

annual science review

March 2017



Helping
Great Britain
work well



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Tackling ill health: These case studies illustrate how our science is contributing to action to improve health outcomes.



Keeping pace with change: A selection of case studies which show how our science is being used to anticipate and tackle new health and safety challenges.



Acting together: A series of case studies which demonstrate how our science and evidence is being used to promote broader ownership of health and safety in Great Britain.



Managing risk well: Our science is being used to simplify risk management and help businesses to grow: the case studies in this section show how.



Supporting small employers: These case studies demonstrate how we are supporting simple advice for SMEs so they know what they have to do.



Sharing our success: The case studies in this strategy theme show how our specialists are using science to promote the benefits of Great Britain's world-class health and safety system.

43 References and further reading

HSE scientists produce over 100 publications a year. We are committed to making research findings 'open access' – accessible online at no cost to the user. We ensure open access to research papers in peer-reviewed journals and journal-like conference proceedings (provided the publisher gives this option) describing research led by our scientists.

Foreword



WELCOME TO HSE'S second annual science review. High-quality science, evidence and analysis underpin HSE's risk-based, goal-setting regulatory regime and are vital for ensuring effective and proportionate risk management that protects workers and safeguards the public while enabling productivity, innovation and growth. Our Science and Evidence Strategy 2016-2020¹ is at the heart of HSE's approach to developing the evidence base in support of our

regulatory and policy activities, and in supporting the delivery of the Helping Great Britain Work Well² strategy for the health and safety system.

This annual science review uses case studies to illustrate how the six themes within Helping Great Britain Work Well are being supported through our delivery of science and evidence. The review provides fantastic examples of where our scientific work, funded either by HSE or by external sources, is helping to progress the strategy.

Of particular note has been the concentrated effort undertaken to review the evidence base to inform the development of the new Health and Work Strategy³. This year, our specialists used a combination of internal events, support from the Workplace Health Expert Committee (a scientific advisory committee to HSE) and external consultation with key stakeholders to ensure that the new strategy was based on the best available evidence, both in published form and from the "coal-face" of the real world of work. I hope that you will agree that this approach provided a robust yet pragmatic evidence-based view of the current priorities for action in the area of work and health.

The science and evidence cycle within our Science and Evidence Strategy shows how we take foresight activities and synthesis of evidence to anticipate new challenges, develop the evidence base for effective interventions, and embed this in policy and enforcement approaches so that workers and the public are protected. This in turn helps to catalyse the whole health and safety system into delivering effective actions to protect workers and safeguard the public. We open this year's review by illustrating our science and evidence cycle in action – taking the example of our work to develop the evidence base and underpin actions to reduce workers' exposure to respirable crystalline silica (RCS) and the incidence of severe associated health consequences such as silicosis. We give further detail of this work in our case studies: these look at our RCS research to develop the evidence base; how our scientists engage with SMEs on the risks; the development of videos to help drive home key messages for protecting health; and the work one of our stakeholders is funding to understand the risks in the railway industry.

In our 'Meet the Staff' section, we introduce our new team of six Priority Science Hub Leads. They act together to focus our scientific activities in areas of longer-term strategic importance. I'm looking forward to presenting more of their thinking, the associated outputs and subsequent impact of this work in future reviews.

This year also saw the introduction of the Science, Engineering and Evidence Assurance Committee, a new sub-committee of the HSE Board. SEEAC has begun its work to provide the HSE Board with independent and objective assurance on the quality and relevance of our science and evidence strategy and delivery.

In summary, I hope that you enjoy reading this review of our activities over the last year. It has been a year of significant change in the way that we organise and populate our portfolio of science and evidence activities, and I think we are now better placed than ever to use the knowledge we generate to Help Great Britain Work Well.

Professor Andrew Curran
Chief Scientific Adviser and
Director of Research

The HSE Science and Evidence Cycle in action: Reducing ill-health from exposure to respiratory crystalline silica (RCS)

We catalyse engagement by others and improve performance

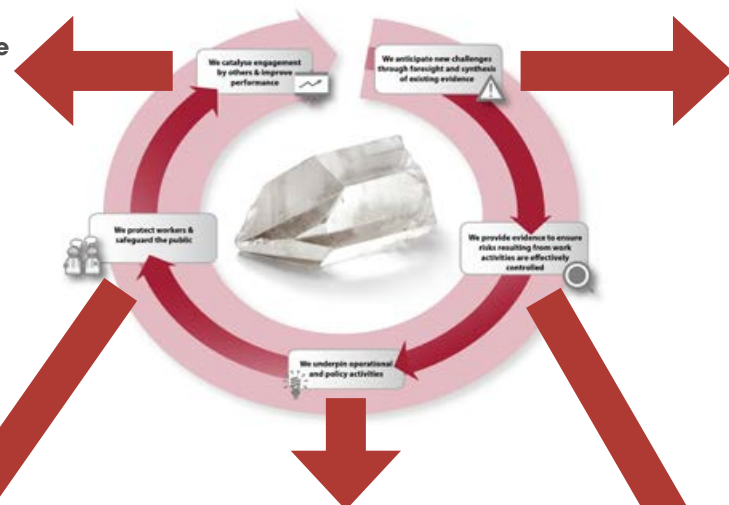
Significant engagement by scientists with stakeholders, eg

- › Engagement with British Ceramic Confederation such as keynote speech at annual pledge, and member meetings.
- › Support for Institute for Occupational Safety and Health (IOSH) 'No Time To Loose' Campaign, including lecture for Bristol branch on dust at work.
- › Support for the Chartered Society for Worker Health Protection, BOHS, 'Breathe Freely' Campaign including joint 'Spotlight on Silica' events with IOSH.
- › HSE Chief Medical Adviser contributes to the European Lung Foundation healthy lungs campaign, including occupational dust awareness - led to a media campaign including London underground posters.
- › Meetings with physicians in the British Thoracic Society to progress the planned national Registry for Silicosis.

We protect workers and safeguard the public

Activities to raise awareness of control measures and identify cases of ill health:

- › Introduction of updated Health Surveillance Guidance leads to identification of cases of silicosis.
- › Development of worker experience 'YouTube' video stories.
- › Delivery of commercial training course on Silica Health Surveillance & Control.
- › Work with the Rail Safety and Standards Board to better understand and take action to reduce silica exposures.
- › Delivery of training for managers in brickmaking, stoneworking and foundries on behavioural change, health issues and effective exposure control done within strategic research programme.
- › Planning and ethical agreement to introduce multi-disciplinary team assessment of potential silicosis cases at Sheffield Teaching Hospitals Trust.



We underpin policy and operational activities

Scientific evidence used to underpin RCS activity eg:

- › Supplementary RCS Health Surveillance Guidance published informed by disease modelling.
 - › New enforcement campaign agreed of over 500 silica exposed workplaces.
 - › Partnership work with 'Healthy Liverpool' and key sectors including construction, quarries & foundries;
 - › Support for BOHS and IOSH on their campaigns.
- Operational support to establish the efficacy of Local Exhaust Ventilation systems in stonemasons.

We anticipate new challenges through foresight and synthesis of existing evidence

Identification of novel techniques to address RCS issues:

- › In mask sampling for exposure measurement.
- › Use of exhaled breath condensate to monitor inhaled silica particles.
- › Novel approaches to modelling disease outcome.

Synthesis of over 20 years of HSE and others' research findings into improving exposure control. Evidence review by WHEC on relationship between silicosis and RCS-related lung cancer.

We provide evidence to ensure risks from work activities are effectively controlled

Longitudinal Workplace Research Study Underway:

- › 29 workplaces visited;
- › 668 workers participated;
- › 259 exposure measurements;
- › 20% of measurements exceeded the Workplace Exposure Limit;
- › 72 people found with airways obstruction;
- › 4 cases of silicosis;
- › Disease model tested and validated.

New research started into on-tool extraction in stonemasons.

Further information

Case studies on pages 20, 23, 35, and 37. *HSE Science and Evidence Strategy*¹, *RCS Health Surveillance Guidance*⁴, *Silica Training Course*⁵, *Research on RCS ill health & surveillance*⁶⁻¹², *Healthy Liverpool*, *BOHS and IOSH*¹³⁻¹⁵



Events and achievements

Events and Achievements

Visitors

HSE's Laboratory at Buxton, Derbyshire, has hosted a number of important visitors in 2016:

- › In May a group from the **Government Office for Science** visited and toured the facilities. They were particularly interested in how our science is used to enable innovation, including the hydrogen economy.
- › **Health and Safety Northern Ireland (HSENI)** and the **Health and Safety Authority (HSA)** were hosted by HSE Chief Executive Richard Judge on a visit to the laboratory in February.
- › **Paul Maltby**, former Director of Data at the Government Digital Service visited in May. It succeeded in giving him a better understanding of the contribution that HSE can make in the area of data science and analytics. He tweeted about his visit with one of 'gov's best data science teams'.
- › MP for Macclesfield **David Rutley**, had an opportunity to see and hear about the extent of HSE's involvement in the Bosley wood-flour mill explosion. He was impressed with every aspect of the investigation work saying after the visit, 'I know that all those who have been affected by the event will be grateful to know that such a full and thorough investigation is being taken forward'.

