HSE Science and Evidence Research Summaries

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Introduction

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 2016-2020[1] is at the heart of HSE's approach to developing the evidence base in support of our regulatory and policy activities, and the delivery of HSE's strategy and plans[2] for the health and safety system.

The current portfolio of scientific research by HSE is delivered through science hubs. These are:

- regulatory frameworks which are fit for the future;
- the right intervention strategy for the British industrial asset base;
- taking responsibility for health at work;
- the right evidence for the future;
- the impact of demographic change on the future workforce.

In each science hub, research and other planned work is undertaken to ensure that the appropriate evidence is available to inform and underpin our regulatory and policy activities and that the impact of our science and evidence on the health and safety system is maximised. These summaries provide information on the research and other planned science projects currently underway in each of the science hubs.

Details of our research publications in scientific journals and conference proceedings, as well as Research Reports published by HSE, can be found at http://www.hse.gov.uk/research/. This webpage also hosts our Annual Science Reviews, which contain case studies describing the benefits of our research.

[1] http://www.hse.gov.uk/research/content/science-evidence-strategy-1620.pdf
[2] http://www.hse.gov.uk/aboutus/strategiesandplans/index.htm

Regulatory frameworks which are fit for the future

The aim of the programme of work in this science hub is to develop our understanding of the current and future world of work and ensure that our regulatory framework is fit for purpose.

Commissioning local exhaust ventilation systems (LEV) – PH00645

Every year, thousands of people in Great Britain die of lung disease or get asthma because of airborne contaminants they have breathed in at work. Local exhaust ventilation (LEV) is an extract ventilation system that takes dusts, mists, gases, vapour or fumes out of the air so that they can't be breathed in. Many employers install LEV to protect their workers' health, but it doesn't always work effectively. It needs to be of the right type, and properly installed, used and maintained.

Most LEV systems need a thorough examination by a competent person and test (TExT) by a competent person once each year (legally, you are allowed no more than 14 months between tests) to make sure they work well and continue to protect employees. Some LEV systems (such as those controlling more critical or high-hazard processes) need more frequent thorough examination and testing (see HSE guidance HSG258). The aim of the TExT is to ensure that the LEV system continues to perform as intended, so LEV commissioning information or results from a previous TExT are necessary to provide a performance benchmark against which the TExT data can be compared.

The current research explores the use of initial commissioning information when performing TExT and aims to understand how dutyholders use TExT and commissioning data to manage LEV systems.

Investigation of critical factors for the safe use of recirculating local exhaust ventilation (LEV) – PH20034

Every year, thousands of people in Great Britain die of lung disease or get asthma because of airborne contaminants they have breathed in at work. Local exhaust ventilation (LEV) is an extract ventilation system that captures dusts, mists, gases, vapour or fumes from work processes to prevent them entering the workplace air so that they can't be breathed in. For LEV to work effectively, it must be regularly maintained and routinely checked.

One type of LEV is a 'recirculating' system, where a filter cleans the air and recirculates it back into the workplace. If the filter is not working correctly, harmful contaminants can be returned to the workplace, potentially causing significant exposure that may result in ill health.

The current research is being done, in collaboration with LEV industry professional bodies and trade associates, to increase HSE's knowledge of what recirculating LEV systems are currently being used and how they are being tested and maintained. The information gathered will help us understand what the key factors for the safe use of this type of LEV system are.

From machinery controls to collaborative robots and beyond to artificial intelligence – PH00763

UK industry is increasingly using new and emerging technologies and new ways to

better control existing machinery to increase its operational flexibility and reduce running costs. Examples of emerging technologies are collaborative robots (where people work in collaboration with robots), mobile robots (where people and robots can work near each other) and autonomous guided vehicles (which can travel around a factory avoiding dangerous interaction with people and other machinery, without the intervention of people). These technologies bring with them new hazards and opportunities, and therefore require new ways of working and assessing this risk to ensure that the risks they present to people are as low as is reasonably practicable.

The use of artificial intelligence (AI) in machinery control provides for greater flexibility and autonomy of their operation and capability within widely varying circumstances. However, artificial intelligence implies complexity in its implementation, and with complexity comes increased difficulties in ensuring the health and safety of people working with, or near, these systems, as well as system security and reliability. Machinery control AI includes methods that allow a machine control system to learn from, and adapt to, its surroundings and circumstances using data it collects via sensors, while it works.

Many new and emerging technologies used in industry are subject to common risks due to the likelihood of their being incorporated as part of a network of industrial automation and control systems (IACS). Cyber security is a term used in this work to define measures taken to protect these systems against threats through accidental circumstances, actions or events, or through deliberate attack. The threats can originate from the Internet, external networks (corporate or third-party), maintenance activities, software upgrades and unauthorised access etc, with the potential to result in incidents with major health, safety or environmental consequences and/or loss of essential services.

The aim of this project is to build up knowledge providing HSE and industry with a one-stop pointer to relevant legislation, standards and guidance for machine control systems, so that when using these new systems and methods, industry can do so safely and within a recognised legal framework.

Advanced Imaging Systems - PHF20023

The Advanced Imaging Systems team (AIS) provides HSE colleagues with wide-ranging photographic, video and graphic design support. A proportion of this work includes support to non-project-specific reactive or scientific activities, corporate publications, internal activities (including safety videos for staff/contractors etc) and supporting corporate events (e.g. dutyholder awareness events). Work in this area also includes 3D-modelling, aerial imaging (stills and video), and CCTV recovery/analysis in support of HSE's regulatory work.

Data analysis and spatial analysis – PHF00797

Work in this project ensures that essential maintenance, updating and support of HSE's geographic information systems (GIS) and data analysis assets (data, software, infrastructure and services) is carried out to provide GIS and data analysis services for HSE. This project also provides analytical support services and ad-hoc GIS operational support as required.

Safe use of desktop 3D printers in workplaces – PH00799

Printing objects in three dimensions (3D) is a new and exciting technology that is leading to breakthroughs in manufacturing, healthcare, medicine, food production and fashion. These developments are possible because of the wide variety of materials that can be printed to form solid objects. The availability of affordable 3D printers has encouraged their wider use in education and by small and medium-sized enterprises (SMEs). However, desktop 3D printers are often not completely enclosed, giving rise to risks that users may inhale hazardous fumes or injure themselves on moving parts or the heated printer heads used to melt the material. New types of liquid resin desktop 3D printers are also gaining popularity and present a risk of inhalation of hazardous vapours from the resins and solvents used.

HSE has investigated these risks in partnership with other organisations and supported the Consortium of Local Education Authorities for the Provision of Science Equipment (CLEAPSS) to publish a good practice guide for school technicians and teachers on safe use of 3D printers. Working with a UK manufacturer, a capture hood fitted over the 3D printer was shown to prevent most of the small airborne particles being released from the printer into the wider environment.

The new research will add to this work and investigate whether emissions from desktop 3D printers in other environments (such as offices or workshops) are raised to hazardous levels, particularly when a larger number of printers are used in the same space. The emissions from liquid resin 3D printers will also be investigated.

HSE will work with external experts to adapt the CLEAPSS guide for use by SMEs using 3D printers, setting out safety standards for this equipment in education and commercial settings.

The research will be published and shared within HSE to support the work of staff involved in policy and regulatory work in the manufacturing sector.

Additive manufacturing using metal powders – PH00799

HSE scientists are collaborating with national manufacturing technology centres (MTCs, also known as UK Catapult centres) on the safe use of metal powders in additive three-dimensional printing. 3D printing is a method by which layers of metal powder are fused together, under intense light sources, such as lasers, to form components. This technique is starting to enter into day-to-day manufacturing.

There is good evidence from traditional manufacturing processes, such as welding, that the inhalation of small metal particles and fumes can cause lung disease and cancers. This has led to concerns about the safety of employees working in 3D printing using metal powders.

This new research will consider the potential for exposure from a new method of 3D printing in which metal powder in a stream of air is deposited onto a surface and fused together using intense laser light. Published evidence about risks to health from metal powders used in additive manufacturing will also be reviewed and a summary published. HSE scientists will work with staff from the MTC in Coventry to complete the development of a good practice guide on safe use of metal powders within the aerospace industry. Working with other government departments, industry and MTCs, an expert workshop will be held to discuss options for the safe disposal of the waste

metal powders produced from 3D printing processes.

These outcomes are consistent with national policies to encourage the safe use of advanced manufacturing methods. The results will be published and shared within HSE to support the work of staff involved in policy and regulatory work in the manufacturing sector.

Assessing hazards and exposure risks from advanced carbon-based materials – PH00799

New carbon-based materials can be used to form very strong but light composite materials used in aircraft and car manufacture. More recently, novel carbon-based materials of very small size have been discovered. Examples include graphene, which is composed of one or a few sheets of individual layers of carbon atoms, and carbon nanotubes which are made up of one or more layers of carbon atoms formed into a tube. These novel types of carbon have unique physical strength and conductive properties. They are suited for use in composite materials and in batteries, filters and electronic and optical devices.

Concerns have been raised about potential health risks to employees working in industries using these materials. This may occur when employees inhale, or ingest, tiny carbon particles released during manufacturing processes. After entering the lungs, these tiny particles may enter the body, and be retained because they do not easily break down.

In this study, emissions from the machining of carbon-based materials will be assessed in collaboration with the Advanced Manufacturing Technology Centre (AMRC) in Sheffield and the Graphene Engineering and Innovation Centre (GEIC) in Manchester University. Published studies that have investigated the occupational risk to health from work with carbon-based materials will also be reviewed and a summary of this evidence published.

The research will investigate how to detect and quantify tiny carbon particles released into the air and determine whether the proposed monitoring methods are practical for day-to-day use in manufacturing environments. With experts from the AMRC, GEIC and industry, work will be undertaken to develop advice on safe working practices for manufacturers using novel carbon-based materials. The research will be published and shared within HSE to support the work of staff involved in policy and regulatory work in the manufacturing sector.

Using wireless sensors for the monitoring of workplace health hazards – PH0747

This project aims to determine if low-cost sensors can be deployed and used in the workplace to provide continuous remote monitoring of occupational hazards and potential health impacts to improve understanding of health and safety practices.

Conventionally, the collection of measurements to assess exposures, health impacts and the performance of control systems has been resource-intensive, which has limited the volume of data collection. New sensors, however, have benefited from miniaturisation of electronics and improved data connectivity, which has the potential to revolutionise data collection methods within health and safety, enabling better decision-making by HSE and dutyholders.

In this project, we will investigate the potential for workplace sensing technologies, data communication and data analysis tools, to enhance and complement standard methodologies and strategies currently used for workplace health and safety monitoring. In phase one, work will focus on respirable dust in collaboration with international partners. The workstreams will investigate sensor performance, data connectivity and storage, data analysis, worker acceptability and the potential to improve health and safety performance. Subsequent phases will look at additional health priority risks such as musculoskeletal stressors, mental health issues caused or aggravated by work, as well as reviewing sensors used to monitor physiological health markers associated with workplace exposures.

