huge market for sales if companies are able to position their products successfully in China,” Lawton believes. “Doing business in
China has always been challenging and is perhaps more demanding today as a result of the recession. But it is simply too large to be ignored by UK manufacturers – and we should embrace the developing and changing opportunities it provides.”

Source: http://www.worksmanagement.co.uk
20/02/2009

ANNUAL MANUFACTURING JOB LOSSES TIP OVER 100,000 MARK

New UK labour market statistics published today (11 February) showed manufacturing jobs at a new low but across the economy unemployment stayed stubbornly below the two million widely predicted by pundits. Figures from the Office for National Statistics revealed there were 2.8 million employee jobs in the manufacturing industries during the three months to December 2008, down a startling 101,000 on a year earlier. Across the economy as a whole, the jobless total was 1.97 million, up 146,000 on the three months to September and 369,000 higher than a year ago. Meanwhile, a TUC analysis published today shows that while UK unemployment is lower than the European average it is now increasing twice as fast as the average across Europe. The UK has one of the lowest unemployment rates in Europe (6.3%, compared to 7.7% across Europe), but between December 2007 and October 2008, the UK had the third sharpest increase in unemployment (one percentage point), behind Spain (4.4 percentage points) and Ireland (2.7 percentage points).

Source: http://www.worksmanagement.co.uk
11/02/2009
STANDARD NEWS

WINTER 2008

In the Summer 2008 edition of The Vitreous Enameller I reported on three transposition of ISO to EN ISO standards

- prEN ISO 13805 Vitreous and porcelain enamels – Determination of the adhesion of enamels on aluminium under the action of electrolytic solution (spall test) (ISO 13805:1999)
- prEN ISO 13807 Vitreous and porcelain enamels – Determination of crack formation in the thermal shock testing of enamels for the chemical industry (ISO 13807:1999/Cor 1:2000)

These documents were approved in November 2008 and were published and endorsed in the UK as EN ISO’s in January 2009.

The transposition of EN to EN ISO standards has progressed further and the following standards have been published.

- ISO 28706-1 Vitreous and porcelain enamels – Determination of resistance to chemical corrosion – Part 1: Determination of resistance to chemical corrosion by acids at room temperature.
- ISO 28706-2 Vitreous and porcelain enamels – Determination of resistance to chemical corrosion – Part 1: Determination of resistance to chemical corrosion by boiling acids, neutral liquids and/or their vapours.

• ISO 28721-2 Vitreous and porcelain enamels – Glass-lined apparatus for process plants – Part 2: Designation and specification of resistance to chemical attack and thermal shock.


As reported in the Winter 2008 edition of The Vitreous Enameller on standards with a similar status the ISO standards above will not be adopted in the UK as it is our intention to progress these into EN ISO standards. Once this process is complete the above standards will be adopted and will replace the currently endorsed EN 14483-1, EN 14483-2, EN 14483-4, EN 14483-5, EN 15159-1, EN 15159-2 and EN 15159-3.

Other recent activities have included the following:

• EN 15711 Vitreous and porcelain enamels – Glass lined flanged steel pipes and flanged steel fittings – Quality requirements. The UK voted positively at the formal vote stage and the standard has been published and adopted in the UK.

• prEN 15286 Vitreous and porcelain enamels – Terminology. The UK have voted positive on the draft for approval to launch formal.

I would like to inform readers that further the IVE has supported the request from STI/36 (BSI technical committee on vitreous enamel coatings) to become a member of the mirror US technical committee. I am therefore pleased to inform you that the IVE has become a member of ASTM B08.12 – Materials for Porcelain Enamel and Ceramic-Metal Systems. Membership of the committee will ensure we have visibility of the standards being developed in the US.

Finally, to assist readers we intend to provide an updated list of current vitreous enamel related standards in the next edition of Standards News and I am sure you will find the information very useful.

SAQLAIN ALI
Chairman STI/36
IVE Council Member
MEPS BACK BAN ON TOXIC SUBSTANCES IN ECO-LABEL PRODUCTS

The European Parliament’s Environment Committee has backed an amendment to the proposed regulation to revise the European Union eco-labelling scheme that would prevent the label being awarded to products containing “substances or preparations classified as very toxic, toxic, dangerous to the environment, carcinogenic, mutagenic or toxic for reproduction”. It would also broaden the ban to include substances that are persistent, bioaccumulative and toxic (PBTs), or very persistent and very bioaccumulative (vPvBs), or those for which there is scientific evidence of probable serious effects which give rise to an equivalent level of concern. However, the amendment adds that “for specific categories of goods, for which there are no equivalent alternatives without such substances or preparations, and which otherwise would have a significantly higher overall environmental performance compared with other goods of the same category, the [European] Commission may adopt measures to grant derogations.” Full details of the compromise amendments are available at: http://www.europarl.europa.eu/meetdocs/2004_2009/documents/dv/envi_20090216_ecolabelcompr/envi_20090216_ecolabelcompre.pdf