(right to left) HSE Chief Executive, Richard Judge, with Mary Trainor, Jill Swan and Helen Balmforth

Events

- › **Gillian Frost**, epidemiologist, co-ordinated the 10th Annual UK and Ireland Occupational, Environmental and Epidemiology Conference which was held at HSE's Laboratory in April 2016.
- › In May HSE economists organised and hosted the annual conference for **Government Economists in the North**, in Liverpool. It included external speakers, as well as the opportunity for the different participating departments to share good practice. Feedback from participants on the organisation and content of the conference has been excellent.
- › **HSE participated at the launch event of the Government Science and Engineering Profession Strategy** at the Royal Society in October 2016. Following workshops in HSE in support of the development of the strategy, Helen Balmforth, HSE's Head of Data Analytics, presented our cross-government data analytics work to underpin regulatory activity and emergency response for major natural and industrial hazards. We also demonstrated the impact of science on improving the world of work through a stand on our specialist incident investigation work.



Awards and honours

This year the value of our science expertise has been recognised by others who have presented staff with various awards and honours.

- **Helen Chambers**, occupational hygienist, has been appointed to the UK Expert Committee on Pesticides. This provides independent, impartial advice to the government on the science relating to pesticides. The appointment was made by Defra's Deputy Director, Chemicals, Pesticides and Industrial Emissions.

- **Mike Gray**, ergonomics and human factors Principle Specialist Inspector, was awarded the Chartered Institute of Ergonomics and Human Factors (CIEHF) Otto Edholm Award for his contribution to ergonomics and human factors.



Mike Gray (left) being presented with his award by Ian Randle, CIEHF President.



Graham Atkinson receiving award

- **Graham Atkinson**, experimental fire and explosion specialist, was awarded the International Symposium on Tunnel Safety and Security prestigious Achievement Award at a ceremony in Montreal, Canada in March 2016 for pioneering fire-safety research. The award recognised that his work is helping to build safer tunnels and save lives in tunnel fires.

- **Stuart Hawksworth**, Head of HSE's Centre for Energy, has been invited to join the task force on standards relating to the UK gas grid, set up by the Institute of Gas Engineers and Managers, IGEM. He was also invited to join the international editorial board for the new *Hydrogen Safety Journal*.

- HSE's **Statistics and Epidemiology Team** were awarded the Government Statistical Service's Presentation and Dissemination Committee quarterly 'Champion of Champions' award for their infographics statistics poster which was produced jointly with commercial and design colleagues. www.hse.gov.uk/pubns/statsposter15.htm

- The **Government Office for Science** featured the work of our specialists in response to the Ebola outbreak in West Africa and the Alton Towers 'Smiler' ride crash, in 'The 'Government Science & Engineering Story' launched in September 2016 www.governmentscienceandengineering.blog.gov.uk/the-gse-story-the-story-of-scientists-engineers-in-government/

- **Jason Gill**, experimental fire and explosion research specialist, won the IChemE 'Hazards' conference best poster prize for the work he led on 'Vapour Cloud Explosions in Steel Clad Structures'.

- **Nick Vaughan**, personal protective equipment specialist, was awarded a 'Distinguished Service Certificate' by the British Standards Institute.



Mike Clayton receiving his outstanding contribution award from Sarah McOnie at the British Safety Industry Federation.

- **Mike Clayton**, Head of the Personal Protective Equipment (PPE) Team, was awarded the Outstanding Contribution Award by the British Safety Industry Federation (BSIF). This award celebrates the contribution Mike has made to health and safety in the industry for example through his work on the Fit2Fit PPE testing scheme. Mike was also invited to join the judging panel of the BSIF 2016 Safety Innovation Awards and to give a keynote address at the 2016 annual conference of the International Society for Respiratory Protection in Japan and at the Taiwan Occupational Hygiene Association.

- **Peter Stacey**, analytical chemist, has been invited to become an assistant editor of the *Annals of Workplace Exposures and Health*.

› **John Saunders**, measurement specialist, has been invited to sit on the steering committee of the Institute of Local Exhaust Ventilation Engineers, and to participate in an international expert workshop on sulphur hexafluoride in ventilation studies being hosted at the French National Institute for Research and Security.

› **Owen Butler**, analytical chemist, has been invited to join the Editorial Board of the Royal Society of Chemistry's *Journal of Analytical Atomic Spectrometry*.

› **Paul Hamey**, Head of the exposure team in HSE's Chemicals Regulations Division, was awarded an MBE for services to the regulation of pesticides. A specialist in human exposure to pesticides, Paul is recognised as a



world-leading regulatory scientist and had a key role in the introduction of harmonised European guidance on exposure assessment.

Paul Hamey
with his MBE

› For the second year running, our **Economic Analysis Team** has been rated number one in government for their economic impact assessments during 2015/16.

› **Anne Helen Harding**, technical team lead epidemiology, was appointed as an expert member of the North West Greater Manchester Research Ethics Committee.

› HSE's **Data Analytics Team** were shortlisted for the Civil Service Awards 2016, in the 'Analysis and use of evidence' category. The team worked with Ordnance Survey and the Cabinet Office to incorporate information from the national population database into Resilience Direct (RD) – an online application used by ministers and the emergency services to better plan their response when natural and man-made disasters occur.

› **Nina Day**, senior engineer, led the transport load safety work which was highlighted in the Annual Reports of the Transport Commissioners 2015-16 to the Secretary of State. *'Safe Loading has been high on the safety agenda for some time... I particularly want to commend the national work Nina Day ... has done with the Driver and Vehicle Services Agency (DVSA)*

and the police, educating and now enforcing this road risk'. Sarah Bell, West of England, Traffic Commissioner.

› **Chris Barber**, Deputy Chief Medical Adviser, was appointed Chair of the British Thoracic Society Occupational and Environmental Lung Disease Specialist Advisory Committee

› **Mary Trainor**, Head of Science Impact and Quality, was elected to the position of Chair for the Scientific Steering Group of PEROSH, the Partnership for European Research in Occupational Safety and Health.

› **Professor David Fishwick**, Chief Medical Officer, delivered the 2016 Lane Lecture¹⁶: a prestigious annual lecture in the field of occupational health in the UK at the University of Manchester Centre for Occupational and Environmental Health. This showcased how we need to think about the impact of getting things wrong on respiratory health at the individual, organisational and national productivity level.

› **Kate Jones**, Biological Monitoring Technical Team Lead, was invited to join the International Advisory Board of the *Annals of Work Exposures and Health*.

HSE's New Science, Engineering and Evidence Assurance Committee

In March 2016 HSE's independent **Science, Engineering and Evidence Assurance Committee** held its first meeting. This group of external experts is providing independent and objective assurance on the quality and relevance of HSE's science strategy and delivery.



SEEAC (from left) Professor Len Levy, Dr Lesley Rushton, Professor Peter Buckle, Professor Neil Bourne and Professor Martyn Thomas.



Meet
the staff

Nell Townsend

Regulatory chemist



NELL JOINED HSE as a regulatory chemist in June 2014 and works in HSE's Chemicals Regulation Division. On a day to day basis Nell assesses the physical chemistry properties of pesticide and biocide products and active substances and evaluates residues data in food, conducting consumer risk assessments. Prior to this Nell was studying for her PhD in phosphorus/carbon main group chemistry. As a new recruit, Nell found it interesting to discover the

role HSE plays in everyday life and chemical regulation. Nell comments that she received comprehensive on-the-job training and excellent support from her colleagues and managers while finding her feet in her new role: 'There is such a friendly and engaging atmosphere in the office, I was made to feel welcome'.

Nell values the fact that she is contributing to the safety of consumers on a day-to-day basis and appreciates the atmosphere of scientific discussion and working with specialist colleagues. In addition to her technical role, Nell is a member of the Learning and Development team which enables her to mix with a wide range of colleagues from new recruits to senior managers. She says 'I enjoy organising the training events and hopefully I contribute to the continued development of my HSE colleagues'.

Nell features on this video (www.youtube.com/watch?v=3UDjUJ7Ni8g) where specialist staff share their experiences of how they came to HSE and the positive impact it has had on their career.

Melissa Reed

Regulatory ecotoxicologist

MELISSA HAS WORKED at HSE for eight years, following the movement of the Pesticides Safety Directorate from the Department of Food and Rural Affairs to HSE, with a total of eleven years in the role. Before joining the civil service, she held two post-doctoral posts focusing on ecotoxicological modelling, one in archaeology and one in aquatic ecotoxicology.

She is involved in all aspects of ecotoxicology, mainly assessing the risk from chemicals to all organisms (animal and plant) in the terrestrial and aquatic environments. She has retained her interest in ecological modelling and has contributed to a number of international projects including 'CREAM', which was a Marie Curie Initial Training Network focussing on mechanistic effect models for ecological risk assessment of chemicals and a Society of Environmental Toxicology and Chemistry workshop aimed at providing guidance on applying ecological models to regulatory risk assessment.

Melissa has also been involved in two European Food Safety Authority (EFSA) expert groups: one producing a Scientific Opinion on good modelling practice in the context



of mechanistic effect modelling for risk assessment of plant protection products and the other evaluating a honey bee colony model for use in risk assessment. She is also a UK flexible member of the European Chemicals Agency Environment Working Group for biocides and attends EFSA peer review meetings on behalf of the UK. Asked why she enjoys her job Melissa says, 'I've had an interest in ecology since I was a teenager and working as an ecotox specialist allows me to apply my interest and knowledge to protecting the environment. It can be challenging but never dull'.

