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

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As mentioned in the last journal, the IVE has started a process of change. It sounds obvious, but the IVE is there for its members. This means, for example, that we want to investigate what the members expect from the IVE. We also want to make clearer the benefits of the today’s IVE membership.

It is clear that in the past, the IVE played an important role in the development of the enamel industry in Great Britain and Western Europe. You only have to think at the nice enamelled English cookers and heaters which are famous all around the world.

However, due to globalisation and environmental aspects, the enamelling industry is moving to countries with lower labour costs and less rigid legislation. That means mainly to countries in East Europe and sometimes even further to countries in Asia. Only companies with a unique brand name or a high quality can survive. On the other hand competitive products like plastics have yet to be optimised for high temperature resistance and hygienic aspects. Just these two properties make enamel a unique product. However, only by the development of innovative products and optimised production processes will the enamel industry have a future in Western Europe.

Probably you are thinking - what can the IVE do for me? That is not so easy to answer, as there are a lot of different enamel applications. Every company has its know how and, unfortunately, their own problems. Of course, I know that there is always the difficulty of “intellectual properties,” but listening and discussing other opinions maybe will give even the best companies that spark which leads to an innovative product change or the solution for a problem.

It is always difficult to speak for somebody else, so for that reason I will mention my own experience over the last 3 years. As a representative of Corus, I am a member of the working group that has upgraded the European standard 10209. This standard describes cold rolled steel grades for enamelling applications. Although it is a steel standard a delegation of frit suppliers joined the meeting in Paris. The enamel production industry was not represented.
Recently a discussion has been started “does it makes sense to standardise hot rolled steel grades for enamel applications?” But even more importantly, what are the consequences of this standard. In council meetings of the IVE, for example, we discuss these important issues to ensure that our member’s interests are fully represented.

Another positive item of the IVE membership is the journal and the access to the Basic Approach Course and the seminars.

As a relatively new member, networking is one of the important issues for me. I meet new people and have interesting discussions on all kinds of enamelling concepts. I meet end users, some of them are clients, and others are not. But there is always a positive atmosphere. For me the attendance of suppliers and government health and safety officers at our seminars is also very important. For example, during the last seminar in Edinburgh we had two interesting presentations on the topic of what REACH means for the enamelling industry. You can find more information on this topic in the new member zone of the IVE website. At the seminar there was also time for a questions session where we discussed how to decrease energy costs. On the second day, an interesting visit to Pfaudler Balfour was made. As an employee of Corus I am more or less used to large and hot devices but it is always interesting to see large enamelled reactor vessels, especially when your guide is a well-experienced enthusiast like Ron Black.

Both personally and as a representative of Corus, I am convinced that the IVE has a right to exist.

RONALD van DUIJN
Member of the “Stichting email”, The Netherlands
Council member IVE

--ooOoo--
Unfortunately as usual I managed to start this trip by double booking myself; this time with the Isle of Wight music festival. Luckily I only missed Sting and the Police so no real loss. However I did have to get up far too early as David Gatrell and I had to catch a multitude of different modes of transport to make our way to this year’s seminar.

On arrival it was a real treat to be situated right next to the Forth Railway Bridge and such spectacular views all down the Firth. After a brief walk to take in a few sights we met up with the other early arrivals for dinner and had a chance to catch up with some familiar faces.

The day for me started with the introduction of the infamous full Scottish breakfast, which seemingly the only comparative difference to a full English breakfast is the addition of haggis. Arguable this could be considered a bad idea but it tasted great and certainly keeps you full until lunch. In hindsight this was a wise choice as there was a lot of information to absorb in one day and it used up a lot of energy.

The day’s events were started with a presentation on Ferro’s new range of Evolution frits presented by Martin Crew, which was very relevant as we have already been using this product and have got some beautiful results. It is great to see innovations such as this and it is up to us as end users to utilize these products and find equally new and exciting ways of using them.

Next was a paper on the Warping of Enamelled Panels by Filip Van den Abeele of Arcelor that took a very comprehensive look at factors affecting distortion during the firing process. The paper was both informative and interesting utilising detailed computer generated models. The morning took a more relaxed but still informative detour with Mark Nutting and Mike Collins and their Sigma Experiments. The idea was to demonstrate how though a small number of experiments involving paper helicopters you could predict the most efficient design.
After a short break and a chance to stretch our legs Dr Wendel of Wendel GmbH continued the day’s papers with his in depth presentation on rheology. I was most excited by the title of the next paper simply titled Kryptonite. Although any preconceptions of a green glowing superhero-killing mineral from the planet Krypton were quashed it was fascinating to hear about a new mineral that shares some of the same characteristics as Jerry Siegel’s fictional counterpart.

Pfaudler Balfour was a great insight into a heavily industrial enamelling
Next followed a series of REACH based presentations firstly by Jennifer Hopkins of the UK Competent Authority and then after lunch Jean-Paul Roose of Pemco. Ron Black of Pfaudler Balfour presented the last paper of the day on failure mechanisms and attribute defects in glass lined chemical process equipment. This was both informative and a great introduction to the site visit we would make the following day.

Pfaudler Balfour was a great insight into a heavily industrial enamelling set up which until now I had not seen. The sheer scale of the factory was amazing and I was especially impressed with such a high level of skill in every aspect of what they do.

The whole weekend was a great success and as usual it was great to mix with other people in the industry and I look forward to next year. I would sincerely recommend this event to anyone in the industry as it brings together all the major annual developments from around Europe. I found the whole experience both informative and enjoyable and I hope to see many new faces at future events.

David Knight
A. J. Wells & Sons Limited

--ooOoo--
FORTHCOMING EVENTS

September 18th - 19th 2008  International Foundry Forum 2008
Venue: Vienna, AUSTRIA
Contact: The European Foundry Association
Tel: +49 (0)2 11 / 68 71 - 217
Web: www.international-foundry-forum.org/default.asp

September 19th - 25th 2008  World Tunnelling Congress
Underground Facilities for Better Environment and Safety
and 34th ITA General Assembly
Venue: Delhi, INDIA
Contact: Mr. G.N. Mathur
Tel: 91-11-26116347
Web: www.cbip.org/image/File204.pdf

September 21st - 24th 2008  Metal Forming 2008
Venue: Krakow, POLAND
Contact: Barbara Krzemien-Kotula,
Tel: +48 12 617 29 21

September 22nd - 23rd 2008  2nd Global Silicone Business Outlook
Venue: Shanghai, CHINA
Contact: Lee Lin, TAN
Tel: (+65) 63469146

September 23rd - 25th 2008  Inhaled Particles X
Venue: Sheffield UK
Contact: Joanna Hayes
Tel: +44 (0) 1332 250718
Web: www.hse.gov.uk/campaigns/conferences/ipx.htm
September 24th 2008  Worldwide Progress in Refractories
Venue: Rotherham, UK
Contact: Alan Hey
Tel: +44 (0) 1709 830630
Web:www.ireng.org/Docs/ireconfad0508.pdf

Sept. 27th - October 1st 2008  4th Balkan Conference on Glass Science and Technology
Venue: Varna, Bulgaria
Contact: University of Chemical Technology
Tel: (+359 2) 81-63-120
Web:www.uctm.edu/index_en.html

Sept. 30th - October 2nd 2008  Eurocoat 2008
Venue: Lyon, FRANCE
Contact: Groupe E-T-A-I
Tel: +33 (0)1 41 98 40
Web:www.eurocoat-expo.com/Eurocoat/en/contact/contact.php?lien=qui&rb=Who%20are%20we%20?

Sept. 30th - October 4th 2008  Tecnargilla 2008: The Future of Ceramics
Venue: Rimini, ITALY
Contact: r.magnani@tecnargilla.it
Tel: (+39) 0541 744 111
Web:www.tecnargilla.it/

October 16th -19th 2008  ANKIROS International Iron, Steel & Foundry Technology, Machinery & Products Trade Fair
Venue: Istanbul, TURKEY
Contact: Stephan ALKER
Tel: +90 312 4396792
Web:www.ankiros.com/

October 21st - 24th 2008  NanoSMat 2008 - 3rd International Conference on Surfaces, Coatings and Nanostructure Materials
Venue: Barcelona SPAIN
Contact: Dr Nasar Ali
Tel: +44 (0) 1772 895304
Web:www.nanosmat2008.org/
Venue: New Delhi, INDIA
Contact: Oleg Netchaev
Tel: +44 (0) 1923 491063
Web:www.metal-mineral.com

November 18th - 21st 2008 Metal-Expo 2008 - 14th International Industrial Exhibition
Venue: Moscow, RUSSIA
Contact: Mr. Alexey A. Efimov
Tel: +7 495 901 9966
Web:www.metal-expo.ru/en/

December 11th 2008 Cutting Edge Developments in Coil Coating
Venue: Ebbw Vale, UK
Contact: Mr Brian Baker
Tel: +44 (0)1495 304404
Email: brian_baker@talktalk.net

December 11th - 12th 2008 29th International ATS Steelmaking Conference
Venue: Paris, FRANCE
Contact: Maryse Julien
Tel: +33 (0) 1 71 92 20 18
Web:www.ats-ffa.org/anglais/

December 14th - 15th 2008 12th Middle East Iron and Steel
Venue: Dubai, UAE
Contact: Dominic Halahan
Tel: UK +44 (0) 20 7779 8120

--ooOoo--
HIGH COSTS SQUEEZE SMALLER MANUFACTURERS

Record growth in the costs faced by small and medium-sized manufacturers has resulted in firms raising the price of their goods to try and limit a significant squeeze on profit margins, a CBI survey said today (12 August). These tough conditions, combined with a fall in both domestic and export orders over the past three months, have also knocked business sentiment.

During the three months to July, 65% of survey respondents said their average unit costs had increased, and 3% said they had gone down. The resulting balance of +62% is the strongest since the survey started in April 1994. Only some of these growing cost pressures are being passed onto customers and consumers, as a balance of +20% of firms raised domestic prices over the past three months. This rate matches April’s, which was the strongest since April 1995, and the price increases are expected to sharpen again in the coming three months.

The price of SME manufactured exports also grew, but at a slower overall rate. This is also predicted to increase over the next three months. Export order levels did not stabilise as firms had expected but fell instead, with a balance of -9% reporting a drop. Domestic order levels also fell instead of stabilising, with further drops expected in the three months ahead.

More positively, the number of jobs in SME manufacturers in the past three months was better than expected, with an overall balance of +6% of firms expanding their workforce. This increase was mainly driven by smaller firms, but both small and medium-sized firms expect to cut jobs in the coming three months at the fastest rate in five years.

The gloomy business climate saw optimism about the overall business situation fall by a balance of -39%, which is a sharper rate than in April (-20%). Plans to invest in buildings and plant & machinery have further weakened since April, and intentions to spend on R&D and training over the next 12 months have flattened.
Russel Griggs, chairman of the CBI’s SME Council, said: “Although pockets of stronger performance do exist in the manufacturing world, it is a real concern that orders and output have fallen and are set to fall again. There is no doubt this is a challenging time for many small and medium-sized firms. Many are trying to stay on top of higher energy and raw material costs, and are finding it difficult to pass these onto customers through higher prices.”

Source: http://www.worksmanagement.co.uk/News/index.aspx, 12 August 2008

AGA LOOKS TO NEW RANGE FOR STRENGTH

Upmarket cooker manufacturer Aga says new products like its programmable gas Agas, wood burning stoves and hob range cookers will strengthen its position following this current economic down cycle. Aga Rangemaster, which makes and sells premium branded cookers and refrigerators, was announcing half year financial results that showed almost static revenue and pre-tax profits. Revenue from continuing operations was, in fact 1.9% up at £145.1 million (£142.4m last time) while pre-tax profits remained at £12.3 million.