Source: http://www.britishsafetycouncil.org
20/02/2009

IOSH 2009 CONFERENCE AND EXHIBITION

The Chief Executive of the Health and Safety Executive (HSE), Geoffrey Podger, is to discuss the future of health and safety regulation at the 2009 Institution of Occupational Safety and Health (IOSH) Conference and Exhibition, which is due to take place from 17 to 18 March 2009 at the BT Convention Centre in Liverpool. The theme of the event is “Health and Safety: Fresh ideas — practical solutions” and besides Geoffrey Podger, another key speaker from the health and safety watchdog on 17 March will be Eddie Morland, Chief Executive of the Health and Safety Laboratory. The discussion
THE VITREOUS ENAMELLER

will be chaired by Channel 4 Newscaster Krishnan Guru-Murthy and the event will also feature, as a guest speaker, 2008 Olympic Champion canoeist Tim Brabants. Organised by IOSH, the theme of the two-day conference and exhibition will focus on sharing best practice to reduce risks, minimise workplace injuries and illnesses, and keep costs down. Delegates will be able to choose from 30 conference sessions featuring more than 60 speakers sharing their frontline knowledge and experience. Expert guidance will be on offer covering a broad range of topics including; culture and behaviour, regulatory and legal changes, risk management in practice, work health and wellbeing, emerging risks. Further information on the event can be found at www.ioshconference.co.uk.

Source: http://www.britishsafetycouncil.org
09/02/2009

NEW GAS SAFE REGISTER

The Health and Safety Executive (HSE) recently issued a reminder regarding changes to the gas installer registration scheme in Great Britain. The scheme currently operated by CORGI will be replaced on 1 April 2009 by the new Gas Safe Register™ system, to be operated by Capita. The Gas Safe Register will be the only gas installer registration scheme approved by the HSE from 1 April under the Gas Safety (Installation and Use) Regulations 1998. All gas installers wanting to undertake domestic gas work in Great Britain from 1 April will need, under those regulations, to be registered with the scheme in order to be able lawfully to carry out any work on gas fittings, which includes gas appliances. The Gas Safe Register™ will maintain an up-to-date register of gas installers who are qualified to install or repair gas fittings and appliances. It will also have systems in place to check the competence of gas installers, inspect their work and to deal with complaints about unsafe gas work. The operation of the Register will be overseen by the HSE as the regulator with responsibility for gas safety. Therefore, from 1 April 2009, in order to ensure that gas installers are lawfully able to carry out the gas work, domestic users of gas should ask for a Gas Safe Registered Engineer and not any other. The CORGI register will no longer count for those purposes.

Source: http://www.britishsafetycouncil.org
06/02/2009
LOCAL EXHAUST VENTILATION

The British Occupational Hygiene Society (BOHS) has recently announced the launch of a local exhaust ventilation (LEV) awareness course, aimed at controlling the exposure of staff to hazardous dusts and fumes. The BOHS says that every year, many employees are made ill as a result of exposure to hazardous dusts and fumes that have not been adequately controlled, yet LEV is — or should be — an important part of many exposure control strategies. The BOHS course is aimed at buyers and owners of LEV systems, ie employers, but also facilities managers, works managers, health and safety managers, and union health and safety representatives. The BOHS pointed out that the Health and Safety Executive (HSE) recently published new guidance on LEV in the form of HSG258: Controlling Airborne Contaminants at Work — A Guide to Local Exhaust Ventilation, and HSE inspectors are planning a new campaign of checking workplaces for appropriate and effective LEV systems. In recent years, the BOHS has also developed two new qualifications for testers and designers of LEV systems (referenced P601 and P602, respectively) and the new HSE guidance refers to both of these as one measure of competency in these areas. The BOHS has produced a short video offering further information on the BOHS awareness course (see www.bohs.org/lev/intro.swf).

Source: http://www.britishsafetycouncil.org
05/02/2009

SKIN DISEASES ARE SECOND MOST COMMON WORK-RELATED HEALTH PROBLEM IN EUROPE

The European Agency for Safety and Health at Work (EU-OSHA) published a report on skin diseases related to work in the European Union (EU): Occupational Skin Diseases and Dermal Exposure in the European Union (EU-25): Policy and Practice Overview. The report, based on analysis of information from throughout the EU, found that skin diseases are the second most common work-related health problem in Europe. They represent more than 7% of all occupational illnesses. The report presents the principal policies relating to the recognition and recording of skin diseases, as well as the recognition, assessment and control of dermal exposure to chemical, biological and physical risk factors in the EU Member States. The report concludes that there is a clear, urgent and general need for a unifying European framework of criteria for recognition of occupational diseases. Furthermore, much work is still needed...
to raise employees’ awareness and keep doctors up to date with current developments in this field. It notes that there is no scientific method to measure the level of the body’s exposures to risks via dermal contact and their physiological consequences. The report is available at http://osha.europa.eu/en/publications/reports/TE7007049ENC_skin_diseases