Jules Tuvey

Specialist diving inspector

JULES JOINED HSE in early 2012 having worked at the University of Plymouth for 10 years. He qualified as an HSE Part 1 Commercial Diver in 1997. Since graduating as a Civil and Coastal Engineer he taught HSE Professional Scuba to scientific and engineering undergraduates and took part in numerous postgraduate scientific diving projects. He was also a part of the hyperbaric medical team at the local dive chamber, dealing with serious diving casualties and chronically ill patients. He has recently completed HSE's Regulatory Training Programme.

As a part of a team of regulatory diving inspectors, Jules has worked with scientific, recreational, media and commercial diving contractors. His work has included numerous inspections and accident investigations including fatalities. During a diving accident investigation, faults with diving equipment may be identified as a potential cause of the incident. The equipment is sent to HSE's Laboratory at Buxton, where Nick Bailey undertakes thorough testing regarding its performance, both against the Standards and for the incident conditions. The scientific reports produced can form a key



part of the evidence either at inquest or during a prosecution. During one investigation microbiological testing was carried out after potential contamination was identified by Nick.

Jules says 'Commercial diving has always been regarded as a major hazard industry and I know that we are increasing diving safety. The wide range of diving projects and the variety of people involved with them makes the job really interesting'.

Nick Bailey

Diving safety scientist

NICK JOINED HSE in 2004 as a scuba diving specialist. He originally learned to dive during his time in the Royal Air Force, attaining a number of instructor qualifications. He then spent 9 years in the scuba diving industry, where he developed his knowledge of scuba equipment and gained a number of manufacturer qualifications.

Much of his time at HSE has been spent on incident investigations, both occupational and recreational. Using laboratory apparatus that can simulate dives under controlled conditions, Nick is able to forensically inspect diving equipment, and carry out equipment tests at conditions similar to the incident being investigated. Work on scuba diving has given Nick a lot of experience of dealing with hyperbaric conditions, frequently used in the tunnelling industry, and he recently gave a keynote speech in Hong Kong at the Occupational Safety and Health Seminar. He says 'I get the chance to do almost something new every day'.

Nick has also worked on other aspects of personal protective equipment, including respiratory protection, thermal stress and head protection.

Jules Tuvey (left) and Nick Bailey

William Harris

Materials scientist



WILL JOINED HSE in October 2013 straight from university. He is part of the Materials Science team at HSE's Laboratory in Buxton. He specialises in composite materials, primarily their design and use in industry. He is involved in HSE research and incident investigation work, as well as supporting a range of commercial customers with their research and has completed failure investigations for global oil and gas companies. Since joining HSE, Will has started his PhD, researching the effect that damage has on the safe continued use of composite materials used in the offshore oil and gas industry.

As a materials scientist for HSE, Will has been involved in a number of high profile investigations helping to minimise their risk of reoccurrence. Will is also exposed to a range of research projects spanning a variety of industry sectors. He is currently involved in the structuring and delivery of a Strategic Research Program on 'Advanced Materials and Manufacturing'. This research program focuses on various aspects of both composite materials and additively manufactured (3D printed) materials. His involvement in this project has allowed him to present the research at a number of internationally attended conferences.

Will says, 'The varying nature of the work I complete is really enjoyable and keeps me up to date on engineering techniques and practices used across a wide range of industries. Using modern engineering and materials to help solve safety related issues is personally satisfying and helps support HSE's objectives'.

Paul Brereton

Noise and vibration specialist inspector



FOR OVER TWENTY five years, Paul has been helping HSE to equip industry with the advice and tools it needs to manage risks from occupational exposure to noise, hand-arm vibration and whole-body vibration – to prevent deafness, dead hands and bad backs. Paul contributes to our guidance on the good practice management and control of those risks, provides training and advice for our operational inspectors on reasonably practicable controls and assists at court as an expert witness.

Paul works closely with our noise and vibration specialists to develop the knowledge that underpins negotiation and drafting of fit for purpose legislation, standards and guidance for the protection of workers and for free trade. Quality research ensures that our advice on control of noise and vibration risks remains current and

that we can propose improvements to EU Directives and European Standards when they are found weak.

Collaborative work with manufacturers of powered hand-tools and the most influential purchasers of those tools has contributed to large reductions in the hand-arm vibration hazard in tools available for purchase. Paul and his team are now pursuing widespread integration of proven noise controls into new machinery.

Compliance of manufacturers with their duty to produce machines with minimum risk from noise and vibration makes it easier for employers to meet their duty to manage the remaining risk. Where non-compliance is found, Paul and his team are 'on hand to provide advice, assist with investigation or provide expert evidence'.

Alison Higgins and Bev Bishop

Social researchers and Joint Heads of Profession for social research

ALISON AND BEV work in the Economic and Social Analysis Unit and have shared the role of Chief Social Researcher since 2012. They both joined HSE as principal researcher officers but with varied backgrounds in social research. Alison started work as a government social researcher in 1997 and has previously worked for the Department for Communities and Local Government and the Department of National Savings. Bev started her career as a university lecturer in 1993 and has worked in analytical roles in academia, research consultancy and government social research in the UK, New Zealand and Japan.

The role of Head of Profession involves setting the strategic direction of the profession across government and delivering this within HSE, for example through upholding professional and ethical standards and improving the use of social science evidence in policy making. The role also involves supporting existing Government Social Research (GSR) members and ensuring new members are recruited and promoted in accordance with GSR standards.

Bev's main areas of work have been around evaluating the effectiveness of our interventions and applying behavioural insights to health and

safety. This has included developing an evaluation strategy for HSE and developing the 'INSPECT' tool to apply behavioural insights to health and safety.



Alison Higgins (left) and Bev Bishop

Alison has a key role supporting policy teams when conducting post implementation reviews and was part of the group who drafted the cross government guidance. Recently she has been working closely with policy colleagues, psychologists, and an economist to assess the effectiveness of the Control of Asbestos Regulations.

Both Alison and Bev work closely with economists to provide evidence-informed impact assessments and with specialist colleagues to design and conduct a variety of research projects to inform or evaluate our interventions. The work is both varied and multi-disciplinary.

They represent HSE on external boards such as the Government Social Research Board, Cross Government Evaluation Group, UK Evaluation Society, and the Paris Risk Group (an international network of social scientists working in risk agencies).

The Fluid Dynamics Team

THE FLUID DYNAMICS Team was set up in 1998 to provide Computational Fluid Dynamics (CFD) modelling expertise for HSE. The need for this expertise was identified as a result of the 1987 King's Cross fire where it was used to help understand the phenomena that led to rapid fire spread. The Fluid Dynamics Team has evolved to provide expertise in a wide range of areas including occupational health, as well as major hazards such as fire, explosion and gas dispersion. It provides support to HSE in many different ways including research, regulation and incident investigation.

Members of the team come from different backgrounds including mathematics, engineering and particle physics with the majority of the team holding a PhD based on CFD modelling. The team has wide experience analysing and modelling fluid flows using approaches ranging from simple empirical/integral models to large complex three dimensional CFD simulations.

The team work frequently within large multi-disciplinary projects and as a consequence carry out most of their work in collaboration with experimental scientists. The work of



The Fluid Dynamics Team (left to right): Adrian Kelsey, Simon Coldrick, James Hoyes, James Stewart, Matthew Ivings, Rachel Batt, Simon Gant, Andrew Newton

the team is highly varied and no two pieces of work are ever the same.

In hazard assessment, the ability to predict consequences, rather than measure them or wait to learn from an accident, is almost essential. However, since predictions are based on a simulation of reality there is always a need to examine the correspondence between the model predictions and

the real world. As computers have become more powerful and software has become more accessible, models have advanced to the point where it is possible to create predictions that appear highly realistic. A great deal of the team's work involves evaluating models and developing formal procedures against which models can be evaluated to assess whether predictions are fit for purpose.

Much of this work has been carried out through European projects and collaborations with other institutions that have similar needs and requirements to HSE. The team publishes its work widely to help promote best practice in the use of models, share its work with industry and to encourage the continued improvement of models.

HSE's Priority Science Hub Leads

LAST YEAR, ENGAGEMENT with HSE policy, enforcement and scientific specialists led to restructuring HSE's portfolio of scientific work into six priority hubs. Each hub is led by a Priority Hub Lead. Although each Hub Lead is responsible for shaping their own area of responsibility, collectively they contribute to ensuring we have the necessary scientific and analytical intelligence to underpin our regulatory and commercial activities, and that the impact of our science and evidence on the health and safety system is maximised.

HSE's Priority Hub Leads (left to right): Yiqun Chen, Helen Pitts, Nick Warren, Steven Naylor, Helen Beers and Joseph Januszewski



The Hub Leads come from a variety of academic backgrounds (including mathematical modelling, materials engineering, social science research, epidemiology and geospatial data analysis) and bring a wealth of experience to the role. Each has a track record of undertaking high impact science and all have a strong understanding of the role of scientific and analytical evidence in the regulatory context and the science-policy interface and have the ability to take strategic oversight of research activities. They work with a wide range of colleagues across HSE e.g. policy makers, operational and communications staff, foresight and commercial specialists and other scientists.

The individuals and their associated Priority Science Hubs are:

Joe Januszewski

Regulatory frameworks, which are fit for the future

Exploring issues such as - how will current regulatory frameworks accommodate expected trends in work demographics, working patterns, technologies, health hazards, and new uses for old substances.

Yiqun Chen

The right evidence for the future

Exploring issues such as - what is the appropriate evidence to improve and update our understanding of industry issues and workforce targeting.

Helen Beers

The impact of demographic changes on the health and safety of the future workforce

Exploring issues such as - the impact of multigenerational working, migration and other social trends on workforce skills, capabilities, safety culture and behaviour.