If these initial phases are successful, further work will provide information on the broader use of sensors in the health and safety regulatory context, as well as support appropriate adoption and use of the technology in workplaces.

Understanding the mechanisms of resonant acoustic mixing – PH20077

Resonant acoustic mixing (RAM) is a recently developed mixing technique that uses a combination of moderate-frequency sound waves and rapid shaking to mix chemical formulations. As RAM mixing provides a combination of mixing mechanisms, the technique is applicable to the mixing of solids, liquids, viscous materials, slurries and pastes, meaning that the same piece of kit can mix a broad range of materials without the need for modification. RAM is also recognised as offering a number of advantages over conventional mixing techniques including reduced mixing time, preparation of more consistent mixtures, and efficiency in power use during the mixing process.

These attractive qualities of RAM mixing have resulted in the explosives manufacturing industry within the UK being keen to adopt RAM mixing for the preparation of energetic mixtures to replace more conventional techniques. However, it has been identified that there are gaps in the safety knowledge of RAM mixing when applied to energetic materials, such as the effect of the additional mixing mechanisms present during RAM mixing on the physical properties of the energetic mixture, and the uniformity of any temperature rise observed during mixing. This project aims to determine the extent of relevant safety knowledge within the RAM community by conducting and publishing a literature review. This initial research phase will focus on establishing the extent of knowledge by those currently using RAM relating to the key safety areas and identify knowledge gaps.

Going to the right places – PH00584

The guiding principle in UK health and safety legislation, embodied in the 1974 Health and Safety at Work Act, is that whoever creates a risk is responsible for managing it. We use a variety of techniques to inform, persuade or, if necessary, compel dutyholders to comply with the law and protect their employees and others from work-related risks. We do not need to directly intervene with all the estimated one million businesses that we regulate in Great Britain, so we concentrate our face-to-face regulatory efforts where we want to have the biggest impact.

This project supports collection and interpretation of intelligence that can be used to direct our face-to-face regulatory efforts through use of the FIND-IT tool. FIND-IT is an IT application that has a unique data engine comprised of algorithms to match and link disparate datasets. HSE uses this tool to search and filter a variety of different HSE datasets, allowing staff to identify, locate and prioritise high-risk businesses for

inspection.

The benefit of using the systematic Find-IT approach will lead to:

- improved efficiency – focusing on high-risk businesses;
- an evidence-based audit trail;
- a reduction in time taken to plan inspection visits;
- fewer wasted visits – effective use of resources.

The right intervention strategy for the British industrial asset base

The research programme in this science hub will ensure that we have the science and evidence needed to underpin our policy in key areas across the UK industrial asset base, in sectors including oil and gas, chemicals, explosives, mining and the bioeconomy.

10K wave - Extreme environmental loading - PH00593

Offshore installations are subjected to severe loading from the harsh offshore environment to which they are exposed and are designed to withstand both cyclic fatigue loads and maximum loads from extreme events. Current design standards require structures to survive the 10 000-year event. However, a significant number of offshore installations on the UK Continental Shelf (UKCS) are considered to be ageing installations which were designed to older standards with extreme loading requirements typically for the 50-year and 100-year events. As a result, they have not been designed to survive the 10 000-year environmental event which will affect the loading in the jacket and, more significantly, the loading on the deck, which can cause structural collapse. The situation is complicated further by the considerable uncertainty associated with the interpretation of the environmental data and complexity of evaluating structural loads. This presents considerable uncertainties in the demonstration of structural integrity and suitable enforcement action to control the risks to the structural integrity of offshore installations.

HSE's Energy Division has undertaken a study on the prediction of extreme loads in fixed offshore structures to develop an informed policy position that will lead to improved industry practice and regulation. Its key objectives are to establish a robust approach to predicting the structural integrity of fixed offshore installations subjected to the 10 000-year wave event and to assess the risk associated with extreme loads acting on fixed offshore installations, for inclusion in the risk assessment to demonstrate whether the ALARP requirement has been met.

The scope of work consisted of three parts:

1. Review of methods for predicting extreme environmental loads acting on fixed offshore installations:

- imitations of and differences between current code (API, ISO and NORSOK) requirements which do not represent state-of-the-art knowledge for wave-in-jacket and wave-in-deck loading;
- procurement and analysis of metocean data by metocean specialists;
- overview of metocean research and current knowledge;
- derivation of 10 000-year crest heights, wave particle velocity profiles;
- application of metocean data: statistical analysis of hindcast metocean data and identification of areas for further development;
- requirements for the combination of different extreme loading events to derive the overall target reliability level for use in safety cases.

2. Development of a risk-based framework for assessing the integrity of offshore installations:

- survey of operators' structural data for all fixed platforms on the UKCS;
- development of guidance on the evaluation and management of the risk of structural failure associated with extreme environmental loading for fixed installation on the UKCS, including procedures for the management of structures which are unable to withstand the 10 000-year event;
- a summary of all findings for the development of guidance on the evaluation and recommendations on the management of the risk of structural failure associated with extreme environmental loading.

3. Participation in the LOADS joint industry project, which is developing a methodology for the accurate prediction of the substructure and the wave-in-deck loads for application in both deterministic and structural reliability analyses based on the latest knowledge on environmental loading.

The study will enable the identification of offshore installations with the highest risk of structural failure from extreme environmental events, and demonstration and assurance that the risks to offshore installations from extreme environmental loading are being controlled, and that suitable action is being undertaken to ensure the safety of the offshore workforce.

Parts 1 and 2 of the study have been completed. The LOADS joint industry project is ongoing and HSE is liaising with industry stakeholders on the need for a focused collaborative effort by the offshore industry to validate the methodology prior to implementation of a unified approach for installations in the North Sea.

Assessment of secondary guarding on mobile elevating work platforms (MEWPs) – PH00458

MEWPs have contributed significantly to reductions in falls from height statistics. However, increases in their use have revealed other issues, most notably the potential for operators to be crushed between the moving machine platform/partial enclosure and fixed obstructions while elevated. In response, the industry has produced a range of secondary guarding devices. There is no standard for such devices, although manufacturers have tested devices against their own specifications.

This work includes an independent engineering/ergonomics analysis of the limitations of currently available products. Current guidance refers to the importance of risk assessment but offers no information on selecting appropriate secondary guarding systems. The expected benefit of this work is a clear understanding of the benefits and limitations of secondary guarding devices to allow dutyholders to improve assessment of risk and selection of appropriate equipment for specific applications.

HSE's Construction Division will take the results forward with the Strategic Forum for Construction Plant Safety Group MEWPs subgroup, and HSE will work with industry to develop a plan for guidance on production, promotion, implementation and evaluation.

Stress corrosion cracking - PH05833

Stress corrosion cracking (SCC) is a specific crack growth mechanism which has led to numerous failures of metal pipework and structural elements in a wide range of situations ranging from pressure vessels to swimming pool ceilings. A combination of three factors is needed for SCC to occur – a susceptible material, a corrosive environment and a tensile load or stress.

It is a common assumption that stainless steels do not suffer from SCC below 60^{o}C. However, there have been several major incidents were SCC has caused ceilings to collapse and chemical tanks to fail at ambient temperature. These faulty assumptions can lead to susceptible materials being incorrectly selected during the design and building stages of projects, with the potential for a major incident when facilities and structures fail well within their expected service life.

This project aims to update a previous review of ambient temperature chloride-induced SCC that is widely used by industry; to develop a test to study the formation of SCC cracks at near room temperature; to compare the performance of several stainless steels; and to study the effects of residual stress induced by heat during welding on the likelihood of SCC cracks forming.

The results of this work will help further our understanding of when SCC can occur at or around room temperature and help define the conditions in which it is unsafe to use a range of stainless steels. The research will be published to raise awareness of the issue of ambient temperature SCC and allow industry to improve material selection and fabrication processes to reduce the risk of SCC occurring in-service.

Factors affecting severity of vapour cloud explosions – PH03117

During the last ten years, several large vapour cloud explosions (VCEs) have occurred at fuel depots and other sites handling gasoline or liquefied petroleum gas around the world. These have caused total destruction of plant and buildings over an area extending up to 700m from the actual leak. In some cases, scores of people were killed beyond the site boundary. These VCEs have been more powerful than would have previously been predicted.

The objective of this research is to advance our understanding of the factors that affect the power of these explosions. We are investigating the effects of particles on explosion propagation, weather protection cladding in process areas on explosion pressures, and switch-rooms/electrical sub-stations increasing explosion pressures.

Several VCEs have started with ignition in an electrical control cubicle. Part of the project is investigating how ignition in starter cubicles, then propagation within the switchroom itself and venting to the surrounding cloud, can act as a progressive trigger for severe VCEs. It is believed that this progression or ‘nesting’ of ignition sources can lead to progressive escalation of flame speed and may lead to a shock wave that can cause detonation of the whole vapour cloud. This part of the project is collecting data to show how this kind of flame acceleration depends on the design of electrical boxes and their contents. The objective is to provide guidance for industry on minimising the risk of violent explosions and support HSE’s enforcement work in this area.

The findings of this research are being openly published, allowing a more realistic assessment of risk in a wide range of industries. They are contributing to the

fundamental understanding of VCEs and informing the development of HSE policy relating to the assessment of liquefied natural gas refuelling sites and refineries.

The testing of synthetic fire-resistant fluids to determine the effects of degradation – PH00761

In recent years, work carried out underground in the United Kingdom has seen significant change. Deep mining for coal has disappeared but the number of non-coal mines has increased, as has tunnelling for transport and other infrastructure purposes. This means the range and nature of machinery now underground is different from before.

Underground plant is now dominated by vehicles equipped with a variety of hydraulically powered systems running at greatly increased pressures compared to previous machines. This places more demands on the fluids used to power transmission systems. Fluids are generally combustible and have been shown to be the major risk of fire underground in the UK.

Historically, the approach to reduce fire risks has been to develop fire-resistant fluids. Machinery developed for above-ground use is not always compatible with these fluids, leading some manufacturers to develop new fluids based on synthetic oils which have the enhanced lubricity required with the current machinery, but their behaviour in fire is not fully understood.

This project will identify machinery now used underground and their operating parameters. These will be compared with the test conditions used in the current testing regime (developed and used by HSE and standardised internationally), to decide if the current tests are ‘fit for purpose’ to assess the risks of fire as they now exist or require modification to better reflect the current environment. If modifications are required, a search for alternative/new tests will be specified. If appropriate testing can be identified, a range of fluids will be tested, including those previously deemed to have provided acceptable fire resistance and the newly developed fluids. The results from this testing will be used in a previously developed risk assessment tool to understand the risks of fire on machines now used underground and to identify the benefit or otherwise in terms of fire risk provided by the new fluids.

Taking responsibility for health at work

The work in this science hub aims to identify and develop the evidence necessary for HSE to implement its Health and Work Programme, and more widely to help people in the health and safety system take greater responsibility for health at work.