Source: http://www.britishsafetycouncil.org
05/02/2009

FLASH-BANG SCIENCE BACK IN THE CLASSROOM

The Chair of the Health and Safety Executive (HSE), Judith Hackitt CBE, recently urged school science teachers to stop using a fear of breaking health and safety rules to prohibit exciting and engaging practical classroom demonstrations. In order to demonstrate the concept, Ms Hackitt illustrated to a classroom of children the principles of combustion by setting her hands alight — safely. Ms Hackitt and Dr David Brown, Chief Executive of the Institution of Chemical Engineers (IChemE), performed “The Flaming Hands” science demonstration, one of IChemE’s safe, risk-assessed “Top 10 Flash-Bang Demos” in a bid to encourage more engaging, hands-on science lessons in schools. By releasing methane into a bubble mix solution of soap solution, glycerol and distilled water, they were able to set alight the bubbles on their hands, safely displaying the scientific principles of combustion. The demo campaign was launched in October 2008 after Schools and Learning Minister Jim Knight called for “more flash-bang science in the classroom”. Since its launch, there have been more than 11,000 downloads of demonstration videos and more than 8000 downloads of the supporting instruction sheets, which encourage science teachers to add greater practical focus to their lessons. Ms Hackitt said, “I fully support IChemE’s and Government’s initiatives to bring science to life by integrating these sort of classroom demonstrations that make children excited about science — “flash-bang” makes it enjoyable and memorable … Classroom demos can be spectacular and safe, and here are 10 of them that can be easily downloaded and put into lessons, as hundreds of other teachers have done because they’ve already been fully risk-assessed. So, no excuses!” The experiments can be accessed at www.whynotchemeng.com

Source: http://www.britishsafetycouncil.org
04/02/2009
BRITAIN WARNED OVER AIR QUALITY

The European Commission has warned Britain that it could face court action if it continues to fail to meet EU air quality standards with respect to airborne particles. The particulates are of concern because they can cause asthma, heart problems, lung cancer and even premature death. The principal sources of these particulate emissions are industry, transport and domestic heating. The new European directive on air quality came into force last year. Member States were given a limit period of “extra time” to meet the air quality standards which have been in force since 2005. However, the European Environment Commissioner, Stavros Dimas, warned the UK that, whilst the new directive made provision for time extensions for compliance, subject to certain conditions being met, this did not mean that measures to reduce emissions could be delayed. Furthermore, in situations where time extensions are not applicable, there must be full compliance with the air quality standards. A spokesman for the Department for Environment, food and Rural Affairs said that, if the UK was granted an extension, it would have until 2011 to meet the air quality criteria. He also expressed the confidence that there would be no breaches by then, because the measures already in place will have taken effect. So far, only two Member States are within the limits on all criteria, namely Luxembourg and Ireland. The European Commission has given a strong warning to the others that any flexibility with respect to timescales will be complemented by strict enforcement action.

Source: http://www.britishsafetycouncil.org
03/02/2009

--ooOoo--
CHEMICALLY RESISTANT ENAMEL

The following paper by Eckhard Voß* was presented at the XXI International Enamellers Congress, Shanghai, China - 2008

* Eckhard Voß (Dipl.-Ing.), Wendel GmbH, Am Güterbahnhof, 35683 Dillenburg, Germany

1. INTRODUCTION

Especially at low firing temperatures, it is difficult to achieve a good resistance against acids. When the firing temperature is approximately 700°C, the possibilities are limited. The development presented in the following lecture provides a simple method to improve the resistance of low melting enamel. I would like to give an overview of various quartz modifications. The significant improvement of the chemical resistance of the enamels is confirmed by boiling tests. The application of the new batch compositions is demonstrated using a series of examples.

2. IMPROVEMENT OF THE CHEMICAL RESISTANCE

To reach the optimum possible chemical resistance, enamels with appropriate composition are selected. Two possibilities to improve the chemical resistance and their related disadvantages are given in Figure 1.

1. An increase of the resistant frit portion has the following disadvantages:
   1. Higher viscosity
   2. Bad wetting
   3. The enamel does not burn out thoroughly
   4. Higher price with equal viscosity

2. An increase of the quantity of resistant mill batch additives has the following disadvantages:
   1. Matt surfaces
   2. Altered colour
   3. Poor adhesion

Fig. 1
The chemical resistance of enamels is determined mainly by the content of quartz.

Enamels with a SiO₂ content higher than 60% will become accordingly viscous and are difficult to process. The firing temperatures are above 850°C and closed, flawless direct-on enamelling is hardly possible.

To achieve better processability, these enamels may have a higher alkali content. Lithium, in particular, enhances the chemical resistance and permits a lower firing temperature. As a side effect, however, the enamels become much more expensive.

To regulate the firing behaviour and the chemical resistance, it is a common practice to influence the properties by means of batch additives. The most frequently used additive is quartz in various grain sizes. Zirconium silicate and various other silicate compounds are also used.

These additives do not only make the enamels harder, they also change the brilliance and the colour.

With direct-on enamels, the additives also cause impairment of the adhesion.