Helen Pitts

The right intervention strategy for the British industrial asset base

Exploring issues such as - how materials and structures degrade over time and ensuring we have effective, evidence-based safety checks, calibration, testing requirements for existing and new (newer) technologies.

Nick Warren

Taking responsibility for health at work

exploring issues such as - identifying and developing the evidence that is needed to help people in the health and safety system take more responsibility for health at work.

Steven Naylor

Learning lessons from our incident investigations

Exploring issues such as - the methods by which the knowledge generated by our incident investigation activities are captured, recorded and subsequently stored. Joe says, 'What I am enjoying most about the role is being involved with different regulatory colleagues to develop common solutions. It's great to get into the detail of how regulators discharge their responsibilities and how science can help'.

Case studies



Tackling
ill health



Keeping
pace with
change



Acting
together



Managing
risk well



Supporting
small
employers



Sharing
our success

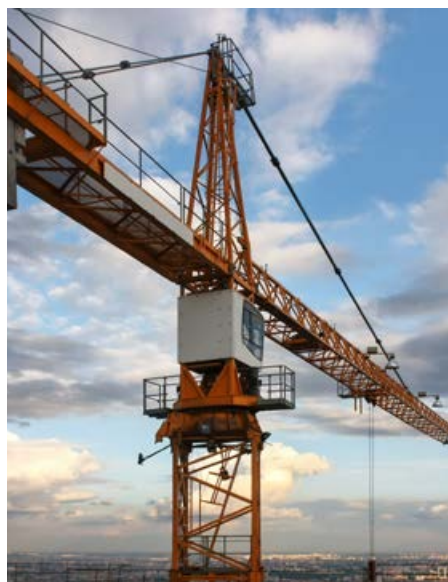


Underpinning the new Health and Work Strategy for Great Britain with best available evidence

THE NEW 'HEALTH AND Work Strategy for Great Britain' aims to be a catalyst for delivering real and substantial improvements in occupational health. Stakeholder engagement on the draft strategy began with its publication in December 2016.



To ensure that the strategy and associated plans are underpinned and informed by best available evidence, HSE scientists refreshed the evidence base on health and work. A robust and pragmatic process was developed to meet the timescales needed by policy colleagues. This involved contributions from: HSE's scientific experts, policymakers and operations specialists; external scientific experts; and external groups - health and safety representatives, practising health care



professionals, and current apprentices. The multi-stranded approach included: focussed reviews of recent scientific literature; focus groups and questionnaires; compilation of statistics; a prioritisation exercise; and foresight activity to explore the future world of work. Engagement within HSE on the implications of the evidence included a workshop-format event with the HSE Management Board facilitated by the HSE Chief Scientific Adviser and the HSE Chief Medical Adviser.



What were the benefits?

During the refresh of the evidence base on health and work, engagement with external groups was a hugely valuable sense check to ensure that policy makers and scientific experts were not developing ideas in isolation. The evidence refresh, combined with active engagement with policymakers on its implications, ensured that the draft Health and Work Strategy is informed by best available evidence. Perhaps most importantly, the resulting health priorities have been influenced by some of those just embarking on their own working lives.

For more details, see *Developing the evidence base for a new health and work strategy for Great Britain*¹⁷, *A man with a Plan*¹⁸ and draft Health and Work Strategy for Great Britain and plans: <http://www.hse.gov.uk/aboutus/strategiesandplans/health-and-work-strategy/>



Improving detection of exposure to carcinogens in the electroplating industry

HEXAVALENT CHROMIUM (CrVI) compounds are classified as both skin and respiratory sensitisers and carcinogens. Occupational exposure can cause a range of health effects from nosebleeds and skin irritation to respiratory problems and cancer. Electroplating is one industry where workers are at significant risk of CrVI exposure, primarily by inhalation.

The measurement of total chromium in a urine sample is a widely accepted biological monitoring practice for exposure assessment. However, after exposure to CrVI our bodies naturally convert it to the non-toxic trivalent form. Therefore, urinary chromium levels will reflect both chromium species and all exposure (for example dietary and occupational).

A promising alternative might be exhaled breath condensate (EBC). An EBC sample will represent what is present in the lungs, making it ideal for understanding inhalation exposures with the possibility of detecting the toxic chromium form, CrVI.

Our specialists developed a novel analytical method to separate and measure both chromium species. A pilot study collected both urine and EBC samples from workers potentially exposed to CrVI and a control group (not occupationally exposed). The occupational group consisted of CrVI workers, bystander workers and administrative staff within electroplating companies. The results showed that all workers had significantly higher levels of CrVI in EBC than the control group, in addition to higher total chromium levels in urine.



What were the benefits?

The study shows that all workers within electroplating companies can be exposed to CrVI compounds, including bystanders. The publication of this novel analytical method has improved scientific understanding of exposure and emphasised the need for exposure assessment and worker protection in order to ensure that risks resulting from work activities are effectively controlled.

For further details, see *Development of a method for the simultaneous detection of Cr(III) and Cr(VI) in exhaled breath condensate samples using μ LC-ICP-MS¹⁹*, and for HSE information on working with chromium, see *Chromium and you. Working with chromium – are you at risk²⁰?*



Developing the evidence base to reduce lung disease from exposure to respirable crystalline silica



UP TO HALF A MILLION workers are routinely exposed to respirable crystalline silica (RCS). Exposure can lead to a number of lung diseases including silicosis, Chronic Obstructive Pulmonary Disease (COPD) and lung cancer. HSE research suggests that over 500 workers die each year from lung cancer as a consequence of RCS exposure. Even more are likely to suffer from COPD caused or made worse by their exposure.

To better understand the risks from RCS and identify effective approaches to protect workers' health, we are undertaking a longitudinal study of RCS exposed workers in stoneworking, brick-making and foundries. We have undertaken comprehensive exposure and health assessments for approximately 700 workers from 30 sites. We have made over 1,000 personal exposure measurements and more than

2,500 sets of lung function measurements. The study includes piloting an intervention incorporating training for workers and managers, plus tailored advice on control strategies. The participating sites have responded positively and are making changes to improve the control of RCS. The next phase of the study will determine the impact of these measures.

Reliable measurement of workers' exposure to RCS is essential to understand the context of the health information obtained through this study. To this end we are developing new techniques such as in-mask sampling and Raman spectroscopy. Our new miniature sampler fits inside a worker's RPE and has the potential to make workplace exposure measurements more relevant for employers, occupational hygienists and researchers alike. Allied to this, in collaboration with Sheffield Hallam University, we have improved the sensitivity of RCS detection by using Raman spectroscopy analysis.

Our interpretation of findings from the workplace study has been enhanced through the development of a 'virtual population disease model'. This is a computer simulation of the GB workforce that allows the long-term health and economic impact of interventions to be evaluated. Working with our scientific partners from the Partnership for European Research on Occupational Safety and Health (PEROSH), we have used this model to estimate the number of cases of COPD that could potentially be prevented by rigorous compliance with a proposed EU exposure limit for RCS.

Early indications are that HSE's revised guidance on health surveillance for RCS exposed workers is leading to new cases of worker ill health being

identified to HSE physicians. We are now embarking on new research work to identify whether and to what extent this is happening across GB.



What were the benefits?

The evidence from this research programme is informing HSE's policymaking and operational activities to reduce the risks of occupational lung disease from respiratory crystalline silica (RCS). It has:

- › supported engagement on improving working health with the stoneworking, brickmaking and foundries industries – industries where RCS is a significant concern;
 - › provided a robust evidence base on worker health in these three industries;
 - › provided benchmarks for control, exposure and health
- against which future changes and the impact of interventions can be determined;
 - › influenced the choice of industries included in our targeted inspection campaigns; and
 - › informed the supplementary guidance that we provide on control of RCS exposure and health surveillance for exposed workers.

For further information, see *A microsimulation model for the development and progression of chronic obstructive pulmonary disease¹²* and *Health surveillance for those exposed to respirable crystalline silica (RCS): Guidance for occupational health professionals⁴*.