Professional cleaning and occupational risk(s) for asthma - addressing knowledge gaps - PH00597

There is growing evidence that cleaners and those who undertake cleaning tasks have an increased risk of developing respiratory ill health. A review of published evidence identified consistent reports that certain types of cleaning work are associated with an increased risk of developing asthma and/or experiencing respiratory symptoms consistent with asthma. This was described both in new cases and exacerbation of pre-existing conditions primarily in healthcare workers and domestic cleaners. Similar associations have been shown with respiratory symptoms, including chronic obstructive pulmonary disease (COPD). Chemical irritants, e.g. chlorine-based disinfectants, were identified as a frequent cause of respiratory symptoms, and spray application of chemicals was also associated with increased risk for asthma symptoms.

This project focuses on use of disinfectant products in healthcare, use of spray application of chemicals and transfer of safety information down the supply chain. The aims are:

- to raise the profile of respiratory health within the healthcare cleaning and infection prevention disciplines;
- to identify and validate practical control solutions to minimise respiratory exposure to cleaning and disinfection chemicals and so reduce ill health.

This will be undertaken primarily within healthcare, but the findings could be disseminated and implemented across the whole cleaning industry. We are working with people from a range of disciplines in the healthcare cleaning and infection protection disciplines to understand the disinfection tasks undertaken, products used and use of control solutions. We are looking at how health and safety information is transferred down the supply chain to end users.

Personal exposure monitoring at hospital sites will help us understand the potential for respiratory exposure to disinfection products and effectiveness of proposed controls. We are working closely with relevant parties to further our knowledge on potential respiratory exposure via spray application of cleaning products. We are currently working with NHS Improvement to support their review of the National Standards of Healthcare Cleanliness.

The causes of occupational chronic obstructive pulmonary disease (COPD) in the UK – PRJ283

Chronic obstructive pulmonary disease (COPD) is a major cause of disability and death. Thousands of people die each year from work-related lung diseases, and in many cases, due to exposures that took place many years before. COPD describes several breathing problems where there is damage to the breathing tubes and air sacs within the lung. Breathing in certain dusts, fumes, chemicals or gases in the workplace can cause serious long-term lung damage.

Although the research evidence for the important contribution occupational exposures

in general have made to the burden of COPD is well established, the strength of evidence about the role of specific agents is more mixed. There is also a lack of evidence about the contribution of specific occupational exposures in Great Britain.

This project is a nationally representative epidemiological study to determine the key determinants of occupational COPD in Great Britain. The results should provide specific information about exposures or occupation/industry groups to provide a stronger basis for targeting and prioritising intervention activity by HSE.

Assessing practical methods for monitoring exposure to metalworking fluid mist to inform control practice - PH00606

Machining with water-mix metalworking fluids (MWF) is an established risk for occupational lung and skin disease. Hazardous bacteria are thought to be involved in the development of allergic occupational lung disease in machinists. New genetic research is being undertaken by Manchester Metropolitan University and the HSE's Buxton laboratory to identify the hazardous bacteria that grow in MWF and determine measures to prevent their growth.

The research is considering practical monitoring methods for MWF mist. With the UKLA Product Stewardship Group and other industry partners, a research workshop was held to discuss the use of real-time sensors to monitor MWF mist and the findings published. The next stage is to evaluate the use of these sensors, alongside other methods to visualise MWF mist such as dust lamps.

The research is investigating the effect of air quality on lung disease. Air pollution monitors have been used in machine workshops to track changes to air quality throughout the working day and over longer periods, both at the operator's position and in other areas away from the machines. This is providing insight about the deterioration of air quality inside busy machine workshops.

Consultative workshops have been held with machine manufacturers (the Manufacturing Technologies Association) and manufacturers of local exhaust ventilation (Extraction Manufacturers and Designers Association) used to remove MWF mist from machines. This is to identify improvements to the design of machinery and local exhaust ventilation systems to enhance the control of MWF mist. It will assist in producing a good practice guide on purchasing LEV systems for MWF.

The outputs from the research are published, shared through industry communications and within HSE to inform the development of guidance and the work of inspectors, health specialists and policy makers.

Ambient levels of asbestos in current workplaces - PH00663

Asbestos causes around 5000 deaths every year, mostly due to past exposures. However, asbestos is not just a problem of the past. It can be present today in any building built or refurbished before the year 2000. This includes domestic dwellings as well as workplaces such as factories, offices, schools and hospitals.

Current HSE advice about asbestos in buildings is that it only presents a health risk when disturbed; asbestos that is safely managed and contained does not give rise to exposure. HSE also advises that asbestos should not be removed unnecessarily, as the removal process has the potential to lead to exposure (both to the workers

undertaking the removal and to building occupants), and therefore can be more dangerous than leaving it in place and managing it. However, there have been challenges to this position and there is an argument that all asbestos should be removed from public buildings. There remains a lack of reliable evidence to indicate the ambient levels of asbestos in buildings today, and no data that allows a comparison of ambient levels in buildings constructed post-2000 (where there is no asbestos), buildings constructed pre-2000 with undisturbed asbestos, and buildings constructed pre-2000 in which asbestos removal has been undertaken.

This study will look at the ambient levels of asbestos in buildings for each of these scenarios and will provide HSE with a more robust evidence base to determine if the current policy remains the most appropriate to prevent asbestos-related ill health for workers and members of the public. The main aim of this study is to measure ambient levels of asbestos in a range of workplaces (primarily public buildings), to enable comparisons to be made between levels in buildings with no asbestos, those with undisturbed asbestos, and those where asbestos removal has been completed.

Further analysis of asbestos lung burdens of young adults in Britain – PH00459

This research project supports an ongoing epidemiological study of the levels of exposure to airborne asbestos fibres in the UK. The analysis uses analytical electron microscopy to identify, size and count asbestos fibres in lung samples collected from young adults for other diagnostic purposes.

This information will help HSE assess whether the controls and legislation for asbestos are effective in reducing exposure, and hence the risk of asbestos-related diseases.

Longitudinal study of respiratory health in brick, stone, wood and laboratory animal workers – PH00708

Occupational lung disease (OLD) remains an issue for workers in certain industries in Great Britain. Exposure to dusts, fumes and gases in the workplace may put workers at increased risk of developing chronic obstructive pulmonary disease (COPD), silicosis, asthma and other lung diseases.

In 2011, the Health Impact Assessment and Surveillance Strategic Research Programme was commissioned by HSE to establish an evidence base from workers in multiple sectors (foundry, stone, brick, wood, laboratory animal workers) for diseases of high concern such as COPD, silicosis and occupational asthma. The programme combined field-based longitudinal occupational health and hygiene studies, measurements of health status and health questionnaires, behavioural interventions, mathematical modelling and economic impact assessment. The current project is a continuation of these studies and will deliver the follow-up surveys of the brick, stone and foundry sites, plus analysis and reporting of data from these and the earlier surveys in wood and laboratory animal workers.

The research represents one of the largest multi-disciplinary longitudinal health studies of its type and will help our understanding of exposure controls and the associated risks of OLD. It will establish a robust evidence base on Britain’s levels of prevalence of symptoms, lung impairment and ill health. This will assist in supporting employers and employees in improving health and safety knowledge and reduce costs through earlier identification and treatment of

occupational ill health.

The use of biological monitoring to evaluate sustainability of control improvements in electroplating – PH00610

Chromium VI and nickel are frequently used for electroplating within the surface engineering industry. These substances are both carcinogens and exposure can occur through inhalation, skin contact and/or ingestion. Biological monitoring (BM) using urine sampling can quantitatively assess worker exposure to both chromium and nickel.

This work follows previous research (undertaken 2009-2012 reported in HSE Research Report RR963) which was carried out to determine whether repeat BM over a period of time could be used to help drive sustainable improvements in exposure control. Following this, research (RR1042) was undertaken to use the evidence collected in RR963 to determine the efficacy of various control measures and the potential for contamination transfer outside the workplace.

This current research will engage with the same electroplating companies who participated in the previous studies, aiming to involve as many of the original participants as possible. It will assess whether improvements in controlling the risks from exposure to chromium VI and nickel have been sustained.

The study will be undertaken remotely, again using BM (urine samples) to assess exposures, with a written questionnaire to obtain information on relevant work activities and exposure controls. Based on these findings, recommendations will be made to dutyholders on the adequacy of exposure controls.

The results of the study will further improve HSE's understanding of carcinogen exposures in this industry and provide information on the continuing effectiveness of previous interventions.

Review of exposure control of DEEEs in underground mine workings – PH00702

Diesel engine exhaust emissions (DEEEs) are a complex mixture of particulates, gases and vapours which occur when diesel-fuelled engines operate. They are known to cause lung cancer and are associated with other serious health effects. No workplace exposure limit (WEL) has been set for DEEEs as a whole as there is insufficient data to establish a clear, reliable threshold for all potential health effects. However, there are WELS for some of the individual substances in DEEEs. The major sources of workplace exposure to DEEEs are from emissions from heavy vehicles and stationary power sources that use diesel fuel. There is a sound body of research which shows that the highest occupational exposures to DEEEs occur in underground situations where diesel-powered plant is used, primarily in the construction of tunnels and mining.

There is little information available about DEEEs exposure in UK non-coal mines. The aim of this project was to gather information on current exposures and exposure controls in use.

HSE identified mines to be visited for this project, all of whom volunteered to participate. Occupational hygienists visited the mines to collect intelligence on DEEEs exposure and its control. Substances within DEEEs were measured using samplers worn by miners and in fixed locations, and the findings compared to the exposure limits. Controls used to reduce exposure to DEEEs were assessed using a questionnaire, and

the findings compared against HSE guidance.

This work will be used to help make decisions on the current and potential future adequacy of control solutions provided for exposure to DEEEs in mines. Working in collaboration with the mining industry will improve knowledge of the hazards from DEEEs, increase awareness of the proposed new exposure limits and enable the industry to assess how controls may be improved. By presenting the findings to national and regional mine safety meetings, the mining companies have been able to identify DEEEs control improvements.

Dust and bioaerosol exposure in livestock and vegetable farming – scoping study – PH01719

Exposure to agricultural dusts and bioaerosols, including grain and plant dusts, fungal spores, animal dander, bacteria and endotoxins, can potentially cause diseases such as asthma, bronchitis and farmer's lung. This project aims to examine the risk of exposure to dust and bioaerosols in farming.

We have carried out literature searches to identify activities where there is potential for exposure during indoor livestock and vegetable crop farming and where no data was available in the wider scientific community. A series of observational visits to indoor livestock farms were made and the information collected was combined with the literature search data to produce a report for the sector. The information was used to identify where the highest risks lay and to target the exposure assessment phase of this project.

To investigate exposure, we selected cleaning and pressure washing of indoor pig housing units. Several visits have been made to measure exposure during the cleaning process, including moving livestock, mucking out, cleaning with chemicals and pressure washing.

This project is helping HSE to understand where the highest risks of respiratory disease are in livestock and vegetable farming, and the extent of the risk is being evaluated by exposure monitoring and assessment of the controls currently used.