### 3. MODIFICATIONS OF QUARTZ

The normal fireproof batch additive is quartz in the various grain sizes. Quartz is used to improve the chemical resistance and to control the firing behaviour.

If the enamels are fired at low temperatures, for example, 700°C, there is only a limited choice of enamel frits with high chemical resistance. By addition of quartz, the enamels will become too hard quite easily.

In individual cases, solid colloidal silicon dioxide is added to the enamels. With majolica enamel, in particular, solid colloidal silicon dioxide is used to improve the chemical resistance. These fine quartz types also feature a certain suspension and set-up behaviour and change the rheologic properties. The maximum amount of additive is 4%. Higher quantities cause surface flaws and make the enamel surface matt. The specific weight of these silicon dioxides is very low. The high volume of these powders also causes problems during mill filling.
THE VITREOUS ENAMELLER

In order to avoid the disadvantages mentioned above, the use of liquid colloidal silicon dioxide in enamels was investigated.

For comparison, tests using the 3 quartz modifications – fine quartz, solid colloidal silicon dioxide and liquid colloidal silicon dioxide - were made.

The mean grain size, the specific surface area (BET – Brunauer, Edward Teller) and the density are given in the table in Figure 2.

<table>
<thead>
<tr>
<th></th>
<th>Quartz W 500</th>
<th>Solid colloidal silicon dioxide</th>
<th>Liquid colloidal silicon dioxide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean grain size nm</td>
<td>13,000</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>Specific surface area m²/g</td>
<td>1.36</td>
<td>110</td>
<td>330</td>
</tr>
<tr>
<td>Density g/cm³</td>
<td>2.63</td>
<td>0.05</td>
<td>1.21</td>
</tr>
</tbody>
</table>

As shown in the table, liquid colloidal silicon dioxide has the smallest mean grain size. Compared to the finest quartz quality, the mean grain size of liquid colloidal silicon dioxide is by 1000 times lower.

The specific surface area is by 200 times larger compared to the one of fine quartz.

The density of the 3 quartz modifications varies widely.

Due to the large specific surface, in particular, a very high reactivity must be expected.

As shown in Figure 3, the diverging density has a considerable effect on the volume of the substances.

With an equal SiO₂ quantity, the volume of the solid nanoscale SiO₂ is very big. The inclusion of such a volume into the enamel batch will result in a change of the rheological properties. The addition of quartz and liquid colloidal silicon dioxide does not cause any problems.

---

Fig. 2

180
4. ENAMEL BATCHES WITH LIQUID COLLOIDAL SILICON DIOXIDE

Due to these properties of liquid colloidal silicon dioxide, the product can be used for enamel batches very easily. The advantages of liquid nanoscale silicon dioxide in the enamel batch are listed in Figure 4.

Liquid nanoscale silicon dioxide offers the following advantages:

- The portion can be calculated as a batch raw material
- High chemical resistance at low firing temperatures
- Smooth surfaces
- Hard biscuit
- The surface remains wet during a longer time
- Easy improvement of the resistance against acids
Due to the high reactivity of the liquid nanoscale silicon dioxide, the quartz content of the enamel from the enamel recipe can be applied to the mill batch. The quartz from the raw material recipe can be used as a mill batch.

The quartz content and the water from the liquid colloidal silicon dioxide can be calculated and included into the batch.

Consequently, it is possible to use softer enamels and to fire them at lower temperatures. The chemical resistance corresponds to the one of considerably harder enamels.

Due to the low quantity of batch additives, very beautiful surfaces with high brilliance and smoothness are produced.

Portions of liquid colloidal silicon dioxide in the mill batches make the biscuit hard and touchproof. It is also possible to use the product in the ground enamel for the 2c/1f coating. This offers the advantage that the surfaces remain wet during a longer time.

The advantages become particularly obvious when considering the chemical resistance. In normal enamel batches, the mill quartz can be replaced by liquid nanoscale silicon dioxide. This is a simple method to improve the quality significantly.

5. COMPARISON OF CHEMICAL RESISTANCES

Equal portions of 20 parts of quartz of various modifications were milled into a soft frit combination. For the investigations, fine quartz, nanoscale solid quartz and nanoscale liquid quartz were milled into a soft enamel with equal portions of SiO₂. The test plates were burned in at 700 °C during 6 minutes and tested in compliance with EN 14483-2-10. Testing according to EN 14483-2-10 is done using 6% citric acid boiling over 2.5 h.

Figure 5 very clearly reveals a significant improvement of the acid resistance due to the use of liquid colloidal silicon dioxide.
The enamel degradation is 38.0 g/m² without any additive at all, 10.6 g/m² with fine quartz, 8.2 g/m² with solid nanoscale quartz and 0.7 g/m² with liquid nanoscale quartz.

On the picture with liquid colloidal silicon dioxide, the homogeneous enamel structure is demonstrated very beautifully. On the picture relating to the solid colloidal silicon dioxide test, the surface is less homogeneous and reveals areas in which the citric acid has caused noticeable corrosion. Due to the large volume of solid nanoscale silicon dioxide, it is not possible to accomplish a homogeneous surface.