Chief executive William McGrath said Aga Rangemaster had a strong family of consumer brands with a focus on the kitchen providing top class home economics. He went on: “Our performance in the first half proved resilient. Having made disposals, returned cash to shareholders and still with net cash, the business base is strong. Our products – including exciting new ones such as programmable gas Agas, wood burning stoves and induction hob range cookers - are well attuned to the needs of today’s customers and we expect to emerge stronger and even better positioned following this current economic down cycle”.

The company said that its financial strength provided the opportunity to make the most of its production capacity and routes to market. Current market conditions were creating short term constraints but did not detract from an expectation of growing volumes and margins.
In the first half of the year the group had to face sustained higher input costs, notably for stainless steel but international sourcing strategies helped to mitigate these. However, higher input costs and energy prices were likely to restrict near term progress towards Aga’s drive towards a 12% return on sales.

Efficiency gains through moves like the successful re-layout at the Rangemaster manufacturing facility and the wider use of robotics helped to offset the margin impact, the company said.

*Source: http://www.worksmanagement.co.uk/News/index.aspx, 1 September 2008*
Recent focus on standards is beginning to raise awareness of this important area of business. The Standards News article in the previous edition of The Vitreous Enameller provided an excellent overview of the importance of standards, BSI committees and the role of the IVE and I am certain that readers found this article very informative.

Involvement in the development and ongoing review of standards is essential in order to ensure our industry continues to maintain its reputation alongside other industries. An example of why the vitreous enamel standards committees are important is the recent development of a new standard prEN 15771 Vitreous and porcelain enamels Determination of scratch hardness according to Mohs. Many of you will be familiar with EN101 and may not even be aware that the tile industry was withdrawing this standard. Fortunately as a result of representation of personnel from the enamelling industry this was highlighted and the new draft prEN 15771 is currently being developed through the European enamelling committee CEN TC/262/WG5. The transfer of this important and widely used test will benefit many of us and will ensure that other enamelling standards that reference scratch hardness according to Mohs can continue to do so.

Recent activities have included the following:

- Progression of prEN 15711 Vitreous and porcelain enamels Glass lined flanged steel pipes and flanged steel fittings Quality requirements. This draft standard will be used significantly by our member Pfaudler Balfour when it is published and the document is entering its final review stages before it is finally approved.

- Draft prEN 15286 Vitreous and porcelain enamels Terminology. Significant effort has been made by the project leader John Mullis in order to reach consensus in the European community on this complex document. The document has been circulated for voting and the deadline is late September 2008.
There has been further work on the transposition of ISO to EN ISO standards and the following three documents have been circulated for voting:

- prEN ISO 13805 Vitreous and porcelain enamels Determination of the adhesion of enamels on aluminium under the action of electrolytic solution (spall test) (ISO13805:1999)

- 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/Cor1:2000)

- prEN ISO 4528 Vitreous and porcelain enamels Selection of test methods for vitreous enamelled areas of articles (ISO 4528:2000)

Other activities include the continued liaison with standards committees from the steel industry for the development of EN 10129. The proposed standard for the enamelling of hot rolled steels is currently on hold and will not be progressed until the conclusion of EN 10129 at the earliest.

Finally I would like to inform the enamelling community that unfortunately the secretary for the committee CEN/TC 262 Mr. Bernard Shelley has moved on to another post within BSI. We would like to thank Bernard for his assistance during his 8 years as TC 262 secretary and wish him well for the future in his new appointment. We would also like to welcome Mr David Michael as the new secretary of CEN/TC262 who began his post on the 1st September 2008.

SAQLAIN ALI
Chairman STI/36
IVE Council Member

--ooOoo--
IS YOUR FIRM A BUG-BEATER?

Businesses that have new products or technologies that could help prevent the spread of MRSA or similar infections are being asked to come forward to take part in a new NHS programme. The aim is to find the most effective new solutions from across all industry sectors to help in the fight against healthcare associated infections (HCAIs). The ‘Smart Solutions for HCAI’ programme offers businesses the chance to have their technology assessed by a team of independent experts, with a view to evaluating it in a hospital setting and potentially supplying it across the NHS. Reducing HCAIs is one of the top priorities for the NHS in the coming years. It is investing significant sums in improving infection prevention and control and has set itself some challenging targets. While the basic ways of reducing HCAIs are largely unchanged, new technologies and equipment could help to meet these goals more quickly. The ‘Smart Solutions’ programme aims to identify new technologies that are not currently in use, or have not been widely adopted, within the NHS. These may include new types of medical equipment, but could equally be technologies currently used in non-healthcare environments. The programme is open to businesses or other non-NHS organisations of any size, from any sector. Project director Bryan Griffiths from TrusTECH, the NHS Innovation Hub for the north-west of England which is managing the project on a national basis, said that manufacturing, automotive, aerospace, air conditioning and ventilation, food and drink, packaging and pharmaceuticals were amongst the sectors which could offer potential solutions. Applications should be submitted online via the website on or before 26 September.

CHINA OUTSTRIPS UK IN RENEWABLES INVESTMENT TABLE

The UK has dropped from fourth to sixth place in the latest Ernst & Young renewable-energy investment index. China, meanwhile, moved from sixth to fourth as a result of the efforts of the Chinese government to develop the country’s renewables infrastructure in pursuit of a target of generating 15% of energy from renewables by 2020; the US headed the Ernst & Young index, followed by Germany. The UK’s decline in the rankings is thought to be partly attributable to the slow progress through Parliament of the Energy Bill. “A further consultation period over the Bill could lead to up to two years of relative inactivity,” warned Jonathan Johns, the head of renewable energy at Ernst & Young. The British Wind Energy Association (BWEA) sought to play down the UK’s apparent decline. “I think this report says more about China than it does about the UK,” said Gordon Edge, the Association’s head of economics and markets.


BULK PRE-REGISTRATION TOOL FOR REACH

The European Chemical Industry Council (CEFIC) and the Oil Companies’ European Association for Environment, Health and Safety in Refining and Distribution (CONCAWE) have developed a new bulk pre-registration tool for the Registration, Evaluation and Authorisation of Chemicals (REACH) regime. The tool has been designed to be used as easy way for companies to prepare their REACH pre-registrations in cases where they have more than a few substances to pre-register. The transfer tool for bulk pre-registration uses Microsoft Excel and is compliant with the XML format as published by the European Chemicals Agency (ECHA). The tool offers an Excel template for all mandatory and optional data, and an Excel macro which converts the data to the right XML format. Using the tool, companies can apparently rely on the Excel sheet to fill in data and to generate bulk pre-registration files for submission to the REACH-IT Portal. The tool is free of charge for any company and is available, along with a tutorial and user guide, from the CEFIC website at: www.cefic.be/Templates/shwNewsFull.asp?HID=1&NSID=698.

ENERGY FIRMS FAILING TO PROVIDE SMES WITH FAIR DEAL

Energy suppliers are failing to provide businesses with the same fair and transparent service to which domestic energy users are entitled, the British Chambers of Commerce (BCC) complained this week. With energy bills soaring and the economy in a sharp decline, the BCC is urging OFGEM, the energy regulator, to ensure that its current probe into the energy industry addresses a number of serious flaws in the way energy companies deal with businesses. Furthermore, with the consumer champion Energywatch set to be amalgamated with several other consumer groups from 1 October, the BCC is calling for a new, independent and dedicated watchdog to be established that is specifically focussed on the energy concerns and needs of business. Energywatch analysis shows that they receive 32,000 calls a year from businesses seeking help and advice. When compared to domestic energy users, the BCC argued, businesses, and, particularly, smaller firms, are significantly more vulnerable to exploitation and unfair practice by energy firms. BBC Director General David Frost said: “Energywatch is currently providing a crucial service to thousands of businesses who are confused and frustrated by energy suppliers. If a ‘super consumer group’ is to be established, as the Government plans, there is little doubt in my mind that this service will be all but lost, leaving companies at the mercy of the suppliers.” An obvious solution, he concluded, would be establishing a separate watchdog, dedicated to assisting businesses.


NITROGEN TRIFLUORIDE THE ‘MISSING’ GREENHOUSE GAS

A recent study which reveals that a chemical found in the LCD panels of cell phones, TVs and computers has been shown to have a global impact on the climate more than 17,000 times that of CO₂ has been reported this week by ENN. Nitrogen trifluoride (NF₃) is also present in semiconductors and synthetic diamonds, and has been referred to as the ‘missing’ greenhouse gas. However, it is not one of the ‘basket’ of six gases covered by the Kyoto protocol. In 2008, it is predicted that emissions of NF₃ will have a global impact similar to that of Austria’s CO₂ emissions. Next year, production of the chemical could
**THE VITREOUS ENAMELLER**

double, with manufacturing facilities opening in North America and Asia. NF$_3$ is also persistent, remaining in the atmosphere for over 500 years. LCD monitors have been marketed for some time as a greener alternative to inefficient CRT models containing lead. They are reported to consume two-thirds less energy than CRTs. The effect of these new revelations on manufacturers is yet to be seen. The cheapest way of producing NF$_3$ is apparently more emission intensive and, although products could be engineered in such a manner as to emit less NF$_3$, the cost could prove prohibitive. Although production of the chemical and its impacts on the environment are now known quantities, it is not yet clear how much of the gas is present in the air.

*Source: ENN, July 13 2008.*

**G8 NATIONS COMMIT TO EMISSIONS CUT**

The G8 coalition of industrialised nations has agreed a target for the reduction of greenhouse-gas emissions of 50% by 2050. The target was published in a draft communique in July 2008; the communique acknowledges a need for mid-term goals in support of this target, but indicates that it will be up to each nation whether or not they adopt such goals. “There has been major progress on the climate change agenda, beyond what people thought possible a few months ago,” commented UK Prime Minister Gordon Brown. “Countries which previously objected to setting overall targets have accepted these targets subject to there being an international agreement.” The coalition also outlined plans for a £40bn programme of investment - funded mostly by the private sector - in renewable energy in the developing world. “Substantial finance and investments will be needed to meet the urgent challenges associated with the issue,” the communique noted. The announcement of the 50% G8 target was greeted with disappointment by environmental campaigners. “At this rate, by 2050 the world will be cooked and the G8 leaders will be long-forgotten,” said Antonio Hill, a spokesman for the charity Oxfam. “The G8’s endorsement of a tepid ‘50 by 50’ climate goal leaves us with a 50/50 chance of a climate meltdown.”

*Source: The Guardian, July 8 2008.*
MINISTER HIGHLIGHTS BENEFITS OF SUSTAINABLE PRODUCTS

The increasing manufacture and use of sustainable products and materials could save UK households some £5bn a year, claimed Climate Change minister Joan Ruddock. Ms Ruddock was speaking to mark the publication of two progress reports from the Department for Environment, Food and Rural Affairs (DEFRA). One report covers the progress made on ‘Sustainable Products and Materials;’ the other covers the Government’s ‘Waste Strategy.’ Among the measures implemented by the Government with regard to sustainable products are improvements in the energy efficiency of household appliances, an initiative aimed at encouraging retailers to sell only energy-efficient lightbulbs, a new standard - PAS2050 - for product life-cycle emissions, and the development of ‘Product Roadmaps’ for ten “priority products.” The progress report also forecasts further reductions in household food waste and energy and water use. “We know people are concerned about their effect on the environment, but they don’t get to see the full picture of what goes into producing the goods they buy, and they don’t see what happens after they’ve thrown them away,” Ms Ruddock commented. “It needs to be easier for people to buy products that will save them money and reduce their impact on the environment, and that’s exactly what we’re doing. There are real savings to be made: through this action to green the products and materials we use, UK households could save £5 billion a year on their bills. Many businesses are already taking positive steps to reduce the environmental impact of their products.” The minister added, “as fuel prices rise, commodities become scarcer, and families feel the pinch, it becomes ever more important for businesses to use resources more efficiently throughout the supply chain. Those that don’t will miss out on potential savings, as well as big opportunities for growth.” The progress report on the Waste Strategy, meanwhile, notes improvements in household recycling rates and reductions in the amount of household, commercial and industrial waste being disposed of at landfill; however, concerns remain regarding the apparently high incidence of fly-tipping. More information can be found at: www.defra.gov.uk.