Development of exposure profile for painters (decorative and industrial) – PH01822

Painters and decorators can be exposed to various solvents and dusts during surface preparation and painting activities. These exposures have potential to cause harm. HSE’s cancer burden study (http://www.hse.gov.uk/cancer/research.htm) found higher than average rates of cancer among this group related to historic exposures.

Paint formulations have changed over recent decades, so historic exposure data may not be representative of current exposures. HSE holds less information on the current exposure patterns associated with painting and other related tasks. This project will address this in two phases. A telephone survey will be undertaken first to gather information on work tasks and exposure controls. The results will be used to identify representative tasks with significant exposure potential. The second phase will monitor the on-site working practices linked to these tasks and measure associated exposure to solvents and dusts.

The findings will assist HSE in understanding the current profile of the health risks

linked to painting and decorating work and the prioritisation of future work to address this.

Electroplating baths – efficacy of exposure controls – PH06105

Surface engineering refers to technologies designed to modify the surface properties of metallic and non-metallic components for decorative and/or functional purposes. The surface engineering sector is the biggest end-user industry of supplied carcinogens in Britain, with an estimated exposed workforce of more than 3000. The sector supports a much wider range of industry and is crucial to the British economy.

Previous HSE research carried out in this sector used biological monitoring (BM – urine sampling) to assess worker exposures to hexavalent chromium and nickel. The work, published in HSE Research Report RR963, provided clear evidence on high-risk activities within the sector, and also allowed exposure control benchmarks to be identified for these. The work resulted in this follow-up project.

There are a range of measures that can be used to reduce airborne emissions from electroplating tanks. HSE/trade association guidance is available, but in places this is based on expert opinion without supporting robust scientific evidence. Additionally, since the existing guidance was produced, new exposure control options have been developed which potentially offer much more robust control than those previously available.

In this project, we will carry out a systematic evaluation of measures used to reduce airborne emissions and dermal exposures from nickel electroplating tanks. The findings of this work will provide a robust basis for industry guidance aimed at reducing exposures to carcinogens in the surface engineering industry. HSE will also have clear evidence on the effect of different exposure control techniques to inform any future intervention initiatives.

The findings will be disseminated to inform the industry on the efficacy of the different control measures, enabling them to make more informed choices on exposure control and improving health risk management.

Silica – collecting exposure and health data – PH00706

Silica (silicon dioxide) is a natural substance found in most rocks, sand and clay and in products such as bricks and concrete. These materials are commonly found in a wide range of British workplaces, and it has been estimated that around 600 000 British workers have regular contact with silica dust. Breathing in silica dust over many years is known to cause breathing problems, particularly silicosis, but also chronic obstructive pulmonary disease (COPD) and lung cancer.

This research will collect information from a wide range of workplaces that have measured levels of silica dust in the air. The research will also collect health information from silica workers who are having regular health checks at work, and workers who have been diagnosed with silicosis. The information will give HSE a better understanding of workplace silica dust exposure levels and silica-related illness. The information collected will allow us to help workplaces reduce silica exposures and help to keep workers healthy.

Updating the HSE evidence base for wood dust exposure risks in the construction industry – PH00798

Inhalation of wood dust can cause respiratory diseases such as asthma and cancer. Tackling such diseases is a priority for HSE. Thousands of construction workers are exposed to wood dust while working on site. This research will provide information on the significance of these exposures and the risk to workers.

The research will involve site visits to examine the wood dust-generating tasks taking place and the exposure controls used. Exposures will be measured using an HSE-developed method that separates the wood from other airborne dust that may be present. This provides a greater level of measurement accuracy than has previously been possible. The opportunity will also be taken to measure respirable crystalline silica exposures collected in parallel samples. Alongside this, human factors research will explore influences on current management practices to control dust exposure, and the reasons for potentially safe/unsafe behaviour.

The results will provide exposure benchmarking data and increase HSE's overall understanding of wood and other dust exposure in construction. It will also provide further understanding of control effectiveness, the management practices associated with them and ways that these could be improved.

A comparison of welding fume emission rates and welders' exposures – PH20105

Is there a relationship between the amount of welding fume (WF) at the point of the weld and welders' actual exposure?

The amount of fume released per unit time at the point of a weld is termed the fume emission rate (FER). This is affected by several variables such as the electrical power applied to the torch, the angle of the torch to the weld, the distance of the torch from the weld, shielding gas, and the welding consumable. FER can be measured under standard laboratory conditions.

A welder's actual exposure is also subject to additional variables including their posture and the effect of any exposure controls provided. This work aims to establish if there is a relationship between FER and actual welder exposure when welding mild steel (MS).

The Welding Institute (TWI) is currently undertaking research which includes comparisons of stainless steel (SS) welding FERs and personal exposure data, to assess whether a relationship can be established between the two. It is timely for HSE to work in partnership with TWI and MAKEuk (the manufacturers' organisation) to do the same for MS welding, especially since all types of WF are now classified internationally as 'carcinogenic to humans'. HSE estimates there are approximately 190 000 welders in the UK spread across a variety of industries, including manufacturing.

A literature search will be conducted to review any available MS FER and welders' exposure data. These, and data supplied by TWI, will be collated, analysed and used to inform HSE's enforcement position on MS welding.

If any relationship is established, this could then be used as a tool for predicting MS WF exposures from different welding processes.

Exoskeleton technologies – PH20028

Exoskeleton devices are designed to provide an external supporting structure to the human musculoskeletal system. They can enhance human performance and reduce physical demands on the body. Because exoskeletons can change the demands on the human musculoskeletal system, exoskeleton technologies are relevant to the risks of work-related musculoskeletal disorders (MSDs). These disorders are the most commonly reported cause of occupational ill health in Britain.

In this project, we will carry out a scoping study to develop an up-to-date picture of research and development being done in exoskeleton technology; gauge the current and planned adoption of exoskeletons across industry sectors; and develop an overview of the evidence available about the potential impact of adopting exoskeletons in the workplace.

Musculoskeletal disorder (MSD) risks associated with specific tasks in the construction industry – A review – PH00780

Construction is one of three industries with the highest rates of work-related musculoskeletal disorders (MSDs). While not life-threatening, problems such as lower back pain can impair the life quality and mobility of large numbers of the working population. HSE is committed to reducing the cost of this to individuals and society. These disorders are often associated with manual handling activities such as lifting, carrying, pushing or pulling of loads. Some construction tasks create higher risks than others.

The project will review scientific studies and other evidence linking specific construction tasks and trades with an increased risk of MSDs. The conclusions will be used by HSE as part of its ongoing activity to improve the work practices associated with these tasks and reduce MSD rates in the industry.

Evaluation of timing devices for assessment of hand-arm vibration exposure – PH00701

A variety of devices are currently available, designed to evaluate the exposure time of workers exposed to hand-arm vibration. These devices are designed to be mounted either on the tool or on the operator.

This project is investigating the performance of a range of timer types so that suitable, evidence-based advice can be given to dutyholders on the merits, or otherwise, of using tool timing devices. The work contributes to HSE's Health and Work programme in that it will provide dutyholders with better information to enable them to manage employee exposures to hand-arm vibration in the most effective way.

The aim of this project is to acquire enough evidence and knowledge on the applicability of different types of tool timing devices and their relative merits when used as part of a programme of exposure control measures. The project aims to test the timers in combination with a variety of electric, compressed air and internal combustion engine-powered tools.

The project is designed to provide HSE with robust information on which to base its advice to dutyholders on the use of tool timers for exposure time measurement and

hand-arm vibration risk assessment. The information will be incorporated into the advice provided by HSE on the vibration exposure monitoring Frequently Asked Questions information sheet, which is available via the vibration at work pages of HSE's website.

Evaluation of lower vibration solutions for angle grinding – PH20169

Hand-held angle grinders are widely used across several sectors, including steel frame fabrication. These tools typically produce hand-arm vibration (HAV) magnitudes of around 7 – 9 m/s^2; this means that there will be a risk of ill health for operators regularly using these tools for more than 20 – 40 minutes per day. A high number of hand-arm vibration syndrome reports through the Reporting of Injuries, Disease and Dangerous Occurrences (RIDDOR) Regulations are investigated from this industry sector.

The most effective way of controlling exposure to HAV from grinders is to reduce or eliminate the use of these tools. This project will investigate alternative processes to grinding as well as methods designed to reduce HAV from grinders. The techniques investigated may also result in reducing some of the other safety risks associated with using these tools, such as lacerations, eye damage, amputation of fingers and fire risks due to the potential classification of metal grinding as hot work.

Promotion of the efficacy of angle grinder controls to HSE's inspectors, and to the wider industry through guidance drafted in collaboration with relevant trade associations, will create opportunities to enforce up-stream of the RIDDOR process. This work is intended to directly link into HSE's enforcement activities and advice

Battery-operated tools – hand-arm vibration – PH00539

With the recent improvements in battery power technology, the use of hand tools that are battery-powered is becoming widespread. HSE's knowledge relating to noise and vibration exposures from power tools is predominantly based on tools powered by traditional methods, such as mains electricity, compressed air or internal combustion engines.

Battery-powered hand tools have become viable options for many applications, and many dutyholders are migrating towards the use of these tools. Battery-powered machines are particularly attractive in industries such as grounds maintenance, construction and motor vehicle repair, where the mobility of the tool can simplify the site work. Many manufacturers of power tools are suggesting that the use of battery-powered machines is advantageous for reducing both noise and vibration exposures. They quote figures that suggest considerable reductions in the emission values for these tools. However, the validity of these claims and the expected health consequences from long-term use of battery-powered machines for workers are not yet known.

The project is investigating the potential influence on noise and vibration exposures that selection and use of battery-powered tools has when compared with more traditional types of power tool. Taking action to be better informed of the relative merits of this developing technology is clearly important. This will ensure that there isn't a trend towards higher exposures which may then go unnoticed until the consequences to

health become apparent.

The outcomes from the project will be used by HSE specialist inspectors and other sector specialists to further advise dutyholders and other stakeholders on power tool selection. The information will be disseminated widely, including trade associations and power tool manufacturers.

Current control practice and exposures to noise and hand-arm vibration in the construction industry – PH00514

The aim of this study is to establish current noise and hand-arm vibration (HAV) exposures in the construction industry and the current control practices in use that are reasonably practicable to appropriately target HSE's inspection activities and lay out enforcement expectations.

Noise and HAV are significant causes of ill health among construction workers. They are over three times more likely to suffer noise-induced hearing loss and 4.5 times more likely to suffer effects due to HAV than other workers. There is a lack of up-to-date information and practical knowledge of noise and HAV exposures in the construction industry, and which activities are causing the highest risks to workers.

A review of the available literature on construction noise and HAV exposures will establish our existing knowledge. We will engage with the construction industry, interviewing providers of tools and plant machinery as well as a construction major contractor. HSE's Construction Industry Advisory Committee (CONIAC), industry advisers to HSE and HSE Noise and Vibration Specialist Inspectors will also be interviewed.