The liquid, nanoscale SiO₂ integrates itself into the enamel structure very homogeneously and improves the acid resistance considerably.

**Figure 6** additionally confirms the improvement of the chemical resistance using the boiling test according to EN 14483-2-13. The boiling test according to EN 14483-2-13 is carried out using water over 48 h.
After adding liquid colloidal silicon acid, the water resistance increases clearly. The picture shows very clearly that the liquid nanoscale silicon dioxide is included homogeneously into the enamel batch. The behaviour of fine quartz and solid nanoscale silicon dioxide relating to water resistance is equivalent. There are no differences in the degradation during the vapour phase due to the different quartz modifications.

### 6. SUMMARY

The table in Figure 7 gives a summary of the advantages of liquid nanoscale silicon dioxide.

<table>
<thead>
<tr>
<th></th>
<th>Liquid phase g/m²² day</th>
<th>Vapour phase g/m²² day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enamel without additive</td>
<td>4.8</td>
<td>26.0</td>
</tr>
<tr>
<td>Enamel with quartz</td>
<td>1.6</td>
<td>20.8</td>
</tr>
<tr>
<td>Enamel with solid colloidal silicon dioxide</td>
<td>1.7</td>
<td>18.8</td>
</tr>
<tr>
<td>Enamel with liquid colloidal silicon dioxide</td>
<td>0.2</td>
<td>21.9</td>
</tr>
</tbody>
</table>

**Fig. 6**

After adding liquid colloidal silicon acid, the water resistance increases clearly. The picture shows very clearly that the liquid nanoscale silicon dioxide is included homogeneously into the enamel batch. The behaviour of fine quartz and solid nanoscale silicon dioxide relating to water resistance is equivalent. There are no differences in the degradation during the vapour phase due to the different quartz modifications.

**6. SUMMARY**

The table in **Figure 7** gives a summary of the advantages of liquid nanoscale silicon dioxide.

- Easy improvement of chemical resistance
- Ideal for enamels with low firing temperature
- Quartz from the enamel recipe can be added using nanoscale SiO₂
- The mill water is added using nanoscale SiO₂
- After application, the surface remains wet during a longer time
- Homogenous enamel structure after firing

**Fig. 7**
An improvement of the chemical resistance is achieved easily.

The usual quartz content of the mill batches can be replaced by liquid colloidal silicon dioxide simply by calculating the solid components. This does not influence the rheologic properties. A considerable improvement of the acid resistance, in particular, is obtained. The brilliance of the enamel is increased as well.

Very good suitability for enamels with low firing temperature.

At low firing temperature, fireproof batch additives tend to dissolve poorly in the enamel matrix. The melting temperature of the fireproof substances is far higher than the firing temperature of the enamels. For this reason, the enamel dissolution capacity is very low at low firing temperatures. Due to a particle size of 8 nm, however, liquid nanoscale silicon dioxide dissolves excellently in the enamel, also if the firing temperature and firing time are low.

Quartz from the enamel recipe can be added using liquid nanoscale silicon dioxide.

Hard chemically resistant enamels can be softened by reducing the quartz content in the enamel recipe. The reduced quartz content is added from the mill batch subsequently. Due to the nanoscale silicon dioxide particles, an enamel structure equivalent to the hard enamel type made from the melt is produced.

The mill water is added using the liquid nanoscale silicon dioxide.

As the mill batches all contain different quantities of water, the water from the liquid colloidal silicon dioxide can be taken into account as mill water when calculating. The rheologic properties are not changed due to the additive.

After application, the surface remains wet during a longer time. Due to this property, the ground coat of enamel can be processed with liquid colloidal silicon dioxide using the 2coat/1fire method. The processing quality is improved considerably.

Homogeneous enamel structure after firing.

Despite the short firing time and the low firing temperature, the nanoscale structure of the liquid silicone dioxide is integrated perfectly into the enamel matrix.

In summary, it can be said that liquid nanoscale silicon dioxide opens a large variety of possibilities for easy enhancement of the enamel properties.
SILICATE ENAMELS FOR STAINLESS STEELS

The following paper by Bianca Heid, Günther Heinz Frischat and Peter Hellmold* was presented at the XXI International Enamellers Congress, Shanghai, China - 2008

* Institute of Non-Metallic Materials, Research group for Glass and Glass Technology Clausthal University of Technology, Zehntnerstraße 2a, D-38678 Clausthal-Zellerfeld, Germany

ABSTRACT

For the development of enamels with different properties an experimental design was used in which the composition of different raw materials was varied. The enamels were applied on three stainless steel grades with a spray gun and fired at 820°C. Different pre-treatment methods (degreasing, pickling and blasting) for stainless steel sheets were used to find the method which leads to the best enamel adhesion on stainless steel. Blasting with corundum results in sufficient adhesion for all enamelled sheets. The analysis of statistical design shows the influence of the enamel raw materials on the different properties measured (e.g. chemical stability, coefficient of thermal expansion). The reasons for the limits of applicability of differently composed enamels on stainless steel substrates with defined coefficients of thermal expansion are discussed. Furthermore, colouring possibilities of direct-on enamels for stainless steel are mentioned.