NEW EMISSIONS-REDUCTION STANDARD TO TACKLE ‘GREENWASHING’

The Carbon Trust has launched a new emissions-reduction standard that will allow businesses and public-sector organisations that commit to achieving genuine annual reductions in greenhouse gas emissions to be certified, in order to build consumer confidence and discourage “greenwashing.” The new Carbon Trust Standard certificate will provide a way for organisations to prove they are tackling climate change and have made genuine reductions in their carbon emissions. Launching the standard, the Carbon Trust said that it wanted to inspire businesses across the UK to get involved in taking action on climate change, to look at reducing emissions in their supply chains, and to take advantage of the bottom-line benefits that come from reducing carbon emissions. The Standard was developed by the Carbon Trust in response to both growing consumer mistrust of organisations’ green claims and confusion amongst businesses about what to do to reduce emissions and improve efficiency. It is the world’s first carbon award scheme that requires an organisation to measure, manage and reduce its carbon footprint and make real reductions year-on-year. Unlike other award schemes, it requires organisations to take action themselves rather than paying others to reduce emissions via off-setting - a practice seen as credible by only one in ten consumer respondents to a recent Carbon Trust study. Tom Delay, the chief executive of the Carbon Trust, said: “Our research shows that not only do consumers currently mistrust business’ climate-change claims, but that business thinks existing carbon award schemes are confusing and lack credibility. What business and consumers both share is a desire for one credible way to prove an organisation has not only measured but actually reduced their carbon emissions year-on-year without the use of off-setting.”


URGENT NEED FOR ACTION ON CLIMATE CHANGE, PWC WARNS

The cost of preventing catastrophic climate change need not be unreasonable but action must be taken immediately, according to an updated report from the business consultancy PricewaterhouseCoopers. According to the new publication, which represents a revision of a report first published in 2006, a
50% cut in carbon emissions could be achieved by 2050 at a cost of around 3% of global economic growth; the firm has increased its 2006 estimate of 2-3% in response to the explosive growth of economies and industries in India and China. Such a cut, however, would require the G7 nations to reduce their own emissions by 80%. So-called ‘E7’ countries - China, India, Brazil, Russia, Mexico Indonesia and Turkey - would only be required to start reducing emissions after 2020. The report proposes major increases in the use of renewable energy and carbon capture technology; nuclear energy, PwC believes, could play a role in reducing emissions but should not be crucial. PwC head of macroeconomics John Hawksworth warned that the time had come for politicians to “be specific about a number of concrete actions”. “Governments in all major economies must demonstrate their joint political will to establish a well-functioning global carbon market that puts a price on carbon emissions,” commented PwC head of climate change services Richard Gledhill. “That will send the right economic signals to private sector investors and consumers needed to deliver the new technologies and changes in behaviour required to combat global warming.”


ECHA RAISES QUALITY ISSUES ON REACH SUBMISSIONS

The European Chemicals Agency (ECHA) has released a statement urging companies to follow guidance and instructions in making pre-registration submissions under the Registration, Evaluation and Authorisation of Chemicals (REACH) regime, raising questions concerning the quality of data supplied by businesses. In the statement, the Helsinki-based Agency said that, by 13 June 2008, 1,427 companies had signed up on REACH-IT and created 7360 pre-registrations. ECHA said it had reviewed the quality of the first data submissions and, for 2% of these pre-registrations, substance identity information was not provided in line with ECHA guidelines. In addition, 143 notifications and 38 inquiries have been received by the Agency with regard to substances being used for product and process-oriented research and development (PPORD). ECHA says that many of the dossiers submitted via the temporary submission procedures could not be further processed due to inadequate or incomplete information. The Agency found that the most commonly occurring errors in the technical dossiers were related to missing
information on the chemical identity and the composition of the substance. In 50% of the incomplete dossiers, either the correct name or molecular and structural information was incompletely provided. As a result, ECHA has announced that additional instructions will be published shortly. However, in the interim, the Agency has urged companies to follow closely the existing instructions and the relevant guidance. Further information on the rules and guidance for submission can be accessed at: http://echa.europa.eu/home_en.asp.

Source: ECHA, June 2008.

WRAP PUBLISHES THREE-YEAR BUSINESS PLAN

The Waste and Resources Action Programme (WRAP) has published its new business plan for 2008 to 2011 which sets out a series of demanding targets as part of the new three-year programme. Between 2008 and 2011, the business plan specifies that WRAP will develop and deliver programmes that will result in 8 million tonnes less waste being sent to landfill in the UK, save 5 million tonnes of carbon dioxide equivalent, and realise £1.1 billion of economic benefits. Underpinning the three targets set out above, WRAP, now in its eighth year, has outlined four key areas of priority for delivery: collection systems, quality of materials being sent for recycling, food waste, and packaging. The business plan also notes progress made so far in the UK, including the progress made by WRAP in its priority area of reducing food waste, meeting the interim target of reducing food waste by 100,000 tonnes by March 2008. WRAP research shows that the number of UK households committed to reducing food waste has increased by 1.4 million to 3.5 million households since March 2007. The issue has been pushed up the public agenda since the launch of WRAP’s ‘Love Food, Hate Waste’ campaign in November last year. The business plan can be accessed at: www.wrap.org.uk/wrap_corporate/about_wrap/what_does_wrap_do/wrap_business_plan.html.

ONLINE SOLUTION TO Sharing DATA WITHIN REACH

An innovative online service has been launched to help businesses work together to meet the requirements of REACH legislation when registering substances with the European Chemicals Agency (ECHA). REACH concerns the Registration, Evaluation, Authorisation and Restriction of Chemicals and is based on an EU Regulation. REACH-VEN is a simple, cost-effective solution that helps companies to pre-register and begin working together as part of a Substance Information Exchange Forum (SIEF) Preparation Consortium, in advance of forming a full SIEF. Those who sign up with REACH-VEN will be able to quickly find out if the legislation applies to them and, if so, they can begin the process of working together and make contact with other companies intending to register the same substances. Mark Selby from Denehurst Chemical Safety said: “We know that REACH has important implications for manufacturers, importers and distributors of chemicals accessing the European market, and this solution will help companies in the pre-registration process.” Jim Thomas, business development director at VEN, the company that created REACH-VEN, explained that it would help smaller companies that might find it difficult to make themselves heard in negotiations, particularly relating to the costs of REACH. “Users of the site can pre-register all of their substances in a single streamlined system that will save them both time and effort,” he said. The service can be accessed at: www.reach-ven.eu.

Source: VEN press release, June 2008

REVISION OF WASTE DIRECTIVE

The European Commission has issued a statement welcoming the recent second reading vote by the European Parliament approving the revision of the Waste Framework Directive, which has been described as “the central pillar of EU waste management policy.” The revised Directive marks a major change in EU waste policy, introducing Europe’s first-ever general recycling targets. The Directive will also serve to streamline EU waste legislation by replacing three existing Directives: the current Waste Framework Directive (2006/12/EC), the Hazardous Waste Directive (91/689/EEC) and the Waste Oils Directive (75/439/EEC). In summary, the revised Directive sets new recycling targets to be achieved by the Member States by 2020, including recycling rates of 50% for household and similar wastes and 70% for construction and demolition.
waste, and strengthens provisions on waste prevention through an obligation for Member States to develop national waste prevention programmes and a commitment from the Commission to report on prevention and set waste prevention objectives. The Directive also establishes a clear five-step “hierarchy” of waste management options, according to which prevention is the preferred option, followed by reuse, recycling and other forms of recovery and with safe disposal as the last recourse, and clarifies a number of important definitions, such as recycling, recovery and waste itself. European Environment Commissioner Stavros Dimas said: “This legislation marks a shift in thinking about waste from an unwanted burden to a valued resource and helps to make Europe a recycling society. It introduces a modernised approach to waste management, with clearer definitions, greater emphasis on prevention of waste and ambitious new recycling goals.” Further information on the revised waste policy can be accessed at: http://ec.europa.eu/environment/waste/index.htm.


EUROPEAN UNIONS TO PROMOTE REACH AWARENESS

The European Trade Union Confederation (ETUC) has expressed its intention to play an active role in providing information on the Registration, Evaluation and Authorisation of Chemicals (REACH) regime. The regime gathered impetus with the inauguration on 3 June 2008 in Helsinki of the European Chemicals Agency (ECHA). REACH requires industrial operators to register the chemicals they manufacture or import in quantities of more than one tonne a year. The findings of a recent ETUC study assessing the benefits of REACH concluded that the new legislation will make it possible to prevent yearly in Europe some 90,000 cases of skin and respiratory diseases (excluding cancers) caused by exposure to dangerous chemical substances. However, a source at ETUC said that many of the companies concerned - particular small and medium-sized firms - were unaware of the obligation and risked finding themselves in breach of the legislation. ETUC says that it will contribute, through its member organisations, to the information campaign in order to raise awareness amongst European companies’ of the new system.

FEEDBACK SOUGHT ON REVISED GROUNDWATER RULES

The Department for Environment, Food and Rural Affairs (DEFRA) has published a new consultation paper on proposed amendments to the Groundwater Regulations 1998. The amendments to the 1998 Regulations will ensure that the UK meets the requirements of Article 6 of the Groundwater Directive (2006/118/EC), a daughter Directive under Article 17 of the EU Water Framework Directive (2000/60/EC). Regular meetings with stakeholders from the water, chemicals, mining, waste, and agricultural sectors and green NGOs have already taken place to inform the proposed amendments. Now DEFRA is seeking additional feedback from anyone who discharges substances that can cause groundwater pollution or who currently follows the existing groundwater regulations. However, environment minister Phil Woolas said that the practical consequences of the proposed changes for those involved with groundwater would be minor. “It’s a priority for the proposed guidelines to be as simple, workable and cost-neutral as possible, all while safeguarding groundwater,” Mr Woolas said. “While a slightly wider range of hazardous substances will be subject to controls, there will also be greater flexibility around these controls.” The closing date for submissions was 20 August 2008. The consultation paper can be accessed at: www.defra.gov.uk/corporate/consult/wfdgroundwater-transpose-article6/.


CONSULTATION ON WATER POLLUTION

The Scottish Environment Protection Agency (SEPA) has published a new consultation paper on guidance regarding the control of priority and dangerous substances and specific pollutants in the water environment. The guidance on hazardous water pollutants has been produced by SEPA in order to control toxic, persistent and bio-accumulative substances as defined under the two European Directives designed to protect the water environment, the Water Framework Directive (2006/118/EC) and the Dangerous Substances Directive (76/464/EEC). The consultation paper outlines SEPA’s proposed policy and procedures for controlling discharges containing listed substances and will be of interest to those who hold, or are likely to hold, an authorisation allowing discharges of these pollutants into the aquatic environment SEPA is particularly interested in comments on the proposals for determining whether a discharge
is liable to contain listed substances, the proposed thresholds for significant level or loading of listed substances, the method for establishing lower and upper tier numeric discharge quality licence conditions, and the potential impact of proposals upon business. The closing date for responses to the consultation is 18 July 2008. The consultation document can be accessed at: www.sepa.org.uk/pdf/consultation/current/dangerous_substances/Control_PHS_SP_SP.pdf.