These interviews will inform a short list of high-risk activities, relating to phases of work, types of construction activities and specialist activities. This will help to identify industry representatives to approach for site visits to gather up-to-date information. We will then visit five or six sites to cover the activities identified in the interviews. The visits will include measurement of noise and HAV exposures and gathering information about current control practices, working conditions and worker attitudes/behaviours affecting exposure.

Information documents for the activities will be produced. These will detail typical current noise and HAV exposures together with reasonably practicable controls that HSE inspectors should expect to see. The documents will be used by HSE inspectors for both identifying and targeting health-related inspection and stating specifically the types of controls that can be expected for noise and HAV within the construction sector.

Static concrete mixer cleaning – Establishing a benchmark for control of exposures causing ill health – PH00542

Static concrete mixers must be cleaned after each batch of concrete is made, as any remnants start to set after two hours, resulting in a cumulative build-up of product. It is the removal of this accumulation by hand, using powered hand tools, which can expose operators to high levels of hand-arm vibration, noise and dust. Long-term exposure to these hazards can result in hand-arm vibration syndrome (HAVS), noise-induced hearing loss and respiratory disease.

This project aims to investigate good control practice in managing health risks within

the concrete industry and advise the industry on reasonably practicable controls for noise, hand-arm vibration and dust when cleaning static concrete mixers. To achieve these aims, a better understanding of the effectiveness of existing health risk control methods in cleaning of static mixers is needed.

For static concrete mixer cleaning in relation to exposure to noise, hand-arm vibration and dust, this research will review what is known about the process and current practices in the industry. The study will then identify what are reasonably practicable and best practices for the cleaning of static concrete mixers.

JAMACH14 chain saws – Noise testing – PH00729

Chain saws are very noisy, which can lead to hearing loss in users. The Supply of Machinery (Safety) Regulations 2008, which implement the requirements of the Machinery Directive 2006/42/EC into UK law, require manufacturers to reduce risks due to noise emissions to the lowest level, taking account of technical progress and available means of reducing noise.

Assessing the adequacy of the noise control measures relies on the availability of accurate comparative noise emission information. However, a European project 'NOMAD' found that the noise content in 80% of more than 1500 machinery/tool instruction manuals did not meet the legal requirements of the Machinery Directive. The NOMAD project and previous HSE research have shown that the reported noise emission data may not be reliable or representative enough to enable an assessment of the noise reduction measures applied. This non-compliance by manufacturers makes it more difficult for employers to manage the noise risk to their employees.

A European-wide market surveillance exercise 'JAMACH14 Chain saws' has been carried out to assess the compliance of chain saws against the requirements of the Machinery Directive. This exercise has included an assessment of the noise content in chain saw instruction manuals.

By taking measurements of the noise exposures of chain saw operators while performing common tasks with a set of saws, this project aims to investigate if the noise emission data in the instructions provided by the manufacturer is a credible indicator of noise hazard during its intended uses, and if the noise test codes for battery, electric and internal-combustion chain saws are reliable in providing noise hazard information.

Innovations in hearing protection encouraging full use and proper fit – PH20042

Noise-induced hearing loss (NIHL) accounts for 62% of the top ten health-related employer liability claims across all industries. Hearing protection is often considered as the first and only solution where a noise risk exists, but this is not always a simple or reliable solution.

Ineffective hearing conservation programmes are often encountered across all industry sectors. A common issue is that workers fail to fit hearing protection properly. This is often linked to the selection of an inappropriate type of protector and a need or desire to maintain communication with colleagues; for example, lifting earmuffs to discuss work in hand or deliberately fitting protectors poorly to avoid isolation or to improve spatial awareness and communications.

'Non-passive' hearing protection is available, with features such as dynamic

attenuation control, integral communications and/or entertainment (earmuffs/ear plugs) and active noise reduction (noise cancelation). Some of these features are claimed to improve communications and reduce the feeling of isolation experienced by employees when wearing hearing protection. The use of suitable non-passive hearing protectors may encourage employees to fit and wear hearing protection correctly. Hearing conservation programmes can only be effective if suitable hearing protection is worn correctly. Ultimately, improving the use of hearing protection will reduce the number of workers at risk of developing hearing loss.

This project aims to investigate the performance characteristics of non-passive hearing protection and so understand the benefits or possible drawbacks of using these devices in noisy workplaces.

Understanding what motivates dutyholders to undertake risk assessments for work-related stress (WRS) and implement appropriate interventions – PH20133

Work-related stress (WRS) is defined as an adverse reaction that people have to excessive pressures or other types of demands placed on them at work. WRS, anxiety and depression are some of the most commonly reported causes of occupational ill health in Great Britain. Recent figures from the Labour Force Survey estimate that there were approximately 600 000 cases of WRS, anxiety and depression in 2018/19. It is therefore important that employers assess the risks of WRS and take the appropriate steps to manage them.

There is limited information available regarding the factors that influence the extent to which employers conduct risk assessments for WRS and take action. The information available suggests that there may be several factors at play, such as an understanding of the impact of WRS on individuals and organisations, management commitment and organisational resources.

The study aims to obtain a better understanding of the factors that motivate or hinder organisations from carrying out risk assessments and implementing appropriate interventions to manage WRS. The work will involve reviewing existing HSE survey data on WRS as well as carrying out telephone interviews with a range of dutyholders across different industries. Areas that will be explored include dutyholders' understanding of the impact of WRS, the types of actions taken to manage WRS, and the potential barriers or enablers to conducting WRS risk assessments and/or implementing interventions.

It is anticipated that the findings from this research will help inform future HSE strategy and interventions to support dutyholders to actively manage the risk of WRS in their organisations.

Use of Legionella test data to better understand rapid test method real-world experiences and to improve dutyholder compliance – PH20114

Legionella bacteria can colonise industrial water systems, spread by aerosols and cause respiratory infection. Currently, HSE guidance recommends monitoring for Legionella for control compliance with numerical action and alert levels, but only supports testing based on growth of Legionella bacteria on agar plates which takes several days. Rapid monitoring methods such as quantitative polymerase

chain reaction (qPCR) potentially provide a viable alternative, although data interpretation is not fully clarified. HSE needs robust evidence to evaluate qPCR data, especially for trend analysis and in-house action levels, to encourage uptake and adoption.

A UK engineering company had problems with Legionella colonisation in its water systems, and this led to legal action by HSE. To remedy the situation, the company instigated a programme of enhanced monitoring by installing around 100 sampling ports implementing culture and qPCR analysis. They collected over 1000 samples and used rapid feedback from qPCR data to act on significant variations in Legionella levels and implement remediation measures.

The company has agreed to share this monitoring data with HSE, together with contextual information, and how it was used for remedial actions. Taking maximum advantage of this unique opportunity, HSE's microbiologists and statisticians propose to use these data to establish significant associations. The company will work with HSE to put together a 'lessons learned' story, planned for publication as a joint authored paper, to benefit dutyholders facing similar Legionella control problems.

HSE will also use the output to update guidance and advisory statements to provide dutyholders with sensible and proportionate approaches to improve monitoring and control of Legionella risks.

Evaluation of rapid test methods for detection of Legionella in industrial cooling water systems: Improving dutyholder compliance with controls required to reduce infection risk – PH20115

Legionella bacteria can colonise and proliferate in industrial water systems, be spread by aerosols and cause respiratory infection. Currently, HSE guidance recommends monitoring for Legionella as a control effectiveness check, but only supports monitoring by growing Legionella bacteria on agar plates for dutyholders to comply with numerical action and alert levels. These tests take several days, however newer rapid (less than one day) monitoring methods potentially provide viable alternatives. HSE needs robust evidence to evaluate these alternatives and provide an informed choice to dutyholders to encourage uptake and adoption.

The Sellafield nuclear site uses evaporative cooling systems for safety-critical temperature control. These must be monitored for compliance with Legionella control. To do this, they have a microbiological testing laboratory on site, which provides a unique co-location of the water systems that need to be monitored and unlimited access to testing facilities. Samples can thus be taken more frequently and analysed in more detail to evaluate novel test methods, compare test methods and assess the effectiveness of interventions, all of which are of significant interest to HSE.

To maximise this opportunity, we propose that HSE and Sellafield jointly fund a PhD student to undertake projects to address the above. This student will be registered with and supervised by researchers at Sheffield University, with technical oversight provided by HSE staff with Legionella expertise.

The output will be used by HSE to update guidance and advisory statements to

provide dutyholders with sensible and proportionate approaches to improved monitoring and control of Legionella risks.

Stirring animal slurry and release of hydrogen sulphide – PH00479

Cattle slurry is stored on farms and needs to be stirred to allow spreading. Toxic gases, including hydrogen sulphide (H_2S) are released during stirring and can cause acute central nervous system toxicity, unconsciousness and death. Toxic gases have contributed to slurry-related deaths, but little is known about gas release and dissipation during slurry stirring. This project aims to improve our knowledge of H_2S generation and dissipation, understand farmers' knowledge and awareness, and test the reliability of current HSE guidance to reduce the number of slurry-related deaths and accidents in the UK.

We undertook small surveys to investigate levels of knowledge about the release of toxic gases during slurry stirring and awareness and implementation of guidance. Farmers had good understanding of the health effects of slurry gases, but some were complacent about the risks. On-farm, real-time measurements of H_2S gas were taken at a variety of positions during stirring of cattle slurry, along with contextual data on the type of slurry store, stirring equipment and ventilation, and an assessment of current controls.

Many factors are likely to influence H_2S gas production, emission and dispersion. These include the type of slurry store, the position of the stirring point and natural ventilation, and are likely to significantly influence the potential for farmers to be exposed. Many of the factors are variable and unpredictable.

The assessment of risk to workers from gases released during the opening of freight containers at UK ports – PH00587

Freight containers are opened routinely for inspection on arrival at UK ports by various people, including Port Health, Trading Standards and Customs and Excise. There have been incidences of ill health and hospitalisation of workers at ports in the UK during this routine opening. Containers are also opened at distribution centres throughout the UK, following transportation. Incidences of ill health and hospitalisation at these centres occur at similar levels to those at ports. There is a potential health exposure risk for individuals entering freight containers due to the build-up of toxic and flammable gases, or oxygen deficiency. This is due to their contents and the lack of ventilation inside.

The aim of this work is to obtain up to date knowledge on hazardous gas/vapour exposure potential (and controls) for workers when opening freight containers at UK ports and distribution centres.

A literature review to establish the types of cargo and the potential hazards associated with them will be undertaken. We will also undertake fact finding visits to ports to observe practices when containers are opened. The next phase of the work will involve sampling visits at ports and distribution centres. Sampling will be used to determine the levels of hazardous substances in the air when the containers are opened.

Coordinating and advancing human biomonitoring in Europe to provide evidence for chemical policy making – PH00724

Human biomonitoring for Europe (HBM4EU) is a joint project across 26 countries, the European Environment Agency and the European Commission, and is co-funded under

Horizon 2020. Running until 2021, HBM4EU will generate knowledge to inform the safe management of chemicals and so protect human health in Europe. HBM4EU will coordinate and advance human biomonitoring in Europe, providing better evidence of the actual exposure of citizens to chemicals. In addition, there will be a robust interpretation of human biomonitoring data and the possible impact of chemical exposure on human health, using the most up-to-date scientific tools.