INTRODUCTION

Enamelling of stainless steel seems to be an unnecessary rise in cost of an already expensive product. In many cases stainless steel is used because of its higher application temperature and its higher chemical stability. However, extreme conditions (e.g. contact with acid condensates or gases under oxidising conditions at high temperatures) can cause a measurable corrosion of the stainless steel.
Enamels provide an additional corrosion protection and increase the product lifetime of the equipment for the chemical industry. Another advantage is protection of the environment against toxic components released from the alloy (e.g. Ni or Cr). This is of special importance for pharmaceutical, food and housewares industries.

Furthermore, an enamelled stainless steel surface may avoid uncontrolled catalytic effects which can take place in chemical syntheses by contact of the alloying elements (Ni, Mo, W) with the reaction mixture. Other advantages are a better hygienic behaviour concerning the adhesion of spores and sufficient cleaning possibilities and the opportunity of design in terms of colour, e.g. for tubes.

However, chrome-nickel steel is difficultly to be enamelled because of its high coefficient of thermal expansion (CTE). This fact can cause high stress in the enamel coat so that the enamel can chip off. Microstructural changes during heating can cause poor adherence of the enamel on chrome steel.

The main research objective of this work was the systematic development of single-layer enamels for stainless steel substrates with CTEs of $122 \ldots 193 \cdot 10^{-7}$ K$^{-1}$, with chemical and optical properties comparable to standard quality enamels.

A secondary objective was to examine the colouring possibilities of such enamels, based on previous results \cite{3}.

To adapt enamels on stainless steel substrates, different ways of solution were possible. The following factors had to be varied:

- metal substrate
- metal pre-treatment
- enamel composition (chemical components and phases)
- baking conditions (temperature, time)
- coating (one-coat or two-coat enamel).

A variation of the metal substrate could only be realised by a selection of different commercial types of stainless steels, while a stepwise changing of composition of the stainless steels was not possible in this project. Different methods of pre-treatment have been tested. The sheets were pre-treated by degreasing, pickling or blasting. Baking conditions were at 820°C for 4.5 min and a one-coat enamel was used. The chemical composition of the enamel was varied by a statistical design of experiments.
STATISTICAL DESIGN OF EXPERIMENTS

The method of statistical design of experiments is used to reduce the number of experiments and to still get more information per test series \(^6\), \(^7\).

Classical test series only change one parameter per experiment (One-factor-at-a-time). Thereby many individual tests are needed to cover all test alternatives and to interpret certain differences in the results. In contrast to this, by using the method of statistical design of experiments, several parameters can be changed at the same time. Therefore, less individual tests are needed and more data can be obtained for every test result (Fig. 1).

With the aid of suitable software, a mathematical correlation can be established between parameters and target factors, thus objective statements about the influence of these parameters can be made. Furthermore, optimised enamel compositions can be calculated if the composition is within the area of investigation. Extrapolations beyond are not allowed.

Varied factors for experimental design were the raw materials quartz, soda, borax, barium carbonate and lithium carbonate. Constant factors were calcium carbonate, manganese oxide and cobalt oxide (Table 1). The target factors investigated were the coefficient of thermal expansion, softening point, glass transition temperature, chemical stability and visual appearance of the enamel surface and gloss.

---

\(\text{Fig. 1: Difference between classical and statistical design of experiments}\)
The composition of the frit, which represents the basis of the statistical design of experiments, is listed in Table 2.

Table 2: Composition of the basic frit according to HILLER [2]

<table>
<thead>
<tr>
<th>Oxide</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂</td>
<td>57</td>
</tr>
<tr>
<td>Na₂O</td>
<td>22</td>
</tr>
<tr>
<td>B₂O₃</td>
<td>14</td>
</tr>
<tr>
<td>CaO, MnO, CoO</td>
<td>7</td>
</tr>
</tbody>
</table>

Samples and sample preparation

Three different grades of stainless steels were used (Table 3).

Table 3: Coefficients of Thermal Expansion of the stainless steels used

<table>
<thead>
<tr>
<th>Sample number</th>
<th>E1</th>
<th>E2</th>
<th>E3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades</td>
<td>Ferritic</td>
<td>Duplex</td>
<td>Austenitic</td>
</tr>
<tr>
<td>CTE₂₀⁻₃₇⁵°C [10⁻⁷K⁻¹]</td>
<td>122</td>
<td>151</td>
<td>193</td>
</tr>
</tbody>
</table>

The stainless steel E1 was ferritic steel with a low CTE, E2 was Duplex steel with a higher CTE, and E3 was austenitic steel with a very high CTE.