CARBON PERMIT REVENUE ‘SHOULD BE USED FOR CLIMATE CHANGE’

The Confederation of British Industry (CBI), the conservation group the WWF-UK, and the research forum the Energy Research Partnership (ERP) have written to the Government calling for money raised by auctioning carbon emission permits to be used to tackle climate change. In a statement, the CBI pointed out that the Government is set to receive around £1.6 billion from selling permits between 2008 and 2012, as part of phase two of the EU Emissions Trading Scheme (ETS). The open letter on the subject, signed by the heads of the CBI, its Climate Change Task Force, WWF-UK and the co-chair of the ERP, said the Government had a “tremendous opportunity” to demonstrate its commitment to tackling climate change by announcing a similar scale investment programme in green technologies. In a report last year, the CBI’s Climate Change Task Force argued that the two key pillars of moving to a low carbon economy were carbon trading and new technology. However, the CBI says that the UK still lags behind other countries in investment in green research and development and the open letter to the Prime Minister calls for positive action to address this. The letter said: “We believe that climate change can be mitigated and the UK can meet its long-term emissions targets. But doing so will require imagination, innovation and, in particular, investment from across the public and private sectors.”

SAFETY LAB LAUNCHES NEW QUARTERLY

A quarterly newsletter aimed at providing readers with information regarding the activities of the Health and Safety Laboratory (HSL) has been launched this week. ‘The Peak’ has been established by the HSL in response to customer enquiries regarding its work. In his introduction to the first edition of the newsletter, HSL chief executive Eddie Morland described the Laboratory as “the UK’s best-kept secret.” “We’ve taken steps to redress this situation as many of our customers have also indicated that they, too, would like more information about the scope of our work,” Mr Morland wrote. “This is the reason we’ve decided to launch our newsletter. The intention of ‘The Peak’ is to update you with useful and relevant information which can help you to manage your workplace health and safety issues.” The first issue of ‘The Peak’ can be downloaded at: www.hsl.gov.uk.


REPORT ON HEALTH AND SAFETY REFORMS

A new report published by the Better Regulation Executive has examined how health and safety regulation affects low risk and small businesses and concluded that small business could save up to £300 million a year with key health and safety reforms, including better advice and support. The publication sets out recommendations to save firms time and money, while also focusing on improving working environments and the general understanding of health and safety. The report’s suggestions include: better advice to help small businesses know when to buy in the help of consultants for health and safety advice; maximising the resources of Health and Safety Executive and local authority inspectors, making inspection and enforcement more efficient; and developing a new, single assurance scheme so small businesses can have just one process to deal with a range of requirements, including health and safety, fire and food safety regulations. According to the Department for Business, Enterprise and Regulatory Reform (BERR), the average company spends around 20 hours a year, or more than £350, on administration meeting health and safety requirements. Therefore, cutting the time spent by just 5 hours per company would save low risk businesses £150 million a year. Commenting on the report, the Secretary of State for Business, John Hutton, said, “Introducing simple steps, such as making information more easily available and getting better advice to firms that need it, will help save time and money
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for UK business.” The report, entitled Improving Outcomes from Health and Safety, can be ordered from the BERR Publications Orderline, tel: 0845 015 0010, fax: 0845 015 0020, minicom: 0845 015 0030, or e-mail: pubs.unit@berr.gsi.gov.

Source: Better Regulation Executive, August 2008.

ROW OVER HSE HQ MOVE

The Public and Commercial Services (PCS) Union is planning a campaign of industrial action over the closure of the London Headquarters of the Health and Safety Executive (HSE) and its relocation to Merseyside. The union says that so far, only 10 staff out of more than 300 have expressed an interest in relocating to Bootle in Merseyside and the PCS Union says the business case for the single head office assumed this figure would be more like 130. The union said that given the loss of vital skills and expertise, and threats of disciplinary action if staff do not make alternative arrangements, 73% of members have voted in a ballot to take action, short of a strike. The union also highlighted what it called a background of job cuts in the HSE that has seen total staff numbers fall below 3000, a year-on-year reduction in the number of inspections and prosecutions, and a report by the Centre for Crime and Justice Studies which found that at least twice as many people die from fatal injuries at work than are victims of homicide. A source at the union said that already nearly 100 staff and 4 senior managers, including both Deputy Chief Executives, had left and the union says the risks to the organisation of losing vital expertise are now too great. Urging the HSE and the Government to reconsider the move, PCS General Secretary Mark Serwotka said, “Staff in London HQ play a vital and active role in HSE’s efforts to keep people healthy and safe at work. Their technical knowledge of health and safety and understanding of the political environment, magnified by years of experience in building relationships with other government departments and stakeholders, makes HSE the modern, world recognised and relevant organisation that it is today.”

EUROPEAN AGENCY GEARS UP FOR RISK ASSESSMENT CAMPAIGN

The European Agency for Safety and Health has launched its campaign to highlight the potential to reduce work-related accidents and illness through better risk assessment. The Agency recently announced that its new European campaign will focus on risk assessment, with the aim of engaging a wide range of businesses and organisations in all EU Member States over 2008/09. The European Week for Safety and Health at Work will take place from 20 to 26 October 2008 and the following year from 19 to 25 October 2009. In support of the campaign, the Agency has highlighted key statistics on the subject of risk assessment in Europe, noting that every year 5720 people die in the EU as a consequence of work-related accidents. Besides that, the International Labour Organisation estimates that an additional 159,500 workers in the EU die every year from occupational diseases. Taking both figures into consideration, it is estimated that every three-and-a-half minutes somebody in the EU dies from work-related causes. Under EU law, all employers in the EU are required to carry out risk assessments. The Agency is keen to emphasise the message that most accidents and diseases are preventable, and the first step in preventing them is risk assessment. The European Agency’s “Healthy Workplaces, Good for you, Good for business” campaign is to focus especially on high-risk sectors such as construction, healthcare and agriculture, and on the needs of small and medium-sized enterprises. Commenting on the campaign, Vladimír _pidla, Commissioner for Employment, Social Affairs and Equal Opportunities said, “Every occupational accident and disease is one too many. Even if they don’t result in fatalities, the consequences are unacceptable, both for the people concerned and for the economy … Risk assessment is the key to reducing these figures. But it can only be the first step - implementation must follow.”


ECHA LAUNCHES CONSULTATION ON SUBSTANCES OF VERY HIGH CONCERN

The European Chemicals Agency (ECHA) has launched a new consultation on substances of very high concern under the EU Registration, Evaluation and Authorisation of Chemicals (REACH) regime. Substances of very high concern are defined in Article 57 of the REACH Regulation ((EC) No 1907/
2006) and include substances which are: carcinogenic, mutagenic or toxic to reproduction (CMR), meeting the criteria for classification in category 1 or 2 in accordance with the Dangerous Substances Directive (67/548/EEC); persistent, bio-accumulative and toxic (PBT) or very persistent and very bio-accumulative (vPvB) according to the criteria of the REACH Regulation; identified, on a case-by-case basis, from scientific evidence as causing probable serious effects to human health or the environment or an equivalent level of concern as those above (e.g. endocrine disrupters). The consultation sets out 16 proposals for the identification of substances of very high concern which have been prepared by Member States with the view to include these chemicals in the first candidate list of substances that eventually may be subject to authorisation. Placement on the candidate list will trigger new duties for producers, importers and suppliers of articles. Producers and importers of articles that contain substances that are included in the candidate list have, under certain conditions, an obligation to make a notification to ECHA. Likewise, suppliers of articles will need to provide to their customers and consumers available information on the safe use of their articles containing these substances. The candidate list will be published on ECHA’s website and regularly updated when new substances have been identified as substances of very high concern. ECHA plans to publish the first list by the end of October 2008. The consultation documents can be accessed at http://echa.europa.eu/consultations/authorisation/svhc/svhc_cons_en.asp. The closing date for comments is 14 August 2008.


REMINDER ON REACH PRE-REGISTRATION

The British Occupational Hygiene Society (BOHS) has reminded companies to ensure that they have pre-registered any relevant substances under the new the Registration, Evaluation and Authorisation of Chemicals (REACH) regime. In a statement, the BOHS noted that the pre-registration period for REACH began on 1 June 2008 and runs to 1 December 2008. For all non-exempt substances that are not pre-registered or fully registered by 1 December 2008, the suppliers and downstream customers are technically liable for penalties backdated to 1 June 2008. The BOHS is therefore urging companies to check whether and how REACH might impact on them or other firms with which they are involved, and the action that might need to be taken to comply with
the regulation and ensure business continuity. Pre-registration is free, and is a simple procedure involving electronic submission of some basic information about the company and the substances it uses to the European Chemicals Agency in Helsinki. A source at REACH said, “We are now well into the pre-registration period, which means that if you have not yet done so, time is running out fast for you to check whether REACH could affect your business, or businesses you or your clients are involved with, and whether you should pre-register any substances. The relevant pre-registration software systems such as IUCLID5 and REACH IT require some administrative set-up and training, and so it would be advisable to start this process earlier rather than later and certainly to take care not to leave it until the end of the pre-registration period.” The advice from the BOHS is, “If in doubt, pre-register - it may save you a lot of time and money later on!” Further information and help can be accessed via the website of the Health and Safety Executive at www.hse.gov.uk/reach or via the REACH National Helpdesk, tel: 0845 408 9575.

*Source: BOHS, July 21 2008.*

### SILICOSIS VICTIMS SECURE COMPENSATION

Two men who developed the lung disease silicosis as a result of years of exposure to hazardous dust in the workplace have been awarded substantial sums in compensation. The workers were both employed at a Southwick factory from the 1970s to the 1990s. One was responsible for stripping out furnaces and re-lining them with silica mix; he claimed that the safety equipment with which he had been issued was inadequate, comprising only ear-defenders, gloves and a dust-mask. He was diagnosed with silicosis in 1998 and forced to retire in 2000. The second man was forced to take early retirement at the age of 52 at around the same time. Silicosis is caused by inhalation of silica dust; the dust causes the lungs to become inflamed, which in turn can cause irreversible damage to the lung tissue. According to lawyers Pattinson & Brewer, which represented the two men, the firm responsible is facing “many more claims” relating to illness caused by exposure to silica, asbestos and other hazardous substances.

*Source: Pattinson & Brewer press release, July 8 2008.*
NEW GUIDE TO CHEMICALS EXPOSURE PUBLISHED

A new book on the subject of skin exposure to chemicals in the workplace has been published this week by the British Occupational Hygiene Society (BOHS). In the UK alone, around 29,000 people suffer from work-related skin disorders; the BOHS notes that, because the effects of skin exposure can often take months or years to become apparent, many employers are unaware of the risks possible consequences associated with the problem. The new book, ‘Controlling Skin Exposure to Chemicals and Wet-work’ by Rajadurai Sithamparanadarajah, seeks to identify the ways in which skin can be exposed to hazardous substances. Among the occupations targeted in the guidance are agricultural workers, hairdressers, printers, caterers, and construction, manufacturing and healthcare workers. The book provides an introduction to the functions of the skin, the diseases that can be caused by occupational exposure, and the risk-management strategies that can be put in place to minimise the risk. More information can be found at: www.bohs.org.


FIRMS FINED OVER LEGIONNAIRE’S OUTBREAK

Two businesses have been handed fines of £300,000 each after being convicted of health and safety failings that led to an outbreak of legionnaire’s disease in Hereford in 2003. HP Bulmer Ltd and Nalco Ltd both pleaded guilty to breaching the Health and Safety at Work etc Act 1974 in relation to the outbreak, in which two people died and a further 24 were taken ill. A Health and Safety Executive (HSE) investigation found that the firms had failed to ensure that water storage and cooling facilities at a Bulmer site in Hereford were adequately treated and disinfected. “Inadequate management, by neglecting such an obvious duty of care, that can result in the health and lives of the public or employees being endangered, cannot go unpunished,” commented HSE inspector Tony Woodward. “The fines will also help to deter any repetition, although this does not help the members of the public who were adversely affected and to whom our sympathies are extended. The fact that building users engage a specialist contractor does not mean that they have complied with the law; they must work with the contractor and ensure they are receiving
the service required. Equally, specialist contractors and sub-contractors must provide their clients with the expertise which they have been engaged for.”