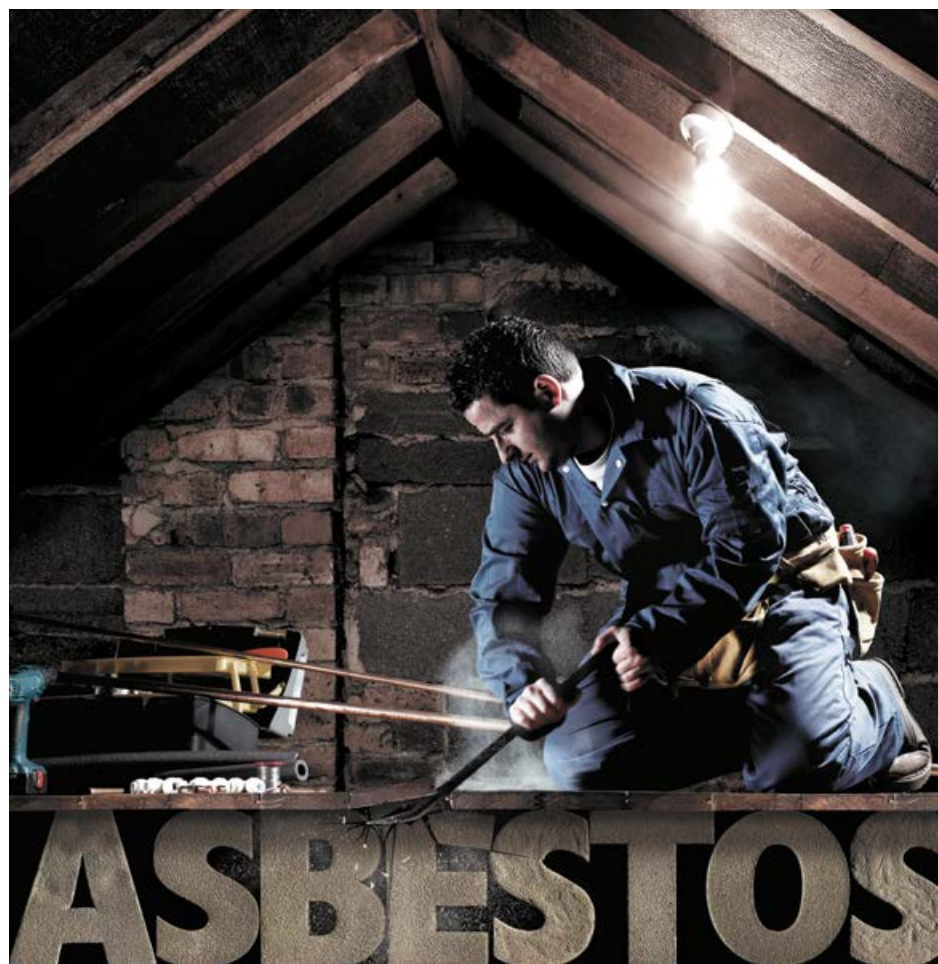
Highlighting asbestos as a potential cause of idiopathic pulmonary fibrosis

IDIOPATHIC PULMONARY FIBROSIS (IPF) is a rapidly progressive scarring disease of the lungs with no known cause. The pattern of scarring in IPF is however similar to that seen in asbestos-related fibrosis (asbestosis), which in contrast is usually slowly progressive. The incidence of IPF is rising in the UK, with an estimated 5,000 new cases per year without any apparent explanation. Previous studies have demonstrated that the rising mortality due to mesothelioma and asbestosis can be predicted from historic asbestos usage.

To explore whether there could be a potential link between IPF and asbestos exposure, our researchers compared annual numbers of deaths due to IPF, asbestosis and mesothelioma (an asbestos-related pleural cancer). They also looked to see if there was a relationship between historic national asbestos imports, and numbers of deaths. As there a long time gap between asbestos exposure and disease development, the research considered imports 48 years prior to death.

The analysis confirmed a statistically significant association between the rising annual mesothelioma and IPF mortality that has been seen over the

last 40 years, both in men and women. A similarly strong linear relationship between historic asbestos imports and mortality due to IPF was also noted.



What were the benefits?

This study is the first to highlight asbestos as a potential cause for IPF - an increasingly important global health problem. There has been significant interest in this work from occupational health specialists. Building on this finding, HSE specialists will be undertaking a collaborative research project with Imperial College, London (funded by the Wellcome Trust) to conduct the first national case-control study of IPF, estimating life-time occupational asbestos exposure by job titles.

For further details, see *Importance of past occupational exposures in the rising incidence of idiopathic pulmonary fibrosis in the UK²¹*, *UK asbestos imports and mortality due to idiopathic pulmonary fibrosis²²* and *Estimating lifetime asbestos exposure in patients with idiopathic pulmonary fibrosis²³*.



Understanding the extent of health risks from respirable crystalline silica in the railway industry



What were the benefits?

This work has given the rail industry clear direction to better understand the risk to workers from RCS exposure during ballast handling. This evidence will enable better targeting within the industry of available resource to improve the control of risks to health.

RESPIRABLE CRYSTALLINE silica (RCS) is a major cause of long latency occupational lung disease in Great Britain. Rail industry stakeholders have identified that worker exposure to RCS is an issue within their sector but do not fully understand the extent of the health risk. The Rail Safety and Standards Board therefore brought in our occupational hygienists to

better understand the issue. Firstly, our specialists liaised with a range of industry stakeholders to scope the problem. Based on the findings, a targeted programme of work was agreed with RSSB focussing on ballast handling activities. Ballast is the crushed stone used as a bed for railway tracks. The programme of work comprised:

- › Three trackside visits to review risk control and working practices on common ballast handling activities.
- › Production of a specification document for the rail industry to use when procuring exposure measurement services.
- › A comprehensive review of existing RCS exposure monitoring data.
- › The proposal of an exposure monitoring programme for the rail industry to develop evidence to enable them to better assess the health risk to workers from RCS exposure in ballast related activities.



Funding Source:
Rail Safety and Standards Board (RSSB)



Evaluation of hazardous substance consequence models applied to new technologies and materials

TO SAFEGUARD THE PUBLIC from major incidents involving the use, storage and transportation of hazardous substances, risk assessments are used to inform decision-making by both industry and regulators. Mathematical consequence models for the release, dispersion, fire and explosion of hazardous substances are used in these risk assessments. However, the reliability of existing consequence models and tools can be uncertain when they are used for assessing new materials, new technologies, or old technologies used in new contexts. For instance, new contexts could include assessing the risks of hydrogen in refuelling stations, and transportation of imported liquefied natural gas.

To address this knowledge gap, the 'SAPHEDRA' European platform was started in 2015 with seven collaborating organisations. This collaboration is developing a procedure and a set of experimental data to evaluate consequence models and tools. The procedure's aim is to understand what

confidence can be given to existing consequence models and tools when they are used for assessing new and emerging risks. Within the collaboration, HSE researchers have reviewed existing model evaluation protocols and made recommendations for the structure and content of the evaluation method.



What were the benefits?

Our specialists have provided input to this European platform based on their extensive knowledge and experience of evaluating consequence models for use in major hazard risk assessment. The outcome of their review is now published and is being used as part of the ongoing wider scientific collaborative work. The overall aim is to support robust risk assessments by industry and regulators for new and emerging technological risks.

For details, see the website at <http://projects.safera.eu/project/14>. This includes details of the model evaluation approach and a list of experimental data suitable for the validation of consequence models. For the HSE report see: *Review of consequence model evaluation protocols for major hazards under the EU SAPHEDRA platform*²⁴.



Decontamination: protecting first responders, healthcare workers, patients and the public

AIRBORNE DISINFECTION, air purification and other interventions can be used to limit the spread of infectious microorganisms, such as MRSA and Ebola. This helps to protect workers such as first responders, healthcare workers and others who may come in to regular contact with hazardous microorganisms or following an accidental or malicious release.

Our microbiologists use their considerable experience of decontamination testing for the evaluation of products and equipment used in areas such as biosafety, biosecurity, pharmaceuticals and healthcare. As part of this work we assess the effectiveness of numerous types of test equipment, including automated room fumigation systems, UV light carousels and filter based



air purifiers. Using our controlled atmospheric chamber we are able to create bespoke microbiological test atmospheres and surface challenges to independently verify the effectiveness of these systems for our customers. To achieve this we prepare microbiological challenges comprising bacteria, spores and viral materials, all carefully cultured and presented on a variety of surfaces or as an airborne 'bioaerosol'.

Recently our team of internationally recognised experts has been asked to assist Thales Alenia Space UK, providing rigorous, independent microbiological assurance that their Inertial Measurement Unit for the Airbus Rover Module for the 'ExoMars 2020' Programme, will be free of microbiological contamination when it leaves Earth for operation on the surface of Mars.



What were the benefits?

Our decontamination service has informed effective decontamination of areas such as hospitals, emergency vehicles and accident sites and to advise on decontamination in the event of malicious releases, protecting the workforce and public from infection.

For further details of our decontamination research, see *Comparison of multiple systems for laboratory whole room fumigation*²⁵, *Proven and Praised – new technology goes anywhere to kill infectious organisms*²⁶, *Increased efficacy of pulsed UV-C against microbial pathogens*²⁷, *Expert assessments help fight infection*²⁸, and *Vomiting Larry: a simulated vomiting system for assessing environmental contamination from projectile vomiting related to norovirus infection*²⁹.



Funding source:

Commercial Service. Includes funding by Thales Alenia Space UK, Thales Alenia Space Italy, European Space Agency



Improving the safety of firefighters breathing apparatus

THE FIRE SERVICE, along with the other emergency services, often put their lives at risk while providing a service to the British public; it is paramount their equipment works correctly. For firefighters, breathing apparatus, which enables them to enter hazardous environments is one such item of key importance. Our researchers have carried out independent breathing apparatus incident investigations, looking at the failure of pressure gauges and warning whistles. The findings pointed to a potential build-up of moisture in the pneumatics of the breathing apparatus, which could potentially cause harm to those relying on this piece of equipment.

It is possible that moisture ingress identified might have been an inevitable consequence of quick, repeated re-use of breathing apparatus; particularly in large scale fire incidents and during training exercises. Our experts carried out a

series of breathing simulator testing regimes, using different breathing apparatus units in controlled experimental environments, to determine the cause of the moisture ingress. An evaluation of repeated cylinder charging was also carried out.



What were the benefits?

This research has provided valuable information to the fire service to enhance the safety of firefighters. Our recommendations have been used to review their procedures relating to the quick re-use of breathing apparatus, how they charge their cylinders and how they monitor their breathable air quality.

For more information, see *Respiratory protective equipment at work: a practical guide*³⁰, *Striking the balance between operational and health and safety duties in the Fire and Rescue Service*³¹, *Common Causes of breathing apparatus failure*³², *Are firefighters 'fit' enough to wear a respirator?*³³ and *The benefits of a collaborative approach to scientific research*³⁴.