HBM4EU partners will effectively communicate results to policy makers, ensuring their exploitation in the design of new chemicals policies and the evaluation of existing measures. Data used and produced under HBM4EU will be made accessible via IPCHEM – the Information Platform for Chemical Monitoring. IPCHEM is the European Commission's reference access point for searching, accessing and retrieving chemical occurrence data collected and managed in Europe.

Within the project, there is a specific working group looking at occupational exposures. To date, we have participated in a field survey for the carcinogen hexavalent chromium that involved eight countries. In the UK, we visited companies involved in electroplating and stainless-steel welding. The protocol has been published (Santonen et al, 2019) and data analysis is currently underway. HSE led a training workshop for other European research institutes on chromium speciation in exhaled breath condensate. This is a new approach that allows specific determination of hexavalent chromium without the need for an invasive blood sample. HSE has also been involved in two literature reviews (for diisocyanates and for polycyclic aromatic hydrocarbons), and both are currently being drafted for peer-review publication.

The occupational working group is now finalising plans for the next field studies that will look at diisocyanates (in understudied scenarios such as painting large vehicles, spray insulation and floor screeding) and chemical exposures (e.g. metals, plasticisers, flame retardants) in the processing of e-waste.

Operator exposure during application of pesticides to tunnel-grown crops – PH20045

This project will deliver information that will enable HSE to improve/confirm our method of assessing the risks associated with the application of pesticides in tunnelled cropping systems. The work will involve operators applying pesticides to crops, determining exposures, and comparing this to currently assessed levels. This will help HSE to improve our assessment of applications for the authorisation of pesticides in these situations or confirm that existing approaches are appropriate and proportionate.

Herbicides applied through weed wipers – PH20046

This project will deliver information that will enable HSE to improve/confirm our method of assessing the risks associated with the application of pesticides using weed wipers (a relatively new method of application). The work will involve operators applying pesticides to crops, determining exposures, and comparing this to currently assessed levels. This will help HSE to improve our assessment of applications for the authorisation of pesticides where this technology may be used or confirm that existing approaches are appropriate and proportionate.

The Prospective Investigation of Pesticide Applicators' Health (PIPAH) study – PHF00615

The PIPAH study is a long-term follow-up study that HSE established in 2013. It was

designed to build on HSE's earlier Pesticide Users' Health Study (PUHS) by recruiting from the same population of professional pesticide users, and to address the main weakness of the PUHS by collecting more contextual information about the pesticide users. The PIPAH study has similar aims as the PUHS, in that HSE established it to monitor the health of professional pesticide users in Great Britain.

In 2013, with the help of City & Guilds, the members of two professional registers of pesticide users (NRoSO[1] and NAsOR[2]) were invited to take part in the study. In 2014, members of the PUHS were also invited to join. The recruitment of new members of NRoSO into the PIPAH study on an annual basis continues. At enrolment, study participants complete a consent form and the baseline general questionnaire. Each year, participants are invited to complete a follow-up questionnaire and at the same time receive a newsletter that updates them on progress with the study. To date, over 6000 men and women have completed baseline questionnaires.

The outcomes used to monitor health include cancer and death registration data received from the NHS Central Registers, and self-reported symptoms and doctor-diagnosed conditions obtained from the questionnaires. The research findings will contribute to the evidence base regarding the safety of professional pesticides in Great Britain.
For more information, visit the website: https://www.hsl.gov.uk/resources/major-projects/pipah.

[1] https://www.nroso.org.uk/
[2] https://basis-reg.co.uk/scheme-amenity

The Pesticide Users' Health Study (PUHS) – PHF00615

The PUHS was established by HSE in the late 1990s as a means of monitoring the health of men and women who use pesticides in their work. It includes around 65 000 of the pesticide users who undertook a Certificate of Competence with the National Proficiency Tests Council between 1994 and 2003, required under the 1986 Control of Pesticides Regulations.

HSE holds basic information on the participants and their certification, and a proportion of the study participants have provided detailed information on their work-related pesticide use through a survey conducted in 2004 to 2006. Information on participants' health, such as cancer registrations, deaths and hospital admissions, is collected through NHS central registers. Analyses focus on comparing ill health or mortality rates to those of the general population and examining differences between participants with differing pesticide use histories. Cancer incidence and causes of death up to 2005 have been analysed and published, and an analysis of neurological disease, eye disease, respiratory disease and skin disease using hospital admissions data is underway.

As the largest national study of men and women in Great Britain who potentially experience long-term low-level pesticide exposure as part of their work, the PUHS has the potential to make a substantial contribution to the scientific evidence base about the role of pesticides in human health, and to help inform future policy decisions. This study complements HSE's new Prospective Investigation of Pesticide Applicators' Health (PIPAH) study.

For more information, visit the website: https://www.hsl.gov.uk/resources/major-projects/puhs.

Occupational health fitness standards for divers – PH00752

Diving is a high-hazard, potentially high-risk activity. As a result, there are specific regulations on diving at work to ensure the risks are controlled. These are the Diving at Work Regulations 1997.

In the UK, there are around 5500 commercial divers carrying out different types of diving work. They include, for example, offshore divers supporting oil and gas industries and inland/inshore divers supporting civil engineering projects, police investigations, scientific research, media and the instruction of recreational divers. To help ensure that all commercial divers can meet the physical and psychological demands of diving, they must have an annual medical examination to assess their fitness to dive. The medical is conducted by an HSE-Approved Medical Examiner of Divers (AMED).

Standards for determining the medical and physical fitness of commercial divers are provided in guidance issued to AMEDs by HSE. They reflect the need to protect the health, safety and welfare of divers at work. The standards were developed largely from expert medical and scientific opinion.

This research project is designed to enhance the evidence base which underpins the standards. The research will obtain anonymous medical data relating to commercial divers who have consented to participate in the study, including assessment of lung function, body mass index, waist circumference and physical fitness.

These values will be compared across different dive types, and also assessed across different levels of fitness to dive. While not offering a complete solution initially, access to this information over time will be invaluable to help inform HSE’s work in this area.

Survey to support evaluation of the Health and Work programme – PRJ1256

HSE's Health and Work programme aims to reduce the number of new cases of work-related ill health, focusing on stress, musculoskeletal disorders (MSDs), and occupational lung disease (OLD).

It is important to measure our progress, to allow us to understand what impact we have had and what outcomes have been achieved; to inform our future activities by giving us a better understanding of what works; and in the short term, to allow us to adjust our approaches to make sure that our actions are having the greatest impact.

Various high-level data sources can be used to monitor changes in levels of work-related ill health. However, these sources cannot provide the contextual information needed to understand the extent to which any reductions in ill health are directly attributable to HSE interventions – contextual information such as changes in awareness of, and attitudes towards, work-related risks. Changes in attitudes and behaviours are best measured through a bespoke survey of workers and dutyholders in the sectors targeted by HSE’s interventions.

This longitudinal survey explores attitudes and views in a representative sample of workers and dutyholders from a range of businesses in priority sectors. A baseline survey has already been undertaken, to measure to what extent workers and dutyholders are currently aware of the risk factors for stress, MSDs and OLD; what awareness they have of measures to prevent risk; and the extent to which such

measures are in place in their workplace.

A follow-up survey will be undertaken after two years, following a programme of HSE interventions. The follow-up will measure changes in attitudes and behaviours, to evaluate the extent to which HSE activities have had an influence. This work will allow HSE to better understand its impact and if it is having a positive influence on behaviours – which in turn, should lead to reductions in work-related ill health.

Creation of the COVID-19 and lung health return to the workplace survey/tool – EM7

The European Lung Foundation (ELF) was founded in 2000 with the aim of bringing together patients and the public with respiratory professionals to positively influence lung health. The aim of this project is to develop and run an online survey/tool that will identify individuals' (primarily with a respiratory disease) concerns about returning to their workplace during the COVID-19 pandemic, and to report its findings.

The tool will be targeted at people who are returning to work during the COVID-19 pandemic, and primarily those who have a pre-existing respiratory disease. All workers can participate, if they wish. Following development of the online tool, and a short period of trialling, the tool will be launched and will remain active for 12 months. This new study and platform will be based on the existing highly successful ELF online tool, also developed with HSE input, to assess occupation as a cause of asthma (http://yourlungsatwork.europeanlung.org/). A launch will be developed by ELF, and social media will be used to promote and advertise the tool.

The data gathered will provide ELF and HSE with insight into the information, support and advocacy needed by individuals with a lung disease returning to the workplace.

The right evidence for the future

The aim of the research in this science hub is to take a long-term view on the development of the evidence base that can support HSE's long-term strategic approach. It is allowing us to keep abreast of advances in measurement science and technology to improve evidence gathering.

SAPHEDRA – best practice in consequence modelling – PH06328

The Control of Major Accident Hazards (COMAH) Regulations are the main legislation dealing with the control of on-shore major accident hazards involving dangerous substances. They came into force on 1 June 2015 and require a detailed risk assessment to be undertaken when an estimation of the consequences of major accidents is required for decision-making.

Predictive models are used in this estimation, so they directly influence the decision-making process. For this reason, decision makers need to understand their strengths and weaknesses. Consequence model evaluation can be used to provide assurance of the robustness of predictions and guide improvements in modelling techniques.

There have been several European initiatives on consequence model evaluation and harmonisation. Adopting a harmonised approach can build on existing experience and update procedures for new and emerging technologies and materials. A need for such an approach was recognised as new scenarios emerge for which existing models have not been evaluated. A project titled 'SAPHEDRA' was initiated to provide a means of objectively assessing the performance of models and related simulation tools. The project involves a consortium of seven international partner organisations and consists of regulators, research establishments and academic institutions. The aim was to derive a commonly agreed model evaluation protocol and a series of test cases derived from well-established experiments.

HSE is providing an 'in-kind' contribution to the consortium and is benefiting by maintaining links with similar organisations. We are helping to ensure that the outputs from the project are compatible with our requirements. Part of our contribution has been the publication of HSE Research Report RR1099 'Review of consequence model evaluation protocols for major hazards under the EU SAPHEDRA platform'. Producing this report has been beneficial for the evaluation of our own models, and its publication and presentation at conferences has helped to share our expertise.

Validation of International Organisation for Standardisation (ISO) Protection Levels – PH00750

Work activities may result in harmful substances contaminating the air, and respiratory protective equipment (RPE) is designed to protect the wearer from these hazards. There are new respiratory protective device (RPD) standards being developed under the International Organisation for Standardisation (ISO), which are expected to be adopted by the European Committee for Standardisation (CEN) and eventually replace the current suite of BS EN ISO standards relating to classification of RPE.