*Source: Health and Safety Executive press release, July 1 2008.*

**UK WORKERS PUTTING IN LONGER HOURS**

A recent analysis of official statistics by the Trades Union Congress (TUC) has revealed that an extra 180,000 people across the UK are working more than 48 hours a week. The analysis was conducted to coincide with the recent debate prompted by the UK’s on-going opt-out from the Working Time Directive (93/104/EC) and is presented in a new TUC report entitled ‘The Return of the Long Hours Culture’. The report concludes that the number of people working long hours has increased at a faster rate over the last year than the decline in excessive working between 1998 and 2006. In the first quarter of 2008, the total number of people working long hours increased by 0.5 percentage points (180,000 people) to 3.3 million; the sharpest increases in long hours working occurred in the east of England (up 2.1 percentage points) and London (up 2 percentage points). Between 1998 and 2006, the report notes, the number of people working more than 48 hours was reduced by 3.7 percentage points (707,000), from 3.8 million to 3.1 million. The TUC says that the recent increase in the number of people working long hours is due to the challenging economic climate, which has made employers more reluctant to recruit new staff and instead work existing employees harder. The TUC has long called for a stronger Working Time Directive to protect employees and prevent the continuation of the UK’s opt-out. Commenting on the report, TUC general secretary Brendan Barber said: “After slow but steady progress over the last decade, long-hours working is making its way back into Britain’s workplaces. Employees across the UK already work the longest hours in Western Europe and the recent increase will mean lower productivity, more stress and less time to have a life outside the office with friends and family.”

*Source: Trades Union Congress press release, June 20 2008.*

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ABSTRACT

In the enamel business the properties of the slurry are very important. This especially so in wet applications in the sheet steel and aluminium enamelling sectors where the quality of the final product depends very much on the properties of the slurry. In the cast iron sector slurry properties are also very important. In the coating of pipes and valves the technique is very similar to sheet steel business. Also for powder applications such as cast iron bathtubs where the final application is a dry process, the slurry properties of the wet ground coat are equally important.

Rheology is a branch of physics dealing with the consequences of the deformation and flow of liquid, colloid and solid systems due to the effect of external forces. The purpose of this work has been to determine the interactions within a rheological system. To ensure that the effects were fully shown, a study of the system was made with the following factors: water; clay; borax; boric acid; kaolin and an enamel frit. The observed responses were shear stress, thixotropy, milling fineness, density, pH value and the viscosity of the slurry. In order to be able to calculate these responses it was necessary to investigate hitherto unknown interactions. The most interesting responses are the detected interactions between clay and borax and borax and boric acid. As is well known, the rheological parameters depend also on the frit [1], and thus the system was extended by a second frit and the differences of the factor effects on the responses were determined. The investigations were carried out by means of design of experiments. The effects of the factors on all responses were determined by multiple linear regression using a model valid for all responses. It is now possible to calculate the rheological properties in advance and to optimise the slurry properties within this system for any application chosen.
Fig. 4: Effect of the interaction between boric acid and borax over the whole range of the factors.

Fig. 8 Interaction of boric acid and borax for the exponent n.
Fig. 2: Typical rheogram of a slurry.

Fig. 9 Comparison of measured data (pink) and calculated data (yellow).

Fig. 12 Effect of the factors clay and borax for the response thixotropy.
The perfect goal of slurry production is to prepare a frit slurry as a creamy liquid which may be applied onto the metal in a thin film. Due to the high differences regarding density the milled enamel frit (density $\rho \approx 2.5 \, \text{g/cm}^3$) will settle rapidly in water ($\rho = 1.0 \, \text{g/cm}^3$) if there are no additions.

To understand the surface processes involved, we can look at the mechanisms which have been studied for the model substance, quartz. As a result of crushing quartz, breaks of chemical bonding appear within the siloxane ($\equiv\text{Si-O-Si}\equiv$) groups, forming the radicals $\equiv\text{Si}$- and $\cdot\text{O-Si}\equiv$ respectively. When a suspension is made in water, the recombination of those radicals plays only a minor role. Rather than that the free bondings are saturated, forming a silanol ($\equiv\text{Si-OH}$) and another silanol ($\text{HO-Si}\equiv$) respectively. Accompanied by hydroxide ($\text{OH}^-$-Ions), the weak base silanol ($\equiv\text{Si-OH}$) is giving away its proton readily:

$$\equiv\text{Si-OH} + \text{OH}^- = (\equiv\text{Si-O-})^- + \text{H}_2\text{O} \quad (1)$$

Forming the silicate ($\equiv\text{Si-O-}$) groups at the quartz surface, hence the particles are negatively charged $[2]$.

Compensating this charge positively charged ions are located close to the surface, forming a diffuse electrical double-layer at the surface of the particles. This mechanism is also similarly valid for enamel frit particles. Regarding a vitreous enamel slurry, these positively charged counter-ions are usually sodium ions ($\text{Na}^+$), which may be exchanged by other ions. This is especially important for clay containing systems. For the different affinity regarding cation-exchange the Hofmeister-series is valid. In ascending order,

$$\text{Li}^+ < \text{Na}^+ < \text{K}^+ < \text{NH}_4^+ < \text{Rb}^+ < \text{Cs}^+ < \text{Mg}^{2+} < \text{Ca}^{2+} < \text{Sr}^+ < \text{Ba}^{2+} < \text{Al}^{3+} < \text{H}^+ \quad (2)$$

adsorptive capacity is increasing. The further right the position of a cation is in this series, the worse it will be exchanged $[3]$.

With regard to hydrophilic colloids, it is rather the combination with water molecules (hydration) with the solvation of the particles, than the electrostatic charge. Hydrophilic colloids show a high disposition to adsorb water molecules,
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which later inhibits coagulation of the colloids into bigger particles \[^4\]. The thickness of the double-layer determines the hydration ability of the particles and hence their tendency to sediment.

The thickness of the double-layer is reciprocally proportional to the field strength of the cations within the double-layer. The stronger the cation, the more the double-layer is drawn tight. Strong cations lead to a coagulation of the particles, forming bigger aggregates and therefore precipitation occurs. Compared to silica gel, the milled vitreous enamel frit particles are relatively big and the obtained charge density is much too low. Therefore to prepare a slurry of vitreous enamel it is necessary to use substances with a much bigger specific surface and these colloids are then used as an agent for suspension. Considering a vitreous enamel slurry with a 5% clay content, one enamel particle faces \(10^4\) to \(10^5\) clay particles \[^5\].

In between the two extremes of the coagulating and the low viscous clay suspension exists the field of thixotropic colloidal systems. A thixotropic slurry stiffens while relaxed and in motion it becomes fluid. For a vitreous enamel slurry this behaviour is desirable: while in motion they are fluid – they can be pumped and sprayed, but after application they do not continue to drain. They will stop draining with a certain thickness on the substrate. The correct adjustment of vitreous enamel slurry is a tightrope walk between liquefaction and precipitation. For an actual modern manufacturing process it is necessary to limit all tolerances especially those for the clay and the water. The use of de-ionised water in enamelling plants has become a pre-requisite and the compositions of enamelling clays are strictly controlled in respect of the amount and nature of the clay minerals. To fully satisfy the requirements of ready-to-use vitreous enamel slurries, it is necessary to know more about the interactions between additions to the slurry in order to react quickly and efficiently to the changing requirements of different uses.

Suspensions of vitreous enamel in water behave thixotropically, although admittedly for that, a very fine milling of the enamel frit is needed. Pure kaolin clay-water systems behave as a rheopex – a liquid, the viscosity of which increases with time while stirring. While adjusting a vitreous enamel slurry with clay the thixotropic vitreous enamel system is superposed by the rheopexy clay system. The use of set-up salts allows a considerable reduction of the amount of clay \[^6\]. This supplements their effect onto the diffuse double-layer that surrounds the clay particles.

DESIGN OF EXPERIMENTS (DOE)

DOE is a method to design worksheets for investigations in such a way as to maximise the information to be obtained and to minimise the number of trials required. To choose the factors, the first two: clay and water, are almost obligatory for vitreous enamel slurries. Regarding set-up salts the combination of borax / boric acid was chosen to observe both the effect on the pH-value and interactions involved with the neutralisation reaction respectively. The choice of kaolin completes the list of factors to make a more simple determination of the effect of the enamelling clay. In order to find interactions it is necessary to make the design with at least three levels. For the chosen system we would have to do $3^5$ trials to receive a full factorised plan. Including repetitions for the centred trial that would be 245 trials. Box-Behnken designs neglect the trials in the centre of the cube faces and at the cube corners. Figure (1) shows the design region for a three-factor design graphically.

![Three factor Box-Behnken DOE.](image)

Using this reduction of the trials the DOE could be finished with a total of 73 trials. To investigate the effect of a frit on the rheological system another plan with 34 trials was completed.
TRIAL EXECUTION

All factors not included in the DOE have been kept constant. The slurries were always prepared using the same milling station, the same mill, the same mill balls and a constant milling time. All measurements have been taken one day after the preparation of the slurry at room temperature (20 – 25°C) and always with the same acceleration (1.1/s²). The variation of the additions is always relative to 100 parts of vitreous enamel frit; the rust protection was kept constant and also does not contribute to the plan.

RESULTS OF THE PLAN WITH ONE FRIT

Figure 2 (page 41) shows one of the rheograms with the typical viscous structure behaviour. The obtained curves for building up the structure and breaking down the structure have been fitted using a potential law. This fit following the Ostwald de Waele flow law for the expected dependence between the shear stress $\tau$, the shear rate $D$ (former deformation-speed) and with the viscosity $\eta^*$, and a substance specific parameter $n$ (equation 3) mostly worked well.

$$\tau = \eta^* \cdot D^n \quad (3)$$

Until now, a universal flow law for non-Newtonian liquids could not be formulated. Therefore for the description, different types of curves are used to define the observed [7]. Most of the flow laws are derived from empirical approaches [8,9]. The flow law of equation (3) delivered up to 150 Hz reasonably good fits. For higher frequencies - potentially for a special spraying application, it would be preferred to use another flow law. For all trials the factor $n$ was smaller than 1, as would be expected for viscous flow structure. The blue curve shows the measurement for the structural degradation (increasing frequency) and the pink curve shows the measurement for return. The area between the two curves gives a value for the thixotropy [10].

All results may be explained by a linear combination of the chosen factors and the two interactions clay*borax and borax*boric acid which have been found.

Figure (3) shows the detected interaction between boric acid and borax for this system.
Interactions are present when the effect of one factor (here: substance) depends from another factor present at the same time. In our example, an increasing amount of borax in the slurry is working in the opposite direction dependent on the amount of boric acid present in the slurry. In the case of a low boric acid content, the addition of borax increases the thixotropy. In contrast, for a high boric acid content in the slurry the addition of borax lowers the thixotropy. By the means of interaction apparently contradictory results may be easily explained.

Figure (3) is showing the extreme cases. In figure 4 (page 76) the effect of this interaction may be seen over the whole range of the factors. The one straight line for a low boric acid content complies in this figure with the front edge of the plane and the other straight for a high boric acid content complies with the rear edge of the plane.

The analysis of all results gives the effects (or the coefficients) of the factors for the different responses. Figure (5) shows the results which will now be discussed.
THE VITREOUS ENAMELLER

Fig. 5: Factor coefficient plot

The density of the slurry results from the effects of clay and water. All the other effects are not significant for this response.

The pH-values of the slurry results are just as expected from the acid-base-balance boric acid and borax. The only surprising thing is that there is no interaction between these factors regarding the pH-value response. The resultant ratio for the neutralisation approximately corresponds with the reaction shown in equation (4):

$$[B_4O_5(OH)_4]^2^- + 2 H_3BO_3 = 2 [B_3O_3(OH)_4]^-$ + H_2O$$

(4)

The difference can be explained by the effect of adsorption of borax on to the clay. This interaction between clay and borax is also realised even when it is not yet significant for that response.