For sample preparation, different steps were necessary. First, the raw materials had to be weighed and mixed for producing enamel frits. This mixture had to be melted in a fireclay crucible at 1300°C and quenched then in cold water. The stainless steel plates for the experimental design were pretreated by blasting them with corundum. The enamel slurry was made by grinding the frits with water and mill additions, and then it was applied with a spray gun on the stainless steel sheets. These enamelled sheets were dried and fired then at 820°C for 4 min.
RESULTS

Influence of pre-treatment of stainless steel

The following different pre-treatment possibilities were tested to elucidate their influence on the adhesion of enamels on stainless steel (q.v. [2]):

- degreasing
- pickling with hydrochloric acid
- blasting with corundum.

Fig. 2 (opposite) shows the effect of the pre-treatment methods on the enamel adherence on stainless steel.

The experiments of the different pre-treatment possibilities for stainless steel sheets show that corundum blasting of the sheets achieves the best adhesion of enamel on stainless steel. The enamel adheres well on all three types of stainless steel. After degreasing and no additional adhesive oxide in the frit, the enamel only adheres on chrome steel, which has a low coefficient of thermal expansion. The two other types (Duplex steel with middle CTE and chrome-nickel steel with high CTE) show no adhesion with the enamel; it chips off immediately after firing. The addition of 1g CuO / 100g frit leads to an enamel adhesion on the stainless steels E1 and E2. Pickling of stainless steel sheets does not improve the enamel adhesion.

Fig. 3 (opposite) displays the differences in surface quality of stainless steel grades used after degreasing and after pickling. The influence of pickling is obvious only on stainless steel 1. The surfaces of stainless steels 2 and 3 show no differences between the two pre-treatment methods. This is due to a higher content of alloying additions of the chrome-nickel steel which leads to a higher corrosion resistance of this steel.
Influence of blasting process on the surface quality of the enamel

Problems with changing of the quality of the enamel surface led to new conclusions about the optimised blasting process. The enamel surface of some samples showed many pin holes. Other samples did not show these defects, although the stainless steel substrates, the enamel and the firing conditions were the same. The different appearances of the enamel surfaces could only be explained by the fact that the substrates were blasted on different days by different persons. It is supposed that the main cause for pin holes on the enamel surface is a too long blasting process and a too rough stainless steel surface. To corroborate this assumption, test series were performed with different times of blasting. The enamel surface of long blasted sheets showed pin holes, the surface of short blasted sheets did not. The different roughnesses of the sheets

**Fig. 2** Comparison of enamelled sheets after different pre-treatment methods:
- a) degreased; no adhesive oxide in the enamel;
- b) degreased; with 1g CuO / 100g frit;
- c) pickled in hydrochloric acid; with 1g CuO / 100g frit;
- d) blasted with corundum; with 1g CuO / 100g frit

**Fig. 3** Microscopic images of the surfaces of the stainless steels, 100x magnified:
- a) degreased;
- b) pickled
were verified by a measurement with a profilometer. The too long blasting time caused an inclusion of bubbles during the blasting process. These bubbles could leave the molten enamel layer too late and led to pin holes on the enamel surface.

**Formation of a wavy enamel surface**

A formation of a wavy enamel surface was observed during the heat-up phase only on chromenickel steel while firing the enamel. This effect was mainly noticed for enamels with more than 60% SiO₂. Increasing SiO₂ content means lower CTE and higher viscosity \[^{[4]}\], \[^{[5]}\]. The formation of a wavy enamel surface is caused by a very high CTE of the chrome-nickel steel and by tearing open of the enamel biscuit layer during firing (see Fig. 4). Increasing the time of firing does not allow the molten enamel layer to be smoothened because of its high viscosity.

![Formation of a wavy enamel surface with increasing temperature](image)

**Computer-based evaluation of the influences of raw materials on desired properties**

The enamels developed show very different property data (see Table 4). Thus the CTE, for example, varies from 99 to 146 \( \cdot 10^{-7} \text{ K}^{-1} \), so that it is possible to find an appropriate enamel for any stainless steel grade.
The analysis of statistical design shows the influence of the individual enamel raw materials on the different properties measured (e.g. chemical stability, CTE). Its impact may be seen from coefficient plots, as illustrated in Fig. 5. The bars specify direction and size of the effect and the 95% probability confidence interval indicates the coefficient value being in this interval.

![Coefficients for enamel properties](image)

**Fig 5: Coefficient plot for enamel properties**

The statistical analysis of the results displays the following influences when increasing the content of the raw materials:

- Quartz reduces the weight loss by chemical corrosion, relative flow length and CTE, and increases T\(_g\) and T\(_{SP}\)
- Soda increases the weight loss, relative flow length and CTE, and reduces T\(_g\) and T\(_{SP}\)
- Borax increases the relative flow length and CTE
- Li\(_2\)CO\(_3\) increases the relative flow length and CTE, and reduces T\(_g\).
Colouring possibilities

When developing coloured enamels for stainless steels, one first has to remove all colour oxides originally present in the mixture. Colour pigments were added then with two different contents (2% and 5%) to the mill batch. The colour pigments used are described in [3]. The colour intensities and shades obtained are illustrated in Fig. 6.