Funding source
Chief Fire Officers Association



Investigation into the Alton Towers fairground ride incident

THE HORRIFIC CRASH on the Smiler Ride at Alton Towers in June 2015 injured 16 people including two teenage girls who required leg amputations. Their carriage crashed into an empty carriage stalled midway round the 14-loop ride.

A multi-disciplinary HSE team conducted a fast-paced investigation into the causes of the incident. The investigation by specialists in engineering, control systems and advanced imaging focused on: the reason for the empty car stalling; the workings of the electrical control system designed to stop the ride in the event of a fault; and the operation and management of the ride by fairground staff. Using CCTV footage and laser scans, the team confirmed that high gusting wind had contributed to the empty carriage stalling. The focus of the investigation then moved to the safety-related systems which directed the progress of the trains through the ride. This identified that operational errors led to the collision. Investigators found the root cause to be a lack of detailed arrangements for making safety-critical decisions. The whole system, from training through to fixing faults, was insufficiently robust to prevent a catastrophic outcome.



What were the benefits?

During the prosecution, HSE incident investigation specialists provided impartial expert evidence for the court. Sentencing, Judge Michael Chambers QC said 'This was a needless and avoidable accident'. Merlin Attractions Operations, the fairground operator, were subsequently fined £5 million after admitting health and safety breaches that directly led to the crash.

For HSE 3D graphics of the Smiler ride, see <https://www.youtube.com/watch?v=KPFjJxqYJ3I>

For more information and guidance on safe practice in fairgrounds and amusement parks, see: <http://www.hse.gov.uk/pUbns/priced/hsg175.pdf>



Estimating the costs to Britain of work-related cancer

UNDERSTANDING THE ECONOMIC and wider impacts of work-related cancer is important to inform HSE's regulatory decision making and engagement with stakeholders on the case for proportionate risk management in the workplace. Monetised estimates are used by HSE in Regulatory Impact Assessments and other evaluations and economic analyses.

Our economists, with support from our epidemiologists and statisticians, undertook new research to estimate in monetary terms the total annual economic burden of new cases of work-related cancer in Britain in 2010. This novel research included a methodology to value the 'human costs' of cancer, over and above financial impacts, in terms of the

effects on quality of life, and loss of life in the case of fatal cancers. The analysis accounts for a broad range of impacts from work-related cancer and how the costs fall to different groups: individuals, employers, government, and society as a whole. The research derived estimates for all 24 work related cancer types identified in the HSE Cancer Burden Study, which was published in 2010, based on both the known and probable carcinogens classified by the International Agency for Research on Cancer.



What were the benefits?

This is the first estimate of the costs of work-related cancer in Britain. It provides the most comprehensive indicator of the overall burden on society available. The results suggest that the total economic costs of new cases of work-related cancer in GB in 2010, arising from past working conditions, were around £12.3 billion. Individuals bear the vast majority of the costs of work-related cancer. The results are now informing HSE decision making and the case for proportionate risk management in the workplace.

For further details, see *Costs to Britain of work-related cancer*³⁵.



Developing a survey for dutyholders who have received an inspection visit

TO OBTAIN FEEDBACK from dutyholders who have received an inspection visit, our statisticians designed a concise Dutyholder Survey. The survey aims to test the assumption that our interventions are effectively focussed and do not impose unnecessary burdens on those

being surveyed. It is mailed every month to a random sample of 10% of businesses who have received an inspection visit. The average response rate is 45%. Our statisticians collate the results and provide a monthly report to colleagues across HSE.

The evidence from the responses is that most dutyholders respond positively: 89% of dutyholders who responded to the survey stated they had taken action as a result of an inspector's visit. The results also 'continue to indicate a high level of satisfaction with HSE and the way we conduct inspections'³⁶. For instance, in 2015/16: 84% of those surveyed considered that inspection was done in an efficient and effective manner; 81% considered that the inspector provided practical advice; and 82% considered that the outcome of the visit was proportionate to risks identified.

Our statisticians have since widened the remit of their survey work to provide a survey design, control and analysis service for HSE colleagues.

What were the benefits?

The Dutyholder Survey has provided insights about how it feels to be on the receiving end of an intervention. There are data for two years (2014/15 and 2015/16) and this is now being used in more detail to identify any areas for improvement.

For further details see, the Dutyholder Survey results in HSE's Annual Report 2015-16 pages 17-18 at <http://www.hse.gov.uk/aboutus/reports/ara-2015-16.pdf>





Estimating the failure frequencies of major accident hazard pipelines

MOST MAJOR ACCIDENT hazard pipelines transport flammable fuels at high pressure. In the event of a release, the fuel could ignite and potentially harm people in the vicinity. HSE provides advice to local planning authorities on planning applications near these pipelines. The aim of this advice is to mitigate the effects of a major accident on the population. The advice is based on 'cautious best estimates' of risk.

One of the inputs to HSE's flammable pipeline risk assessments is the 'PIPIN' (PIPeLine INtegrity) model for determining failure frequencies. PIPIN uses two approaches: one based on operational experience data, and a predictive model that uses structural reliability techniques to predict the failure frequency due to third party activity only. To ensure that PIPIN reflects best available information, our risk estimation

specialists have updated the existing version. This included:

- › Updating the historical incident data used by analysing information from the UK Onshore Pipeline Operators' Association and European-wide sources.
- › Developing an enhanced numerical solution method.
- › Updating the model's scientific basis in liaison with our engineers and metallurgists.

The updated model was tested using the specifications for several hundred pipelines representative of the GB pipeline network. On average, the predicted failure frequencies were reduced. In the majority of cases, this leads to either no change or a reduction in the size of the land-use planning zones around pipelines that are used to provide advice to local planning authorities.

What were the benefits?

The updated model ensures that HSE's land-use planning advice is based on robust up-to-date evidence on failure frequencies. This contributes to ensuring that HSE advice to local planning authorities is not overly cautious, thus enabling development and growth while safeguarding the public.

For further details, see *HSE research reports*³⁷⁻⁴¹, *Failure data within PIPIN*⁴² and *Major accident hazard pipeline failure frequency calculation using fracture mechanics*⁴³.





Understanding 'people factors' that drive safety culture improvements at a timber and builders' merchants

AFTER SURVEYING THEIR staff using our Safety Climate Tool, Ridgeons, a large Timber and Builders' merchants needed to better understand the "people factors" driving their internal survey results. The company wanted a clearer understanding of staff opinions, and how these influenced safety culture, in order to enhance safety performance.

Our experts worked with Ridgeons to run four focus groups with front line staff and supervisors. The focus groups gave staff an opportunity to explain their understanding of the key issues arising from the survey. As our facilitators were not part of the company, their independence was seen as important in obtaining open and accurate feedback. The feedback provided a solid basis for further interpretation and understanding of the survey findings. Staff feedback was seen by the company as a key input to formulating a viable and meaningful action plan to develop their safety culture and performance.



What were the benefits?

The combined survey and focus group intervention helped to raise overall safety awareness levels in the company. Other benefits included benchmarking their survey scores against other organisations, providing a baseline against which to measure future performance.

Ridgeons said "The focus groups worked due to the independence of (the) facilitator and the output gave us meaningful direction for the next phase of our H&S journey".

For further information on our Safety Climate Tool, see <http://www.hsl.gov.uk/products/safety-climate-tool>, *The development of HSL's Safety Climate Tool - a revision of health and safety climate survey tool*⁴⁴, and *Developing a benchmarking service for HSL Safety Climate Tool*⁴⁵.



Funding source:
Ridgeons Ltd



Improving understanding of very large vapour cloud explosions

MAJOR INCIDENTS WORLDWIDE have involved large vapour cloud explosions. Very large vapour clouds extending to many hundreds of metres from the leak point have occurred at a range of sites such as fuel depots, refineries and pipelines. For instance, in less than a decade, there were catastrophic explosions

at: Buncefield, UK (2005); Amuay, Venezuela (2012) which resulted in 41 fatalities and over 86 casualties; San Juan, Puerto Rico (2009); and Jaipur, India (2009) which resulted in 11 fatalities and over 200 casualties. These incidents have shown that one important need for improving the assessment and control of risks

is to increase understanding of the physics of very large vapour cloud explosions. In particular, it is important to identify what circumstances lead to a severe explosion rather than a less harmful flash fire.

HSE specialists have collaborated with the US Department of Transport to review historical vapour cloud explosion incidents. The research has identified two major findings. Firstly, most of the major incidents with the most disastrous consequences were caused by relatively small but sustained leaks in very low wind speeds. In these weather conditions, vapour accumulated around the source of the leak and only moved away under the influence of gravity. The vapour clouds were still flammable many hundreds of metres from the leak point. Secondly, the research identified that once a very large cloud forms, it is very likely that a severe explosion will occur rather than a flash fire. In fact, no examples of flash fires in very large gasoline clouds were identified. This type of scenario is currently not included in many risk assessments, and has not been the normal assumption in emergency planning. Therefore, these findings have significant implications for the assessment, control, and mitigation of major flammable risks.



What were the benefits?

The review has shown how safety assessments for large sites that store and process flammable substances should be modified to give an improved analysis of risk. The study has also shown the potential benefit of flammable gas detection systems in reducing risk. These are particularly useful where a large cloud would accumulate over a long period, when time is available to track down and isolate the leak before an explosion can occur. This is important for protecting workers and safeguarding the public.

For further details see the project report *Vapour cloud explosion historical review*⁴⁶ and *A review of very large vapour cloud explosions*⁴⁷.