The milling fineness of the slurry is determined mainly by the interaction of boric acid and borax which seems to hinder the crushing process. But the results for this response do not have the statistically provided security like the results for the density, the pH-value and the shear stress, which may be shown with the analysis of variance. Fig.(6) ANOVA-Plot.

The applied weight is a fast and easy to achieve test result for the applied thickness of the slurry on the substrate. Increasing the amount of clay corresponds with an increase of thickness. Besides that factor, only the interaction between clay and borax increases the applied weight - with more
trials this interaction would be most probably significant too. Not surprising is the liquefying effect of water and the salts boric acid and borax, but also the interaction between these two factors increases the effect.

The response - thixotropy - is mainly decreased by the factor water and the interaction between boric acid and borax. The interaction effect of the neutralisation (eq. 4) is valid, which means that the product of this neutralisation - the complex polyborate ion \([B_3O_3(OH)_4^-]\) - must be responsible for this effect. The interaction between clay and borax is also already valid (this will also be seen by the good analysis of variance) and it increases the thixotropy.

The results for the maximal shear stress are also definite (value at the end frequency of 200 Hz). Only clay increases this response, the factors water, borax and boric acid lower the result. There is some correlation between the results of the responses for the shear stress and the applied weight - only the effect of the interaction between boric acid and borax differs.

Figure (6) shows the analysis of variance plot. Each left column shows the variation of the response explained by the model. The column in the middle shows the variance of the response not explained by the model. In the case where the third column is smaller than the first one, the reproducibility of the trials using this model is already within the 95% confidence level.

![Analysis of variance plot](image)

**Fig. 6: Analysis of variance for the responses**
As was discussed previously, the curves for the shear stress could be fitted with the Ostwald de Waele law. Now the target was to calculate the rheograms from the factors. Figure (7) shows the effects for the viscosity and the exponent $n$.

![Scaled & Centered Coefficients for Viscosity](image1)

![Scaled & Centered Coefficients for Viscosity $n$](image2)

First of all, this approach is interesting to achieve the result for the apparent viscosity - which was between 1.6 and 13.7 Pas for the range of the trials - but furthermore the analysis of the factor effects onto this response will permit calculation of the rheograms at a later time. This worked well and it is now possible to calculate the rheogram from the factors (fig.(9) page 77). Additionally, it is also possible to calculate the opposite way to give the rheologic factors for a desired rheogram. The two resultant interactions are also significant for these responses - especially for the exponent $n$ (fig(8) page 76).

This analysis also points out that the differences of the viscosity for the structural degradation and the building up of the structure are based on a different effect of boric acid and borax for the two cases. This is valid for the apparent viscosity as well as for the exponent $n$. This effect might also be explained by phenomena of adsorption of the diffuse double-layer.
Figure (10) shows the ANOVA-plot for the responses viscosity and exponent $n$ out of the factors.

The results allow the desired calculation without any restrictions.

**RESULTS FOR THE PLAN WITH TWO FRITS**

It is well known that set-up salts for different frits have a different effect. In addition to the first frit, which has an acid resistance according to EN-ISO 14483-1 class “AA”, a second frit with a lower acid resistance “A” is used. Figure (11) shows the determined coefficients.
The results confirm the first plan. For the pH value response, an increasing effect of the “A” frit is visible. This must be the effect of leaching out the alkali ions from the frit. As a result, the flow out time of the 6mm Ford cup, the applied weight and the shear stress will all be influenced.

Incidentally, during this investigation we also realised that the results for the Ford cup with a 6mm drain hole are much more reliable than those with the drain hole of 4mm. The 4mm drain hole is only usable for a narrow band of the viscosity.

The effect of the frit is less than expected. A frit which will leach to a greater amount might give a stronger effect.

The “AA” frit is not set as an individual factor, because in the mixture system it would only be a pseudo factor having exactly the opposite properties which are found for the “A” frit. This is a consequence of the balance of the model.

Figure (12) shows the confirmed interaction effect of clay and borax in the system with two frits. Due to the interaction effect the plane is twisted. Without interaction, there would only be a slightly tilted straight plane in the diagram.

Within the investigated system, the low setting effect of kaolin is of interest. But compared to the white clay used this is not surprising as this white clay contains a higher amount of illite. The setting effect of illite, a hydro-muskovite, is comparable with montmorillonite.
SUMMARY

From material view, the vitreous enamel slurry consists of the dispersion agent, water with the dissolved salts and the dispersed material comprising water insoluble vitreous enamel frit and clay with its content of feldspar and quartz. The flow rating of such a suspension is difficult to grasp, as it is influenced by many factors. The purpose of this work was to find a way of being able to calculate this flow rating in order to find an optimised rheology for applications such as spraying, dipping and flow coating. The problem is now reduced to definition of what someone wants. To adjust the rheology when we know the factors and the interactions is no longer a problem.

Additionally a vitreous enamel slurry must be optimised for other requirements. Just to name some of them: biscuit strength; low drying shrinkage to prevent drying cracks; brilliance of the surface which may not be reduced; the resistance to ageing of the slurry giving a stable rheology for a longer period; and it’s wetting ability for the substrate.
ACKNOWLEDGEMENT

Thanks to Ms. N. Köker who did all the practical work for this investigation for her Bachelor thesis at the Institute for Applied Material Science from the University of Duisburg in our laboratory.

REFERENCES


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INTRODUCTION

A modern kitchen with pans and a range provides a good overview of recent improvements in porcelain enamels. The key attributes of environmental-friendliness, mechanical toughness, thermal resistance, cost effectiveness and efficiency keep enamels competitive with other materials and lead to the creation of new application technologies.

ALUMINIUM AND ALUMINISED STEEL COOKWARE

With good scratch and heat resistance, aluminium enamels are widely used on the exterior of pot and pans. These are based on frits with a relative low glass temperature and high thermal expansion that is compatible with approximately 590°C (1100°F) melting point and $24 \times 10^{-6}/K$ linear expansion of aluminium alloys.

The original low-temperature frits contained about 25-40% lead oxide as flux. Recent increases in environmental and regulatory scrutiny such as the European Restriction of Hazardous Substance (RoHS) Directive are making the use of toxic substances even in an indirect food contact environment unacceptable.

The solution to the lead content was to replace it with about with about 8-12% vanadium pentoxide as a flux, but this material also has toxic issues. Due to the volatility in commodities prices, the vanadium pentoxide has been reduced to 1% or less. Cadmium-free red colours as well as metallics\textsuperscript{1} have also been developed for cookware to catch consumer’s eye on the shelf. An example of
a lead-free, low-vanadium, cadmium-free cookware set is shown in Fig. 1. A further development in low-temperature enamels has been the development of an easy-to-clean glass/non-stick composite with superior scratch resistance and heat resistance compared to traditional organic non-stick coatings.\cite{2}

![Fig.1: RoHS-compliant red coating on cookware exterior.\textsuperscript{(1)}](image1)

![Fig.2: Thermal image of an enamelled cast aluminium pan support](image2)
Another option for single coat coloured enamel is to apply it over enamelling grade aluminised steel, which is used to make hollowware and architectural panels. This substrate is decarburised steel coated with 25-40mm (1-1.6mils) of a 90% aluminium and 10% silicon alloy. It can be drawn and welded, and the only required surface preparation is an alkaline degrease. Furthermore, a vanadium-free, RoHS compliant clear frit can be used to make colours and metallics. The expansion curve obtained with an Orton Model 1000R dilatometer in Fig. 2 shows how this specially formulated glass fits aluminised steel without containing lead; note vanadium-based frits have too high of an expansion for aluminised steel.

**PAN SUPPORTS**

Cast iron is associated with high quality because of the heat capacity, thickness and weight of the metal. Electrophoresis is a water-based, nearly 100% efficient means of enamelling complex cast iron parts with excellent coverage.[4] The ware is the anode in an electrochemical cell, and the application of a DC current negative charges the porcelain particles. Finally, electro-osmotic dewatering results in a bisque strong enough for part transfer to the furnace. Smooth, acid resistant matt black enamels have been developed as well as durable single-coat grey and taupe colours. Other types of pan supports currently produced are steel wire pan supports of various dimensions coated with spray or electrostatic powder application.

The ferrous pan supports have an uneven heat distribution. An alternative is using cast aluminium as a substrate to take advantage of the thermal conductivity of 140-150W/m.K and density of 2.71g/cm³ compared to 46W/m.K and density of 7.15g/cm³ for cast iron. The thermal image of an enamelled aluminium pan support in Fig. 3 shows the even temperature distribution from the better distribution of heat energy. Aluminium pan supports offer new market opportunities pleasing to consumers such as a lighter weight stove.[5]
STEEL ENAMELS

Steel is an inexpensive material from which to produce major appliances such as built-in ovens, and cooktops requiring superior mechanical and thermal performance. “No nickel-no pickle” ground coats permit enamelling with a minimal alkaline degrease pre-treatment. The wash solution contains hydroxide solutions with surfactants to remove drawing compounds from the metal surface. A typical cleaning cycle for decarburized enamelling-grade sheet steel is shown in Table 1 where ambient is room temperature.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Time (sec)</th>
<th>Temp (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Wash</td>
<td>30</td>
<td>Ambient to 50</td>
</tr>
<tr>
<td>Clean</td>
<td>60</td>
<td>45 to 70</td>
</tr>
<tr>
<td>Clean</td>
<td>60</td>
<td>45 to 70</td>
</tr>
<tr>
<td>Rinse</td>
<td>30</td>
<td>55</td>
</tr>
<tr>
<td>Rinse</td>
<td>30</td>
<td>Ambient</td>
</tr>
<tr>
<td>De-ionized</td>
<td>30</td>
<td>Ambient</td>
</tr>
<tr>
<td>Dry</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Typical cleaning cycle for sheet steel

Steel is typically enamelled in mass production with wet spray, wet dipping, or dry electrostatic spray. A high speed flow coater is an alternative to a dip tank, particularly for oven cavities. It reduces manpower and allows two-sided 100% coverage while meeting surface quality requirements with relatively small footprint. In one published case study[6], a high speed flow coater held 662L (175gal) of enamel that was pumped at 190L/min (50gal/min) to prevent
shear. It was determined that larger flowcoat wands better delivered material than a higher number of smaller nozzles. Overall, the machine operated at 95% first run yield at 13.4m/min (44ft/min).

With electrostatically sprayed enamels, the system is 99% efficient because of the use of recycled material. Single fire colours are possible through 2c1f application of base coats or smelted-in colour. This is frequently used for coating cooktops.

Powder porcelain is more economical compared to alternative materials such as organic powder paint and stainless steel, particularly because of the long-term durability. Table 2 shows the economics of low- and high-end powder paint versus those of powder porcelain in Table 3. The data is drawn from a published case study\(^7\), and the costs for the steel and coatings have been updated.

<table>
<thead>
<tr>
<th>Type</th>
<th>Low Heat Resistance</th>
<th>High Heat Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line Speed (m/min)</td>
<td>7.6</td>
<td></td>
</tr>
<tr>
<td>Steel (USD/m(^2))</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Pre-treatment</td>
<td>Alkaline Degrease + Phosphate</td>
<td></td>
</tr>
<tr>
<td>Pre-treatment cost (USD/m(^2))</td>
<td>0.022</td>
<td>0.022</td>
</tr>
<tr>
<td>Application (mm)</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Potential Pass Yield</td>
<td>98</td>
<td>98</td>
</tr>
<tr>
<td>Cost/Area (USD/m(^2))</td>
<td>1.05</td>
<td>3.49</td>
</tr>
<tr>
<td>Labour (USD/m(^2))</td>
<td>0.65</td>
<td>0.65</td>
</tr>
<tr>
<td>Hanger Cleaning (USD/m(^2))</td>
<td>0.043</td>
<td>0.06456</td>
</tr>
<tr>
<td>Scrap (USD/m(^2))</td>
<td>0.011</td>
<td>0.02152</td>
</tr>
<tr>
<td>Energy Cost (USD/m(^2))</td>
<td>0.136</td>
<td>0.142</td>
</tr>
<tr>
<td>Total Cost (USD/m(^2))</td>
<td>16.91</td>
<td>19.39</td>
</tr>
</tbody>
</table>

*Table 2: Powder paint economics*
Table 3 shows continuous improvements being made to powder porcelain through implementation of changes like no-transfer lines to reduce labour and increase quality. While there is a 0.54 USD/m² premium for porcelain powder on a more efficient no-transfer lines versus a low-heat resistant powder paint, the porcelain offers the advantages shown in Table 4 such as harder, more heat-resistant coating that require simpler, more environmentally-friendly pre-treatment. When compared to heat-resistant powder paint, the powder porcelain is less expensive as well.