When RPE is used, correct selection is critical to the reduction of exposure. As part of the selection process, the expected in-use performance levels, referred to as 'assigned protection factors' (APFs), are critical parameters. The new ISO requirements call for new indicators of in-use performance values referred to as 'ISO Protection Levels' (ISO

PLs). There is a concern whether these will be sufficiently robust to ensure adequacy of the RPE. If APFs are to be replaced by ISO PLs, it is essential that these values are robust and validated.

Previous validation work conducted by HSE and external stakeholders considered only one type of RPE device, and knowledge gaps concerning the applicability of these proposed PLs for other types of RPE remain. This project will involve HSE and external stakeholders testing many common RPE types in accordance with the proposed methods in the draft ISO performance standards. The results will be compared with data relating to the performance of those RPE in the workplace and compared with the new ISO PL classification system for each RPE type against the current APF data. The aim of this project is to provide a clear understanding of how the new ISO PL classification system will affect HSE policy on RPE selection and use.

Measuring asbestos in air and lung samples: Assessment of an alternative method – PH00671

HSE estimates that there are currently around 12 000 deaths per year in the UK from occupational respiratory disease linked to past occupational exposures. Asbestos is responsible for over 5000 of these deaths. The aim of this project is to assess the capability of a new technique for identifying and counting asbestos fibres from air and lung samples.

Existing methods use electron microscopy and light microscopy to analyse and count asbestos fibres. The new technique is based on the selective attachment of a fluorescent marker to the asbestos fibres, so they can be separated from other non-asbestos fibres when viewed under a fluorescent light. For the technique to be useful, it must selectively attach to the six varieties of asbestos fibres (to avoid false negatives) and not attach to the many other types of non-asbestos fibres that may be present in air and lung samples (false positives).

The research will apply the new method to various types of fibres on test filters, followed by filters prepared from existing air and lung samples that have been previously analysed by analytical electron microscopy. This will allow us to assess whether this new method could be a reliable and useful addition to the current light microscopy counting methods in use. If reliable, the new method would offer significant advantages in increasing the limit of detection for asbestos fibre counting and would decrease the need for costlier analytical electron microscopy. If successful, this new technique could help with the monitoring of current asbestos concentrations in workers and other building occupants in buildings containing asbestos materials, which continue to be a source of public concern.

Developing a national exposure intelligence system – PH05708

The HSE cancer burden study (http://www.hse.gov.uk/cancer/research.htm) estimated that occupational cancer in Great Britain, linked to historical exposure to hazardous substances, caused approximately 8000 deaths per year. These estimates depend on the quality of data about the number of workers exposed and their exposures. Although the estimates were based on the best available data, it was apparent that more accurate, current, GB-specific data would reduce the uncertainty associated with these estimates.

This research is developing a GB-specific system using respiratory crystalline silica

(RCS) to assess the system. The research aims to develop a method to find available data sources relevant to workplace RCS exposure in Great Britain and identify information gaps; obtain and analyse exposure data; estimate the number of workers exposed and their exposure levels (by industry sector, occupation and business type/size); and estimate trends in exposure.

Estimates of RCS exposures will be used to determine the future disease burden, how exposures alter over time and what effect this has on the disease burden. The results of this research will allow us to assess trends in occupational disease in the UK. This will enable HSE to better prioritise its operational and policy decisions to reduce occupational disease.

The Health and Occupational Research network (THOR) – PRJ500

THOR is a voluntary surveillance scheme for work-related ill health. Under this network specialist doctors systematically report all new cases that they see in their clinics. These reports are collated and analysed by a multidisciplinary team at the University of Manchester. Two component schemes of THOR are SWORD (based on reports from hospital consultants specialising in respiratory disease) and EPIDERM (based on reports from consultant dermatologists).

HSE's Health and Work programme aims to reduce the numbers of new cases of work-related ill health, focusing on stress, musculoskeletal disorders (MSDs), and occupational lung disease (OLD). Data provided by THOR allows HSE to report progress against the OLD strand of the strategy. The data provide information on causation, including new and emerging issues, and on incidence and trends. It is used to evaluate intervention strategies within specific sectors, providing sufficient detail and numbers to allow longitudinal assessment of progress against priorities over time. THOR provides information on conditions that are clinically diagnosed and identified as work-related to help inform policy and guidance. The data is also the leading source for HSE’s annual statistics on occupational asthma and skin disease. Without THOR data, HSE could not quantify levels of work-related disease or report on progress in the way that it currently can.

Land use planning advice – Onshore major hazards – PH00673

HSE is a statutory consultee for planning applications around major hazard sites, major accident hazard pipelines and licensed explosives sites. For major hazard sites and major accident hazard pipelines, HSE sets a consultation distance within which a planning authority must consult HSE over developments which are likely to lead to an increased population around the major hazard. For licensed explosives sites, a safeguarding zone is specified within which a planning authority must consult HSE over any developments.

HSE’s Planning Advice web app is an online system that allows registrants to obtain HSE’s advice directly on whether planning permission should be granted. For developments around explosives sites, users are directed to contact HSE’s Explosives Inspectorate for advice. Users of the web app can find out if a proposed development lies within the consultation distance/safeguarding zone of a major hazard. If it does, they can, for a fee, use the web app to find out what HSE’s advice would be on the proposal, or be directed to the Explosives Inspectorate for advice if the proposed development is within a safeguarding zone. Developers can also use HSE’s pre-application consultancy service. This service is for more complex proposed

developments and can include providing detailed information about HSE's methodology, information about the major hazard sites and the risk assessments associated with these sites, redesigning layouts, pipeline reassessments and other related tasks.

Our land use planning team use a wide range of skills, knowledge and expertise to deliver HSE's statutory and commercial land use planning advice. The team are the primary point of contact for planning authorities and developers, responding to enquiries and providing a high-quality independent pre-application consultancy service.

Develop and maintain risk assessment models and guidance for land use planning – PH00667

HSE provides public safety advice to planning authorities and developers on the risks from major hazard installations and major accident hazard pipelines. A key part of this advice is a map of the industrial facility and surrounding area, overlaid with contours showing HSE's 'consultation distances', which usually comprise three zones that are graded in terms of risks or hazards. HSE uses this safety information, together with details of the numbers and types of population in the vicinity, to advise on the location of new major hazard installations and developments near existing installations.

The production of HSE's three-zone maps involves several modelling steps and assumptions. HSE bases its advice on the 'residual' risk that unavoidably remains after all reasonably practicable measures have been taken by the operator to comply with all relevant health and safety regulations. HSE then makes predictions of the likelihood and consequences of foreseeable and credible release scenarios from the major hazard site or pipeline.

HSE's predictions are based on risk assessment methodologies and computer models of the consequences of releases of a wide range of flammable and toxic materials. Over time, there is a need to develop, update and, where appropriate, replace these methodologies to take account of developments in computer modelling approaches, changes to IT capability and new technical knowledge on major hazards. It is also essential to keep up to date with changes in industry, e.g. introduction of new technologies. The aim of this research is to maintain and develop the risk assessment methodologies and models so that the overall approach remains fit for purpose and can withstand external challenge, for example during a planning public inquiry.

HardSPEC sensitivity and uncertainty analysis – PH00661

This project will deliver an uncertainty and sensitivity analysis of a model (HARDSPEC) used to predict the run-off of herbicides to surface water and groundwaters. It is being undertaken in conjunction with the original model developers to identify areas of the model where refinements might lead to a more precise estimation of chemical concentrations. These refinements will help HSE to improve our assessment of applications for the authorisation of pesticides for use on roads and railways, and ensure guidance and processes are proportionate and meet the needs of users.

Implementation of a Measuring Strategy with the Health and Work programme – PH00758

The burden of work-related ill health in Great Britain is considerable and costs the national economy billions each year. HSE's Health and Work (H&W) programme is focused on reducing levels of occupational lung disease, musculoskeletal disorders and

work-related stress. The programme is large-scale, multidimensional, cross-cutting and complex. It designs and carries out a wide range of interventions including inspection, enforcement and other regulatory activities. It is anticipated that long-term, sustained and coordinated actions developed as part of this programme will, over time, improve awareness, behaviours, control of exposures to hazardous substances and, ultimately, prevent work-related ill health.

In this four-year project, a multidisciplinary team including social researchers, statisticians, data scientists and occupational health professionals will work alongside policy makers to implement an HSE Measuring Strategy for monitoring and evaluating the effectiveness of the H&W programme. This Measuring Strategy, together with measurement framework and principles, has been developed using the H&W programme as a pilot. The measurement framework draws together data systems and analyses, covering Attitudes (A), Behaviours (B), Control of exposures (C), and Disease and work-related ill-health reduction (D), based on a simple model to provide evidence required for evaluating the short-, medium- and long-term impacts of the H&W programme on the British health and safety system. The Measuring Strategy gives a new focus on measuring behavioural changes and risk reductions, and emphasises the use of longitudinal measurement to assess progress over time.

This project will enable sustained efforts, a coordinated approach and long-term evidence base development for measuring the impact of HSE's activities on the British health and safety system. It will help HSE build the right evidence base for monitoring and evaluating a range of national-level interventions.

Advancing the measurement of exposure to respirable crystalline silica (RCS) – PH00760

Exposure to respirable crystalline silica (RCS) is a substantial contributor to the burden of occupational lung disease, and exposure occurs in a wide range of sectors and workplaces. There is still a challenge to reliably and accurately measure exposure, especially at low levels. There is a need to develop techniques to measure RCS concentrations below the capability of current methods, where there remains a risk to health, and to help dutyholders control exposure to as low as is reasonably practicable.

This project is focused on the development of more sensitive, reliable and practical methods to measure these lower levels of RCS. This involves looking at new devices and samplers that collect samples and different analytical methods that will allow the determination of lower levels of RCS in smaller samples. We are also investigating how effective respiratory protective equipment can be in preventing exposure. To be able to do this, we are developing techniques able to measure the small quantities of RCS and other hazardous materials found behind masks when they are worn in the workplace. To better assess personal exposures, novel analytical methods and matrices such as the collection of exhaled breath condensate from workers to look for particles and RCS determinations in lung biopsy samples from a project looking at longer-term exposures, are currently being developed.

This research will also evaluate workplace monitoring instruments which could be made practicable and widely available to those wishing to use them.

Geoanalytic and geographic information systems – PHF00609

Geographic information systems (GIS) can capture, store, manipulate, analyse, manage and present spatial or geographic data. Work in this project ensures the ongoing maintenance and updating that is required to provide relevant GIS information. This is particularly important for key tools such as the National Population database (which provides detailed estimates of population density and distribution for a wide range of applications), the 'Find-It' tool, land use planning tools and web apps and major accident hazard pipeline risk zone maps.

HSE and local authority operational risk assessment requires the ongoing maintenance of specialist GIS software including 'Map Tool', 'Extranet Mapper' and the 'NPD' tool. This support is required by HSE's operational staff and by local authority colleagues for them to discharge their regulatory duties.

Jack Rabbit II Chlorine Experiments: Validation of DRIFT – PH00748

HSE provides local planning authorities with assessments of the risks posed by major hazards sites (such as refineries and large chemical plants), to help authorities manage population growth around these sites.