Funding source:
US Department of
Transportation Pipelines and
Hazardous Materials Safety
Administration and HSE



Reducing Legionella outbreaks associated with cooling towers

LEGIONELLA IS AN infectious bacterium capable of growing in warm water systems in the built environment. It spreads via droplets and aerosols, causing the lung infection Legionnaires' disease. Major outbreaks can result, with multiple infections and fatalities, through colonisation of industrial evaporative cooling systems (cooling towers). Over a 10 year period, 229 cases with 10 fatalities had been attributed to such systems in Britain⁴⁸. Consequently, HSE and the Office for Nuclear Regulation initiated an inspection programme of dutyholders with cooling towers, to determine compliance with the standards described in HSE's Approved Code of Practice (L8). Inspections of 1,906 sites with cooling towers were carried out between April 2013 and August 2014. Compliance was assessed against agreed criteria and contraventions of health and safety law were found at 33% of sites. Improvement Notices were served at 12% of sites.



HSE's Legionella Committee asked our microbiology specialists to analyse the underlying causes of these Improvement Notices. Sometimes there were multiple reasons, and we recorded 501 failings. These included:

- › 114 attributable to inadequate risk assessment (not being up to date or incomplete);
- › 136 attributable to poor written control schemes (being absent or lacking sufficient information); and
- › 247 attributable to poor implementation of control schemes (cooling towers not being cleaned or properly checked, lack of training of responsible persons).

What were the benefits?

This identification of the most common causes of compliance failure is being used by HSE to target areas to improve dutyholder compliance. Improved compliance should reduce the likelihood of legionella colonisation in cooling towers and associated infection risk. Follow-up inspections are being conducted at selected sites to assess improvements in compliance and to ensure that risks to the workforce and public are effectively controlled.

For more information, see *Legionnaires' disease. The control of legionella bacteria in water systems. Approved Code of Practice and guidance*⁴⁹ and *Control of legionella: Inspection of evaporative cooling systems and investigation of outbreaks of Legionnaires' disease*⁵⁰. Data were presented at a major UK conference attended by key stakeholders, *Combating Legionella*⁵¹.



Understanding the hazards posed by flammable oil mists



HIGH FLASHPOINT OILS do not normally produce flammable atmospheres. Under some circumstances, for example if a leak in a pressurised system creates a fine mist of oil droplets, they could still pose a hazard. There is very limited understanding of the formation and ignition of oil mists, and so current guidance on such hazards is limited, brief, and largely qualitative. This means that dutyholders (and regulators) lack the information to accurately assess any hazardous area around a given oil system.

HSE was joined by 15 other organisations to advance understanding of the formation of ignitable mists. A literature review confirmed that information was relatively sparse and sometimes contradictory or inconclusive. Using equipment at Cardiff University, practical tests showed that different fluids could have significantly different behaviour. For example, kerosene mist could be ignited at the lowest leak pressure tested while one hydraulic fluid was difficult to ignite even at high pressures. Modelling work showed

that computational fluid dynamics models could predict droplet sizes and concentrations with reasonable accuracy, allowing a wider study of the size of flammable cloud that might be produced different leaks.

What were the benefits?

This joint project has shown there is a specific hazard from low pressure fuel leaks that was not recognised before but can now be controlled safely. It has also shown that in some cases costly hazardous area classification around an oil system is not necessary. In a broader context, this work is one more step towards improved guidance for all oil mist situations helping to reduce the risk to workers.

For further details, see *Area classification of flammable mists: summary of joint-industry project findings*⁵², and for more information on Hazardous Area Classification and Control of Ignition Sources, see www.hse.gov.uk/comah/sragtech/techmeasareaclas.htm



Funding source:
HSE Joint Industry Project
with industry sponsors



Engagement with small and medium enterprises (SMEs) on the risks of respirable crystalline silica

HSE HAS A SIGNIFICANT programme of research on the risks to workers of ill health from respirable crystalline silica exposures (see pages 4, 20 and 23). This is providing significant opportunities for engagement between HSE researchers, including HSE's Chief Medical Adviser, Professor David Fishwick, and the worksites and industrial sectors involved. Much of this involves SMEs. For example, work with the British Ceramic Confederation, one of our collaborators for this research, has led to invited speaker roles for Professor Fishwick. The aim is:

- To allow a technical two-way discussion between those who run SMEs and HSE's researchers to enable a mutual understanding of the problems faced by modern workplaces, and how to develop solutions.
- To disseminate within the sector the key messages on solutions to improving worker health.

The Mineral Products Association (MPA) has also worked very closely with HSE during this research. Professor Fishwick and HSE's Chief Inspector of Construction were invited to address their annual Health and Safety Award Conference in November 2015. Nigel Jackson, MPA's Chief Executive said: 'It is clear from the debate that health needs to be elevated to a position equivalent to that of safety and that the challenge to MPA and its members has been clearly set.

We accept it...'⁵³. This initial link has since enabled an excellent dialogue to develop on the development of practical workplace interventions to reduce silica-related ill health.

Finally, this research has led to new opportunities to engage with the Institution of Occupational Safety and Health, leading to two workplace seminars, targeted at workers themselves, relating to dust exposures and respiratory ill health.



Professor David Fishwick presenting to the Mineral Products Association

What were the benefits?

This engagement is allowing our technical specialists to discuss and learn about the practical issues faced by those working in SMEs, and is disseminating key messages to help SMEs further reduce the health risks posed by silica exposure. For further details, see David Fishwick speaking at the British Ceramic Confederation 2016 Conference: <https://www.youtube.com/watch?v=fcUn1emU80U>



Improving health-related risk assessments in the workplace

GOOD QUALITY RISK assessments for health related issues are central to effective health risk management in the workplace. However, there is often less confidence and understanding amongst general health and safety practitioners when it comes to the 'health' side of health and safety.

For small to medium-sized enterprises (SMEs), managing workplace risks shouldn't be complicated or costly. Delegate feedback from our other health related training courses indicated a need for a course dealing specifically with health risk assessment.

Our occupational health experts developed a course to help the general health and safety practitioner better understand the 'invisible' risks associated with exposure to hazardous substances, noise and vibration. We aim to encourage a more confident approach to these issues. The course explains how to conduct risk assessments to meet legal requirements, and importantly, how risk assessment should fit into an overall risk management programme. We aim to debunk the myth that risk assessment is a pointless, bureaucratic burden by showing that effective actions to reduce harm and protect the health of workers, should all flow from an effective risk assessment process.



What were the benefits?

This course provides access to our expertise on health-related risk assessments. Our delegates have included both SME dutyholders and health and safety consultants who support SMEs. Sharing our knowledge via the course supports a key element of the Helping Great Britain Work Well strategy, giving SMEs simple advice so they know what they have to do. Delegate feedback has included:

'(The) course delivered very well with enthusiasm from lecturers,'
Graeme Kay, Promtek Ltd.

'Excellent insight into basic health assessment need...'
Sandra Babbings,
Prohms Health Care.

For further information see: <http://www.hsl.gov.uk/health-and-safety-training-courses/improving-your-health-related-risk-assessments>



Using videos of real-life worker ill health stories to help drive home key messages for protecting health



DURING HSE INTERVENTIONS to reduce occupational asthma, we developed videos of a real-life sufferer's story to use as part of communicating with workers and dutyholders about risks. We found that these videos with 'Phil the Welder' are a powerful way of driving home key messages.

Through our programme of research on the risks to workers of ill health from respirable crystalline silica exposures (see pages 4, 20 and 23), our team of occupational health specialists has access to workers, and patients, who were previously exposed to silica, but have gone on to develop chronic lung problems including silicosis. Terry, a stonemason from Merseyside who developed silicosis, agreed to

be filmed during an interview with Professor David Fishwick. David is HSE's Chief Medical Adviser and a practising respiratory physician with the NHS. David worked closely with both Terry and HSE policy colleagues to develop an appropriate storyboard. Terry then told his story to camera; using his own words. Although various final versions of the video were produced for differing audiences and uses, each summarised the health problems that Terry now has to deal with every day of his life, the impact of these problems on his life, and the key messages he had for younger workers, workplaces and regulators.

This video has been viewed regularly from HSE's website and YouTube. It has been shown at a variety of HSE, and external events that are considering how best to get simple preventative health messages over to a variety of audiences including workers and dutyholders in small and medium enterprises. Given its resonance with audiences, Terry's wife, Christine, has also recently been filmed giving her view on the same set of events, bringing out very emotionally the tragic personal, family and wider consequences of having a family member made ill by workplace exposures.

What were the benefits?

These videos have allowed HSE's occupational health specialists to use real life personal ill health stories to help make the point that ill health caused by work has a very real human cost. David Fishwick says, 'all of those with the responsibility to reduce health risks to workers should work collectively to prevent the "next Terry"'.

For further details see the HSE videos with *Terry the Stonemason* <https://www.youtube.com/watch?v=mHacjn4qjoQ> and *Phil the Welder* at https://www.youtube.com/watch?v=z8J_Uc_BifY



Developing a forecasting model for surface water flood impacts

FLOODING IN THE UK can be devastating for the people affected. Flooding of homes, businesses and infrastructure can have impacts on physical and psychological health, damage property, and cause severe disruption of transport and networks. Surface water flooding is particularly dangerous as it is hard to forecast, and is dependent on rapidly occurring, localised extreme rainfall events.

Preparing for, and responding, to flooding events requires timely and informed advice, based on up-to-date information and scientific understanding. Evidence from recent flooding events has prompted a demand for warning systems that account for both the flood hazard and the impacts.