Table 4 clearly shows the value proposition gained by the premium for powder porcelain and certainly maintained against high-temperature paints. Powder porcelain is even more competitive with 304-series stainless steel, which is estimated to cost 38.74USD/m². While stainless steel is a popular appliance finish, it is not only expensive but has high reject rates and poor cleanability and heat resistance. A recent development has been to create metallic coloured enamels with the performance of porcelain and an appearance suggesting stainless steel or copper.

Table 3: Powder porcelain economics

<table>
<thead>
<tr>
<th>Type</th>
<th>Transfer</th>
<th>No-Transfer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line Speed (m/min)</td>
<td></td>
<td>5.5</td>
</tr>
<tr>
<td>Steel (USD/m²)</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>Pre-treatment</td>
<td></td>
<td>Alkaline Degrease</td>
</tr>
<tr>
<td>Pre-treatment cost (USD/m²)</td>
<td>0.005</td>
<td>0.005</td>
</tr>
<tr>
<td>Application (mm)</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>Potential Pass Yield</td>
<td></td>
<td>92</td>
</tr>
<tr>
<td>Cost/Area (USD/m²)</td>
<td></td>
<td>1.53</td>
</tr>
<tr>
<td>Labour (USD/m²)</td>
<td></td>
<td>0.807</td>
</tr>
<tr>
<td>Hanger Cleaning (USD/m²)</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Scrap (USD/m²)</td>
<td></td>
<td>0.04304</td>
</tr>
<tr>
<td>Energy Cost (USD/m²)</td>
<td></td>
<td>0.185</td>
</tr>
<tr>
<td>Total Cost (USD/m²)</td>
<td></td>
<td>17.57</td>
</tr>
</tbody>
</table>

Table 4: Powder porcelain value proposition

<table>
<thead>
<tr>
<th>Process</th>
<th>Powder Paint</th>
<th>Powder Porcelain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesion</td>
<td>Good</td>
<td>Very Good</td>
</tr>
<tr>
<td>Corrosion</td>
<td>500 Hrs Salt Spray</td>
<td>Superior</td>
</tr>
<tr>
<td>Pencil Hardness (ASTM D 3363-00)</td>
<td>4H</td>
<td>&gt; 9H</td>
</tr>
<tr>
<td>Heat Resistance</td>
<td>&lt;&lt; 1000 °F</td>
<td>1000+ °F</td>
</tr>
<tr>
<td>Gloss</td>
<td>Less Gloss</td>
<td>High Gloss</td>
</tr>
<tr>
<td>Design Restrictions</td>
<td>Less</td>
<td>Some</td>
</tr>
<tr>
<td>Process Controls</td>
<td>Pretreatment needs more control</td>
<td>Similar to paint; more guns</td>
</tr>
<tr>
<td>Environmental Concerns</td>
<td>Pretreatment</td>
<td>Moderate to None</td>
</tr>
</tbody>
</table>
The quality of powder porcelain has improved over time. Fig. 4 shows the data for the percentage of acceptable parts coated for the North American appliance manufacturer from November 2004 to August 2007. A linear fit to the data shows a steady upward increase, and the graph shows fewer significant negative excursions. As light spray and black specks are given as two of the major causes of reject, it can be concluded the supplier has improved the powder quality through process optimization.

It is straightforward the treat the wastewater, dust and furnace gases from the appliance of porcelain enamels, and the technology has been available since at least the 1960s.[9] Degreasing and enamel wastewaters need to be neutralised and treated to remove any regulated contaminants before discharging out of the plant or sending to a landfill. With wet enamels, it is possible to use reclaim with a filter press, mix it with virgin material, and coat more pieces. Dust and furnace gases are removed with dust collectors and/or wet scrubbers. In a wet scrubber, pollution gases are brought into contact with scrubbing liquid to remove the pollutants. The pollutants are either sprayed with liquid or forced through it. These can be designed to collect particulate matter and/or gaseous pollutants, and a mist eliminator separates droplets in the inlet stream from the outlet gases.
SUMMARY

Despite being a mature technology, continuous progress is being made on porcelain enamels. RoHS-compliant single coat colours are available for aluminium and aluminised steel. New uses are being found for low-temperature enamels such as coating cast aluminium pan supports. Also in pan supports, electrophoretic enamelling has been developed to obtain excellent coverage and surface colours as matte black and single-coat colours are also being used. For sheet steel, ground coats requiring only alkaline degreasing offer an economical, environmentally friendly metal pre-treatment. The steel can then be coated in mass in a very cost competitive manor with high flow coaters for wet enamels or no-transfer electrostatic powder porcelain lines. Overall, porcelain enamel continues to be economical, durable, and environmentally friendly.

REFERENCES


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ABSTRACT

Initial testing has shown that specialised porcelain enamel coatings can significantly increase the strength of the bond developed between Portland cement mortar and steel reinforcing materials. Incorporating un-hydrated Portland cement into the vitreous enamel fired onto smooth mild steel rods was found to increase the maximum bond strength by up to 325% compared to similar uncoated (bare) steel rods. Preliminary data from corrosion tests performed with steel samples enamelled with the glass cement mixture showed that the coated steel corroded only where the metal was intentionally exposed. Specialised porcelain enamel coatings can potentially be used to improve the performance and service life of steel used in concrete reinforcement in forms ranging from metal fibre to conventional rebar to sheet metal panels in composite flooring.
INTRODUCTION
Since its invention in the late 1800’s, steel-reinforced concrete has been a widely used and valuable building material; new designs and applications continue to arise. Reinforced concrete structures combine the tensile or bendable strength of metal and the compression strength of concrete to withstand heavy loads. Steel embedded in concrete typically develops a weak bond between the surface of the steel and the surrounding hydrated cement paste. Investigators have noted that unreacted, bleed water from the cement paste accumulates at the surface of the reinforcing steel[1, 2]. Cement paste does not form a chemical bond with the underlying steel and the water-rich paste immediately adjacent to the steel is typically weaker that the average paste in the mass of concrete.

The difficulty in developing strong bonding for steel reinforcement in concrete can be related to the complex nature of the cement paste and the lack of bonding layer that will perform as a coupling surface. Hydrating portland cement paste is largely a mixture of calcium hydroxide, calcium carbonate, and calcium alumino-sulphate in a calcium silicate hydrate gel[3, 4]. Over 20 chemical compounds are thought to form during the hardening of cement pastes[5]. Investigations undertaken with steel reinforcement in conventional concrete indicate that soft crystals of calcium hydroxide are the most common material noted at the steel surface[6]. A dense calcium silicate hydrate phase typically does not form at the surface of steel reinforcement unless the composition of the concrete is altered to prevent segregation of the concrete at the iron-paste interface[7-9]. Even when a hard paste can be produced around steel, the phases at the interface are usually ferrous and ferric hydroxides that are not tightly bonded to the silicate gel in the paste[10]. Modifications of the composition of the concrete and treatments of the steel surface to increase the strength of the bond have been only moderately successful. For example, the addition of methylcellulose to the concrete and the application of sodium silicate to the steel surface produced only a slight increase in bond strength and often the variation in bond strength has scatter that masks the modest effects of surface treatments[7].

Without a bonding layer on reinforcing steel, the best adhesion mechanism that can be postulated is the production of an electrical double layer at the contact of the paste and the steel. Calcium, aluminium and silicon couple by
electrical charges across the interface with hydroxide ions on the surface of the steel and iron atoms couple with unbalanced oxygen atoms in the paste\textsuperscript{10}. Mlodecki\textsuperscript{5} describes the bond between the iron atom and the hydroxyl groups in the cement paste as a form of hydrogen bonding with the hydroxyl ion coupling with the pair of electrons that are held in the outer 4\textsuperscript{th} orbit of the iron atom. It can be concluded that the bond at the steel-cement paste interface is a much lower energy bond than bonds in either adjoining phase.

The strength of reinforcing concrete is also compromised by the eventual corrosion of the steel embedded in the concrete \textsuperscript{11}. As the carbon dioxide from the air diffuses into the concrete it neutralises the alkalinity of the concrete around the steel; the passive coating protecting the steel is destroyed and the steel corrodes. The corrosion products take up a larger volume than the metal and the expansion puts the surrounding concrete in tension and produces cracking. The corrosion problem is accelerated by the presence of chloride ions that can infiltrate into the concrete from contamination of materials used to proportion the concrete \textsuperscript{12}.

Modifying the surface of the steel to reduce the likelihood of corrosion by plating or polymer coating the steel does nothing to improve the bond strength. Galvanising or epoxy coating may actually reduce the bond strength \textsuperscript{13-15}.

The present investigation examines effects that can be produced by fusing modified porcelain enamel to a steel surface prior to embedding the steel in concrete. This approach is different from previous coating technology in that porcelain enamelling can firmly bond a reactive silicate phase to steel and develop an outer layer of cement grains capable of bonding to the surrounding hydrating cement paste.

**EXPERIMENTAL METHODS**

**PREPARATION OF RODS**

The strength of the bond between the steel reinforcement rods and the mortar was determined by measuring the maximum force required to extract a steel test rod from a hardened mortar cylinder cast from a well-defined standard sand-cement mixture cured so as to produce mortar with a consistent known strength. This peak value on a pullout load-verses displacement curve is also
referred to as the ultimate bond strength \cite{16}. The steel test specimens consisted of 6.35mm diameter mild steel (AISI C1018) rods cut to be 76.2mm in length. One end of the rod was threaded to allow it to be attached to the test apparatus. The length of the rod permitted it to be embedded in mortar to a depth of 63.5mm. The rods were finished by the manufacturer (Alabama Speciality Products, Munford, AL) with a smooth, glass bead-blasted surface.

The test rod surfaces were prepared for ground coat enamelling using a grit polishing and an alkaline cleaning process. This cleaned only surface preparation generally involves physically cleaning the steel surface and rinsing with commercial alkaline cleaning solutions followed by a series of clean water rinses.

**COMPOSITION OF FRIT**

The composition of the glass frit applied to the test rods varied with the manufacturer and the exact composition of most formulations is propriety. In all cases the manufacturer was asked to furnish an alkali-resistant formulation that would be a suitable ground coat for a two-firing application. The composition for a typical glass frit prepared for this application is given in Table 1.