The main tool used by HSE to assess hazards posed by releases of toxic or flammable substances is the atmospheric dispersion model 'DRIFT'. The model was originally developed by the UK Atomic Energy Authority in the late 1980s, and it has been further developed with support from HSE over the last 30 years. To have confidence in the model's predictions, it is essential that it is validated by comparing model predictions to data from experiments that recreate scenarios similar to potential major accidents, to assess the accuracy of the model.

In 2015 and 2016, the US Army conducted a series of chlorine release experiments at the Dugway Proving Ground in Utah, known as the Jack Rabbit II trials. These were the largest-scale experiments on chlorine ever conducted. The project sponsors, the US Department for Homeland Security and Defense Threat Reduction Agency, invited HSE to join an international group of dispersion modellers to review the data from the experiments and compare dispersion model predictions.

HSE's participation in this project has provided it with an opportunity to validate DRIFT against this important new dataset. The results have helped to improve confidence in the model.

REACT – Refined Exposure Assessment of isoCyanaTes to protect health – PH00767

Isocyanates are widely used chemicals in the manufacture of polyurethane foams, plastics, coatings, varnish, two-pack paints and adhesives, and they continue to be a significant cause of occupational asthma. Isocyanate products are evolving, and we know that although these newer products may be marketed as 'safer' (with some also available to consumers), they still present significant isocyanate exposures if not properly controlled.

This project aims to provide HSE with knowledge on the latest technologies for isocyanates, including potential risk and exposure issues, and to provide the practical tools to appropriately assess these exposures. The project has three main aims: to determine the most practical and sufficient air monitoring method, given recent

developments; to evaluate more specific biomarkers to better characterise risk; and to undertake site visits to assess exposure to under-studied or new isocyanates or tasks involving isocyanates.

To date, the project has reviewed relevant air monitoring methods (currently being drafted for peer-review publication) and explored the use of isocyanate-specific lysine metabolites in urine (currently being drafted for peer-review publication). A site visit has been completed that looked at a number of tasks involving isocyanates, including the use of hot-melt glues and measurement of a previously unstudied isocyanate.

Our work understanding new products and uses of isocyanates will feed into the occupational lung disease strand of HSE's Health and Work programme.

Measuring exposure to hazardous metals – PH00766

Many workers are potentially exposed to hazardous chemicals at work, including metals. This project aims to improve our knowledge of, and develop, both analytical and sampling methods for metals exposures in a range of workplaces. The research will focus on optimising methods of measuring exposure to metals where the existing workplace exposure guidance levels are reducing internationally. It will also focus on gathering data on exposure to new (e.g. ultrafine elements of zinc, silver, titanium) and emerging metals and exposures in a range of industries such as battery manufacture, electrical and metal recycling, and the use of metal powders in advanced materials manufacturing.

Biomonitoring (monitoring of biological samples collected from individuals such as urine samples) to detect chemical exposures has grown significantly in recent years and is commonly used to assess exposures in both occupational and environmental studies. This research addresses a number of areas where currently there are knowledge gaps in terms of understanding the best biological matrix or biomarker to analyse, the types of exposure occurring, or improving the data and knowledge we have by collecting more relevant samples. Specific projects within this research programme include:

- investigating biomarkers for manganese exposures in relevant workers, e.g. welders;
- correlation of airborne/occupational hygiene values with urinary beryllium values;
- investigating unknown arsenic species in workers' samples;
- investigating novel blood collection devices for lead and cadmium analysis;
- developing new methods for measuring metal exposure in battery manufacture and disposal;
- investigating exhaled breath condensate (breathed out water vapour) for the determination of workplace exposures to hexavalent chromium, a carcinogenic metal;
- using novel particle sensors and samplers to assess

airborne exposures to particles in an urban environment.

The research outlined in this proposal will build on successful methods developed in previous HSE projects, develop new methods where needed and use these to collect samples at workplace visits for validation. The findings of this research can be used to provide information on exposure risks and evaluate the effectiveness of control measures in place to protect workers' health.

An exploration of methods for recording and utilising intelligence on workplace exposure controls – PH00786

A wide range of ill-health conditions can be caused by exposure to hazardous substances in the workplace, and one of HSE's priorities is to raise awareness among employers of the harm and preventability of such conditions and help them put in place systems to reduce or remove risks. HSE inspectors record details of the systems employers have in place for controlling these exposures in their inspection visit reports. At present, this takes the form of narrative descriptions, and the aim of this research is to develop a new method of recording information on this topic.

This recording method collects information in a quantifiable way, providing simple counts to describe the control systems in place. This should result in a better understanding of common control failings, allowing our inspectors to observe problems quickly when they visit workplaces and intervene more efficiently and effectively. Another key benefit of this research is that HSE will be able to directly measure the impact of its risk reduction initiatives and learn lessons about what types of intervention are most beneficial in helping employers manage risk.

The application of next-generation sequencing (NGS) to support health impact assessment following workplace exposure to microorganisms – PH20113

Despite widespread reliance on culture-based methods for microbiological investigations, only around 10% of all bacteria can be cultured and identified by traditional methods, e.g. using agar plates. Non-culturable microorganisms, from the remaining 90%, can also contribute to worker ill health, and any inability to characterise these creates bias during assessments of workplace exposure. This can limit the accurate identification of the microorganisms associated with worker ill health.

This project aims to improve and augment the existing analysis methods for workplace samples by developing culture-independent methods based on next-generation sequencing (NGS) technology. NGS identifies microorganisms using their unique DNA profile, eliminating the need to culture them. It can still be used to identify traditionally cultured bacteria (colonies) that may be difficult to characterise by other means, so has broad application for microbiological identification. NGS is rapid and largely automated, increasing analysis efficiency and removing the uncertainty associated with identifying bacteria by visual means alone.

Methods will be developed and validated for use with new in-house NGS equipment, allowing a more efficient and thorough investigation of the types of samples from workplaces. These include metalworking fluids, air samples, process (grey) water and surface swabs. The developed methods and related competencies will help microbiological research and investigations in HSE's priority areas, such as occupational lung disease in the waste and recycling, manufacturing and agriculture sectors.

Development of a British process for determining occupational exposure limits for substances hazardous to health – PH200181

Many people are exposed to a variety of substances at work, some of which can cause ill health. Great Britain already has a robust and well-established regulatory framework in place to protect workers from health risks associated with exposure to hazardous substances (including chemicals) in the workplace by means of the Control of Substances Hazardous to Health Regulations 2002 (COSHH). Occupational exposure limits, known as workplace exposure limits (WELs) in Britain, are set to help protect the health of workers and are part of the COSHH Regulation.

EU directives, specifically the Chemical Agents Directive and the Carcinogens and Mutagens Directive, mandated the UK to include certain WELs in legislation. However, as the UK has left the EU, it will no longer be required to implement EU directives. To ensure continued protection for workers, it is proposed that a replacement regime for setting WELs is introduced. This project will explore how to address the scientific assessment of data on health effects, methods of exposure measurement and other essential information. The project will produce a methodology for setting WELs.

The project will evaluate existing approaches used in other countries for limit-setting and draw upon HSE's technical and regulatory expertise to develop a new British process. HSE's independent Workplace Health Expert Committee will be asked to give a view on the newly developed approach to limit-setting methodology for Great Britain.

Turning the risk profile project into an intervention – PH20076

This project will develop and evaluate potential interventions for use within the construction sector. The interventions are focused on topic areas that have been identified through analysing formal enforcement at construction sites and priority health and safety topics. Interventions will be developed in areas where there is disparity between formal HSE enforcement and key HSE health and safety topics.

To enable senior leaders within HSE's construction sector to make an informed judgement about what interventions to resource, a multi-criteria decision analysis will be undertaken. This analysis will be delivered by working with senior leaders in workshops and developing evidence packs for each intervention. The multi-criteria decision analysis will provide a mechanism for reaching consensus on what interventions to implement while providing a transparent audit trail.

The project will provide several feasible interventions that HSE's Construction Division can prioritise and consider in its planning in the next work year.

A risk-based heat map – Identifying areas where workplace infection risk of Covid-19 could be high in England – PH20189

To help the British workforce return to work safely during the Covid-19 pandemic, HSE has a role to provide advice and support for businesses and carry out 'spot checks' for controlling potential risk of infection in workplaces so that employers and workers feel confident being at work.

To help target inspections, timely intelligence is required to identify high-risk industries, trades and jobs by geographical region. In addition, intelligence feedback from the spot inspections will advance our knowledge of transmission and its mitigation either

directly, or as a reference point for any subsequent outbreak investigations. A heat map will be created to identify areas where workplace infection risk of Covid-19 could be high in Great Britain.

Investigating the droplet and splash protection of eye wear worn for protection against SARS-CoV-2 – PH20194

Safety glasses, goggles and face shields have been worn by workers in some NHS trusts to provide protection from droplets and splash in the context of Covid-19. There is no standard test to determine the splash protection of safety glasses, and notified bodies say that they would not pass the existing tests applied to face shields and goggles. This has resulted in many near miss reports to HSE. Some face shields have been determined safe for release into the NHS supply chain but failed the standard test to demonstrate droplet and splash protection.

This research will investigate the droplet and splash protection of safety glasses, goggles and face shields worn for protection against Covid-19 to enable HSE to make informed decisions and, via the HSE end user and the PPE Technical Team, provide evidence-based guidance to the NHS in the current pandemic and in preparedness for any future outbreaks.

This HSE-funded work is linked to bids for funding from the National Institute of Health Research and the World Health Organisation. If either is successful, they build on the UK interests in the topic and partly fund the development of the methodology. The methodology thus developed can then be used to transfer the analytical techniques to lower- and middle-income countries to provide cost-effective infection control in a local setting. This last piece of work would be undertaken by other academic partners.

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

The aim of the work in this science hub is to provide a body of evidence that supports mitigation, prevention and management of the impact of demographic changes on the health and safety of the future workforce that informs interventions and solutions and positions HSE as the thought leader in this area.

Demographics rapid evidence reviews – EM6

This project sets out to undertake two rapid evidence reviews that are required to underpin HSE's demographics scientific programme and understand how these issues have changed in the post Covid-19 world.

The reviews will document research completed or currently being undertaken and, where possible, identify evidence gaps. The evidence reviews will inform and underpin HSE's demographic scientific programme and priority research in associated areas.

- Review 1: A demographic picture of the construction sector.

Aim: to identify and document what research is being done on the impact of Covid-19 on construction sector workers that specifically relates to health and safety risks to different demographic groups, including older workers.

- Review 2: Employers' attitudes and behaviours - workplace communication.

Aim: to identify and document any evidence on employers' attitudes, behaviours and competencies around communicating with workers about health and safety in light of Covid-19.

Further information

For information about health and safety, or to report inconsistencies or inaccuracies in this document, visit www.hse.gov.uk/. You can view HSE guidance online and order priced publications from the website. HSE priced publications are also available from bookshops.

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