As displayed in Fig. 6, different colour pigments developed a different covering power. Increasing the content of colour pigments intensified the colour and varied the shade. The surface quality of the enamels was dependent on the stainless steel grade used. Coloured enamels applied on stainless steel 1 always showed a much blistered surface. Most trials showed a more or less blistered enamel surface with pin holes. Because of a late degassing, bubbles could not leave soon enough the molten enamel layer.

SUMMARY

The results of the investigation show that a corundum blasting of stainless steel sheets results insufficient adherence against impact load for all enamelled sheets. A sufficient enamelling at the edges was found for most of the enamelled sheets. The best results were achieved with a raw material composition of \( \approx 45\% \) quartz, 20% soda and 25% borax (for 820°C as a firing temperature).

The three stainless steels used have different preconditions for a successful enamelling. For the chrome steel, the CTE of the enamel frit has to be \( < 130 \cdot 10^{-7} \text{K}^{-1} \), otherwise tensile stresses develop. Chrome-nickel-molybdenum steel is easy to enamel, shows a smooth enamel surface in most
experiments and there are no problems with an aligned CTE of the enamel frit. When using chrome-nickel steel as a substrate for enamelling, compressive stress can develop if the CTE of the enamel frit is too low.

ACKNOWLEDGEMENTS

This work was financed by the program of the AiF (Arbeitsgemeinschaft industrieller Forschungsvereinigungen) for the advancement of the “Industrielle Gemeinschaftsforschung (IGF)” utilizing resources provided by the “Bundesministerium für Wirtschaft und Technologie”, Germany.

LITERATURE


--ooOoo--
OBITUARY

ALLAN FOX 28 NOVEMBER 2008

It is with sadness that we report the death of Mr. Allen Fox at the age of 73. Allan was an Enamel Shop Manager at New World and was also the organiser of the IVE social event that was held in Warrington for a few years in the early 90’s.

Mr. Fox, who had lived in the Paddington area all his life, enjoyed rugby league and played for Latchford Albion. He had trials for Warrington and St Helens, before signing for Oldham Rugby League Club.

Allen died of metastatic carcinoma, and leaves his wife, a daughter and two grandchildren. A celebration of his life was held on December 4th at Walton Lea.
ENGINEERS TO THE VITREOUS ENAMELLING INDUSTRY

Over 30 years experience in:

- Furnace service, spares and repairs
- Firing jigs and tooling
- Furnace design and consultancy

Contact - Gordon Green at
ENAMEL ENGINEERING SERVICES LTD.
P.O. BOX 96, NEWPORT, SHROPSHIRE TF10 7ZE
Telephone: +44 (0)1952 810842  Fax: +44 (0)1952 820925
Email: enenser@aol.com

IVE PUBLICATIONS
ATLAS OF ENAMEL DEFECTS
1996 EDITION (reprint)

Price remains @ 1996 Edition rate
£17.50 + p&p (£1.00 for UK & EU)

Obtainable from:
The Institute of Vitreous Enamellers
39, Sweetbriar Way,
Heath Hayes, Cannock,
Staffs., WS12 2US,
ENGLAND.
Vitreous Enamel Colouring Oxides, Water or Oil-Based Screening Enamels, Opacifiers...

W.G. Ball Ltd.

W.G. Ball Ltd.
Longton Mill, Anchor Road,
Longton, Stoke-on-Trent,
United Kingdom ST3 1JW
Tel: 01782 312286/313956
Fax: 01782 598148
E-Mail: sales@wgball.com
Website: www.wgball.com
A group with a long history

PEMCO International is a worldwide group with proven experience and expertise in porcelain enamels. Well located, with high quality manufacturing and technical capabilities, PEMCO is dedicated to serving the needs of the global market.

For further information please contact:
Pemco Brugge NV., Pathoekeweg 116, 8000 Brugge, Belgium.
Dimitri Buysse  Tel: +32 50 456 509  Mobile: +32 475 970 270
Ben Fieldhouse  Mobile: 0788 074 7390
Leadership. A privilege few enjoy.

You don’t get to be a leader without good reason. You get there because people believe in you. Because you believe in what you are doing. As the world’s leading supplier of vitreous enamels, ceramic glazes and colours, FERRO offers unparalleled state-of-the-art resources capable of transforming current trends into innovative vitreous enamelled products to build value for our customers.

For over 80 years, Ferro has been your global partner. Leading the way - an enduring partnership with vitreous enamel.

Ferro (Great Britain) Limited, Porcelain Enamel Division
Nile Street, Burslem, STOKE-ON-TRENT, Staffordshire, ST6 2BQ, England, UK.
Customer Service: Tel: + 44 (0) 1782 820 446; Fax: + 44 (0) 1782 820 420
Technical Support: Tel: + 44 (0) 1782 820 419; Fax: + 44 (0) 1782 820 402
Switch Board: Tel: + 44 (0) 1782 820 401

www.ferro.com