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silicon dioxide SiO₂</td>
<td>40 - 45</td>
</tr>
<tr>
<td>Boron oxide B₂O₃</td>
<td>16 - 20</td>
</tr>
<tr>
<td>Sodium oxide Na₂O</td>
<td>15 - 18</td>
</tr>
<tr>
<td>Potassium oxide K₂O</td>
<td>2 - 4</td>
</tr>
<tr>
<td>Lithium oxide Li₂O</td>
<td>1 - 2</td>
</tr>
<tr>
<td>Calcium oxide CaO</td>
<td>3 - 5</td>
</tr>
<tr>
<td>Aluminium oxide Al₂O₃</td>
<td>3 - 5</td>
</tr>
<tr>
<td>Zirconium oxide ZrO₂</td>
<td>4 - 6</td>
</tr>
<tr>
<td>Copper oxide CuO</td>
<td>nil</td>
</tr>
<tr>
<td>Manganese dioxide MnO₂</td>
<td>1 - 2</td>
</tr>
<tr>
<td>Nickel oxide NiO</td>
<td>1 - 2</td>
</tr>
<tr>
<td>Cobalt oxide Co₃O₄</td>
<td>0.5 - 1.5</td>
</tr>
<tr>
<td>Phosphorus oxide P₂O₅</td>
<td>0.5 - 1</td>
</tr>
<tr>
<td>Fluorine F₂</td>
<td>2 - 3.5</td>
</tr>
</tbody>
</table>

*Table 1: Composition range of a typical alkali-resistant ground coat enamel for steel* \cite{17, 18}
APPLICATION OF FRIT

Porcelain enamels were applied by making a slurry of frit and clay with water containing electrolytes and the surfactants needed to achieve the desired suspension and viscosity. The test rods were coated by dipping, or flow coating the slurry onto the surface. Where portland cement (Type I-11) and frit were fired in a two-step process, the ground coat enamel was fired and the dry portland cement was applied immediately after the test rod was taken from the furnace. The rod would then be fired briefly for a second time to fix the portland cement to the ground coat. When one-step applications were made, the portland cement was mixed 50% proportion by volume with the frit. The cement was added to the porcelain enamel slurry and applied to the rod surface.

FIRING OF THE FRIT

The porcelain enamel coating was fired onto steel at temperatures from 745 to 850°C. Firing times are typically from 2 to 8 minutes depending on the mass of metal to be heated and the size of the furnace. The goal was to produce a ground coat enamel 50 to 100mm thick with the cement embedded in the ground coat. No attempt was made to obtain an even or smooth coating as would normally be the case for porcelain enamelled appliances, bathtubs, etc. (Figure 1, page 107).

PREPARATION AND TESTING OF EMBEDDED RODS

Each test rod was inserted in a 50.8mm in diameter, 101.6mm long cylinder mould filled with fresh mortar. The rod was clamped at the top so that a 63.5mm length lower portion of the rod was under the mortar. Each cylinder was tapped and vibrated to remove entrapped air and consolidate the mortar. The samples were placed in a 100% humidity cabinet at 25°C and cured for 7 days. After the test apparatus and the maximum force required to lift the rod out of the mortar was measured using an MTS Model 810 Testing Machine (Material Testing Systems, Minneapolis, MN). After testing, the cylinders were split along the centre axis so that the rods could be removed and the location of the fracture surfaces could be determined.
SALT WATER CORROSION EXPOSURE TESTING

The examination of corrosion phenomena in the bare rods, enamelled rods and enamelled rods with the portland cement addition was done by exposing set of three identically prepared rods to a 3% sodium chloride solution in partly saturated sand (Figure 2, page 107). The goal of the testing was to provide conditions that would promote the mode of corrosion that would occur in carbonated (non-alkaline) portland cement concrete that was contaminated with chloride. The pH of the wet, drained sand ranged from 6.0 to 6.5 and the temperature was maintained at 25°C. Because of the typically high electrical resistance of the enamel, corrosion would only occur if a defect (or holiday) that exposed the metal rod was intentionally prepared in the enamel coating. Vitreous enamel typically has a volume resistivity of $1 \times 10^{14}$ ohm.cm, so a perfect enamel surface is an insulator. Defects were prepared in each of the coated rods. All of the enamelled rods were tested using the procedure outlined in ASTM C 876 and showed potentials more negative than -0.35 CSE (copper sulphate electrode) indicating corrosion was occurring. The test rods were examined after 72 hours of salt water exposure. After 40 days of exposure the rods were removed from the sand beds and the surfaces of selected samples were ground to determine the extent of corrosion.

RESULTS AND DISCUSSION

RESULTS OF PULL-OUT TESTS

Table 2 summarises the results of the pull-out testing for uncoated (control) rods glass-enamelled rods, enamelled and abraded rods and rods coated with glass-portland cement bonding enamel. Each series of test rods was prepared in at least triplicate and results are presented as the average value and the standard deviation of the series.
Table 2 Results of Pull out Tests of Uncoated and Enamelled Rods

<table>
<thead>
<tr>
<th>Sample</th>
<th>Treatment of test rod</th>
<th>Average Peak Force Required (N)</th>
<th>Std. Deviation (N)</th>
<th>Location of Failure Surface</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (uncoated)</td>
<td>Cleaned bare steel</td>
<td>2618.2</td>
<td>466.17</td>
<td>Metal surface</td>
<td>Bare steel rod</td>
</tr>
<tr>
<td>Enameled, smooth glass</td>
<td>Glass only, no portland cement</td>
<td>3498.0</td>
<td>540.90</td>
<td>Glass surface</td>
<td></td>
</tr>
<tr>
<td>Enameled, glass abraded with corundum</td>
<td>Glass only, no portland cement</td>
<td>2630.2</td>
<td>519.55</td>
<td>Glass surface</td>
<td></td>
</tr>
<tr>
<td>Enameled, glass abraded with portland cement</td>
<td>Portland cement not fired on enamel</td>
<td>4888.8</td>
<td>292.25</td>
<td>Glass surface</td>
<td></td>
</tr>
<tr>
<td>Enameled with portland cement (T enamel)</td>
<td>Twice</td>
<td>7860.9</td>
<td>1258.8</td>
<td>Metal surface</td>
<td></td>
</tr>
<tr>
<td>Enameled with portland cement (FL enamel)</td>
<td>Single</td>
<td>9116.2</td>
<td>1657.4</td>
<td>Metal surface and mortar</td>
<td>One rod stretched</td>
</tr>
<tr>
<td>Enameled with Portland Cement (FD enamel)</td>
<td>Single</td>
<td>11124.6</td>
<td>235.3</td>
<td>Metal surface and mortar</td>
<td>One rod broke under tension</td>
</tr>
</tbody>
</table>

The bond between the concrete and steel in the uncoated control rods on an average failed at 2618N force. The glass enamelled rods showed bond strengths that were similar to those of the uncoated rods. The rods enamelled with the mixtures of glass and portland cement required 3 to 5 times the force (7860N to 11125N) used to break the bonds between the concrete and steel on the uncoated rods (2618N).

Failure surfaces on the rods with the composite glass frit-portland cement fired coating showed failures at both glass-metal interface and inside the surrounding concrete (Figure 3, page 107). Where the failure occurred on the surface of the metal; small metal fragments pulled from the surface of the test rod could be observed on the glass adhering to the concrete.
One sample enamelled using the mixed glass-portland cement frit (FL enamel) came out of the pull-out test with the rod stretched suggesting the bond strength was approaching the limit at which it could reliably be measured using this experimental design. Comparable results were noted on a sample prepared using mixed glass-portland cement frit (FD enamel) where the test rod failed at the first screw thread at the top of the rod.

**RESULTS OF THE SALT WATER EXPOSURE TESTS**

Examination of the test rods that were embedded in the salt water-sand mixture showed that, as expected, the enamelled surface showed no detectable changes and the cleaned bare steel rods had not spread under the enamel. After 40 days exposure, the uncoated rods were heavily encrusted with iron oxide.

**CONCLUSIONS**

The results of this investigation have indicated that:

1. Conventionally formulated glass-only enamel applied to steel produced bond strength in mortar that was comparable to that developed by uncoated steel.

2. Abrading the conventional enamel with corundum produced no improvement in average maximum bond strength.

3. Abrading the conventional enamel with portland cement produced approximately a 40% increase in average maximum bond strength over smooth conventional glass.

4. Composite enamel composed of a hydraulically reactive component such as portland cement and a commercial enamelling glass can produce a coating that provides an average maximum bond strength that is up to 325% stronger than the average maximum bond strength obtained on bare steel.

5. Reactive enamels (enamels containing a hydraulically reactive component) can potentially be used on a variety of steel reinforcing materials (rebar, fibre and steel sheet metal) to improve the bond from concrete to steel and may reduce the risk of corrosion of the steel reinforcement.
Fig. 1: Examples of test rods prepared with various samples of glass frits. Note the rough, irregular surfaces on samples due to the incorporation of the portland cement in the surface of the melted glass. One inch on the scale equals 25.4 mm.

Fig. 2: Test rods set up for salt water exposure

Fig. 3: Mortar cylinder split after testing to show the surface of the glass adhering to the hardened mortar and the clean surface of the metal test rod. Examination of the surface of the glass showed fragments of metal embedded in the glass. One inch on the scale equals 25.4 mm.
CONCLUSIONS

The results of this investigation have indicated that:

(1) Conventionally formulated glass-only enamel applied to steel produced bond strength in mortar that was comparable to that developed by uncoated steel.

(2) Abrading the conventional enamel with corundum produced no improvement in average maximum bond strength.

(3) Abrading the conventional enamel with portland cement produced approximately a 40% increase in average maximum bond strength over smooth conventional glass.

(4) Composite enamel composed of a hydraulically reactive component such as portland cement and a commercial enamelling glass can produce a coating that provides an average maximum bond strength that is up to 325% stronger than the average maximum bond strength obtained on bare steel.

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REFERENCES


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Overview:

If you want to maintain a competitive edge in the metal finishing industry then you must respond rapidly to customer returns and production issues, using the appropriate analytical techniques to get the right answers fast. If the problem is related to the composition of the surface or near-surface surface region then the traditionally used techniques of optical microscopy, electron microscopy or EDX/EDXS/EDAX will probably only provide part of the solution. In such circumstances, you need surface analysis and depth profiling.

Loughborough Surface Analysis Ltd (LSA) and Midlands Surface Analysis (MSA) in association with the Institute of Metal Finishing are organizing a one-day workshop addressing surface analysis and depth profiling techniques and how they can be used to help with a variety of challenges relating to metal finishing. The workshop draws upon a wealth of real-world experience in using these techniques to assist with issues such as:

- staining
- corrosion
- delamination
- contamination and impurities
- cleaning
- etching
- adhesion
- surface treatment

The workshop will be held at Aston University, Birmingham, located at the heart of England, with good road, rail and air links to all parts of the UK and continental Europe.

The workshop will consist of a series of seminars given by experts in the field on the individual techniques (including case studies), together with practical demonstrations on some of the techniques in the laboratories of MSA. Free analysis and evaluation of participants’ own samples may be undertaken by prior arrangement. Opportunities will also be provided to discuss participants’ specific cases either in an open forum or in private with the analysts present.
Who should attend?
This workshop provides a unique opportunity for failure analysts, process engineers, yield improvement managers, quality control managers and R&D staff to learn about or refresh their knowledge of surface analytical and depth profiling techniques. If you have the task of fixing the material related problems when they arise then this is the workshop for you.

Agenda:
Previous Evening
19.30 Dinner (Optional)

Workshop
9.30 Coffee and Registration
10.00 Welcome, Introduction and overview of workshop
   Mike Petty, LSA
   Peter Farr, Institute of Metal Finishing
10.15 X-ray photoelectron Spectroscopy (XPS)
10.45 Auger electron spectroscopy (AES)
11.15 Coffee break
11.45 Secondary ion mass spectrometry (SIMS)
12.30 Laser induced mass analysis (LIMA)
12.45 Atomic force microscopy (AFM), nano hardness and nano scratch testing
13.00 Lunch, networking
14.00 Laboratory demonstration of XPS, AES and AFM techniques, to include customer sample analysis
15.30 Tea break
15.45 Clinic / open forum
16.30 Close
(There will be the opportunity for participants to discuss problems of a commercially confidential nature with representative from LSA and MSA on a one to one basis after the close of the meeting.
If required, NDAs should be supplied to cover items discussed in these separate meetings).

Registration:
The fee for this workshop is £75 + VAT.
To register please send an e-mail with your contact details to m.petty@lsaltd.co.uk

For further information regarding the workshop please contact:
Mike Petty: 07767 390227 m.petty@lsaltd.co.uk
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