HSE researchers worked with project partners in the meteorological and hydrological sciences to develop a forecasting tool for operational implementation in the forecasting systems at the UK Met Office. The tool applies innovative methods linking cutting edge weather forecasting and impact assessment to provide rolling assessments of the surface water flood risk in England.

Our team led the development of the impact component, using a novel approach that undertakes the majority of the detailed processing in advance so that operational flooding advice can be generated quickly. Validation of the tool has been undertaken based on an innovative approach using news reports developed in partnership with King's College London.



What were the benefits?

The tool was embedded within Met Office systems and trialled for case study flooding events during summer and autumn 2016. The tool has provided valuable new information to forecasters during the trial phase. Full operational implementation at the Met Office will help the forecasters provide more informed risk advice to responders responsible for civil protection.

For further information, see the project reports available on Natural Hazards Partnership website <http://www.naturalhazardspartnership.org/science/hims/surface-water-flooding/>, *Natural Hazards Partnership Surface Water Flooding Hazard Impact Model: Phase 2 Final Report 2016⁵⁴* and *A surface water flooding impact library for flood risk assessment⁵⁵*.



Funding source:
Flood Forecasting Centre



Aeroengine fire test facility to support aircraft safety



AVIATION SAFETY HAS a high profile across the world, and accidents have devastating personal and societal impacts. The aircraft industry is very aware of the need for engineering controls to manage the risks to aircraft users. As part of the demonstration of airworthiness, fire-critical parts of aeroengines, including structural components, control systems and fire separation wall seals, all need to be tested to show they can perform effectively in the event of an emergency.

For several years up to 2015, a team of HSE researchers had been supporting an external contractor to deliver such tests at our Buxton site. However, customer demand was exceeding that partnership's available resource.

At the end of 2015, HSE invested in a new, automated, facility and training for our staff to enable us to deliver component tests to the required international standard.

What were the benefits?

Working with leading aircraft engine and airframe manufacturers, tests with our new aeroengine facility contribute in an important way to the safety of future aeroplanes and help protect the passengers and crew that fly on them.

For more information, see <http://www.hsl.gov.uk/what-we-do/fire-resistance-testing-and-fire-proof-testing>



Funding source
Commercial service



Fire testing of fuel tanks for wheelchair-adapted vehicles

MOST VEHICLE FUEL tanks are made out of steel. In some cases, for example where only a small number of tanks are required or where complex shapes are needed, moulded plastic tanks have clear advantages. In order to be approved for use on the roads, such fuel tanks need to pass a whole range of strength and integrity tests, including test for behaviour in the event of a fire.

A team of HSE specialists provide a commercial service for the full range of this testing. Probably the most challenging, and certainly the most spectacular, of these tests is the fire test. The most recent of these tests was carried out on behalf of a client who converts vehicles to carry wheelchairs. A modified bodyshell containing the new, plastic tank is mounted over a set of rails that allow a large pan of burning petrol to be moved underneath it. After 60 seconds, the intensity of the fire is reduced by placing a perforated screen above it. The fire continues to burn for another 60 seconds before being removed. This simulates a fire from burning petrol spreading underneath the vehicle, perhaps spilled from another car involved in a serious road accident.



What were the benefits?

Together with the other tests, the fire test helps ensure that the vehicles in use on our roads are safe. The recent work on adapted vehicle tanks will help to increase mobility and travel options for wheelchair users, potentially helping to improve their quality of life.

The testing carried out at Buxton meets the requirements of *UNECE Regulation No. 34: Uniform provisions concerning the approval of vehicles with regard to the prevention of fire risks*⁵⁶.



Funding source:
Allied Mobility



Supporting international development through sharing knowledge on regulating the oil and gas sector



IN 2013 THE MEXICAN Congress approved a bill to allow companies other than state-owned to pursue enterprises in the national oil and gas sector for the first time since 1938. This “Energy Reform” required enhancing Mexico’s institutional framework to promote the successful opening up of the sector. In this context the National Agency for Industrial Safety and Environmental Protection of the Hydrocarbons Sector (ASEA) was created as a decentralised administrative body of the Ministry of Environment (SEMARNAT). It is an

independent regulator that oversees the oil and gas industry, to safeguard the workers, public and environment.

ASEA sought HSE’s experience as a respected world leading offshore regulator. HSE carried out a project funded by the UK Foreign & Commonwealth Office’s Prosperity Fund to support ASEA as Mexico moved away from a self-regulation model within the national oil company to having an independent regulator. This knowledge transfer project included independent review

of management arrangements, sharing elements of good regulatory practice and identifying health and safety training needs. As part of this we held workshops for ASEA staff and supported industry engagement events in Mexico. The success of the project led to follow-up support to provide training focussed on major accident hazard awareness and prevention. This included working visits to the HSE’s Health and Safety Laboratory in Buxton and to Aberdeen where a number of UK companies shared their expertise.

What were the benefits?

We worked together to strengthen cooperation, coordination and information sharing related to the development, oversight and enforcement of safety and environmental protection of oil and gas resources, enabling the regulator and safeguarding the workforce, public and environment.

For further information on HSE’s approach to control of major accident hazard sites on and offshore see www.hse.gov.uk/comah/, www.hse.gov.uk/offshore/offshore-oil-and-gas.pdf and <http://www.hse.gov.uk/pubns/books/I154.htm>



Funding source:

UK Foreign & Commonwealth Office’s Prosperity Fund



Identifying interventions to reduce private vehicle load security issues on the road network

Highways England Traffic Officers work on the Strategic Road Network to remove debris and deal with incidents. This is important for keeping traffic moving and reducing delays. Traffic Officers in the East Midlands Region highlighted to our team that they regularly attend incidents on the M1 motorway corridor involving shed loads they believe to have originated from a nearby furniture retailer.

Our specialists were asked to undertake a project to identify interventions to reduce the occurrence of load loss incidents on the Highways England's network. As part of this project, a consultation process was held with Highways England and the furniture retailer; staff were asked about their understanding of the issues and their existing policies and procedures. They were also asked about the equipment

they sell to help customers transport goods by road. An assessment of the retailer's customer interface (services, signage and provisions) in relation to loading and load securing, collection and delivery was made, as well as an assessment of the load securing straps sold by the retailer. Observations of activities within the store's loading area were undertaken during the day, on a weekend, and on an evening during the week to explore any variation in purchases or behaviour. The information gathered during these exercises was used to identify possible interventions to reduce the occurrence of load loss incidents.



What were the benefits?

This work led to a number of practical recommendations for both Highways England and the furniture retailer to reduce the risk of shed loads. This will help both organisations work together to prevent potential road incidents, and reduce disruption to the Strategic Road Network.

For further details, see *Load Securing: Vehicle Operating Guidance, 2015, DVSA*⁵⁷.

YouTube videos: *Load securing: roles and responsibilities*; *Load security: how DVSA enforces the rules* and *Load security: consequences of poor load security*⁵⁸.

For more information on our work on heavy goods vehicle safety, see *The use of vehicle structure in load securing on heavy goods vehicles*⁵⁹ and *Access to and work on flatbed vehicles*⁶⁰.



Funding source:
Highways England



Safeguarding the public: Technical advice to the Singaporean government on quantified risk assessment guidelines for major hazards

SINGAPORE HAS AN industrial zone with a high density of major hazard installations, including petrochemical and other chemical industries, focussed on Jurong Island and the nearby mainland. This includes strategically important industries including three refineries. HSE was asked to help the government of Singapore to provide detailed advice on new technical guidelines and criteria for land planning decisions, to enable cumulative risk from the industrial operations to be evaluated in order to safeguard the public.

We provided an in depth analysis of their current criteria and risk assessment methodologies, comparing this with other approaches taken across the world. We developed new quantified risk assessment guidelines and the criteria for toxic, flammable and explosive hazards that allow consistent proportionate decisions on land use planning to be taken on a sound scientific basis. These guidelines were supplemented by substantial guidance documents and stakeholder meetings with industry and senior figures from government agencies to support engagement.



What were the benefits?

The new Quantified Risk Assessment guidelines have been issued, supporting the management and control of major accident hazard risks to safeguard the public in Singapore. Following on from this work, HSE is supporting Singapore in its move to a UK style Control of Major Accident Hazard (COMAH) safety case approach - a growing trend worldwide. A formal Memorandum of Understanding with the Ministry of Manpower has been agreed to further enable cooperation across a wide range of health and safety topic areas.

For other information on HSE's approach to land use planning for major accident hazard sites, see <http://www.hse.gov.uk/landuseplanning/about.htm> and *HSE's land use planning methodology*⁶¹.



Funding Source:

Singapore Economic Development Board, leading a consortium of agencies: the Singapore Civil Defence Force, the National Environmental Agency, the land owner (JTC) and the Ministry of Manpower.

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Publications

HSE scientists are committed to making research findings accessible online at no cost to the user. We ensure open access to research papers in peer-reviewed journals and journal-like conference proceedings (provided the publisher gives this option) describing research for HSE led by our scientists.

2016 publications by our scientists are listed below. This covers: publications in peer-reviewed journals; papers in conference proceedings; research reports; conference abstracts; and articles in trade and professional magazines.

For a full list of details from previous years see <http://www.hsl.gov.uk/resources/publications>. HSE also commissions reports from researchers in other institutes, for a full list of research reports published by HSE see <http://www.hse.gov.uk/research/rrhtm/index.htm>

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