



# AIOH | THE POWER OF MANY

CROWN PERTH, 30 NOV TO 4 DEC 2019

2019

RECALIBRATE · RESYNERGISE · REBRAND

Australian Institute of Occupational Hygienists Inc  
37<sup>th</sup> Annual Conference and Exhibition



## CONFERENCE PROCEEDINGS



**AIOH**

AUSTRALIAN<sup>®</sup>  
INSTITUTE OF  
OCCUPATIONAL  
HYGIENISTS



**AIOH** | **THE POWER OF MANY**  
CROWN PERTH, 30 NOV TO 4 DEC 2019  
**2019** | **RECALIBRATE-RESYNERGISE-REBRAND**

**37<sup>th</sup> Annual Conference & Exhibition of the  
Australian Institute of Occupational Hygienists Inc**

**30 Nov – 4 Dec 2019**

**Crown Perth  
Western Australia**

**2019 CONFERENCE PROCEEDINGS**

**Editor**

**Martyn Cross**

[www.aioh.org.au](http://www.aioh.org.au)

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## A NOTE FROM THE 2019 AIOH PRESIDENT

Dear Delegates, Speakers, Distinguished Guests, Sponsors, and Trade Exhibitors,

On behalf of the AIOH Council, it is my absolute pleasure to offer you a very warm welcome to AIOH 2019, the 37th Annual Conference and Trade Exhibition of the Australian Institute of Occupational Hygienists.

AIOH 2019 will be held in my home town of Perth and I am proud to show off the many beautiful wonders of this unique part of the world. I do hope you get to experience some of these on your visit.

This year's conference theme is *The Power of Many: Recalibrate, Resynergise, Rebrand*. The conference organizing committee have been working hard over the past two years to bring together local, national and international guest speakers to truly deliver a world class program focused on this theme.

The scientific program will include 9 plenary speakers, 18 concurrent sessions and one panel discussion. This is complimented by the weekend professional development program comprising 16 continuing education seminars including 4 full day sessions and the certification exams for those striving for their COH status. I would highly encourage you all to make the most of the scientific program to invest in your career and "**recalibrate**" your professional knowledge.

As always the AIOH conference social program will be a highlight of AIOH 2019, providing extensive networking opportunities to "**resynergise**" and make connections with colleagues, peers, and mentors that will last throughout your career.

The AIOH 2019 trade exhibition will also provide a unique opportunity for delegates to learn about new technology, try out new equipment and see what innovations are on the horizon. So please spend some time in the trade exhibition and meet our exhibitors who specialize in the instrumentation, equipment and services that are vital to our profession.

In a first for the AIOH, this year's conference will also offer a "Headshot Café". This is a fantastic opportunity for delegates to get a professional headshot completed for a small donation to charity. Use this on your social media platforms, your CV, for Bio's when presenting and take this opportunity to "**rebrand**" your profile!

Obviously organizing a conference of this size is a huge and complex undertaking and I would like to extend my sincere thanks and congratulations to Candice Absalom and her organizing team for putting together this fantastic event. I would also like to acknowledge and thank our long standing conference sponsors who you will see throughout these proceedings. Without their continued generous support, we would not be able to offer the exciting range of opportunities our conference provides.

So please, make the most of "**The Power of Many**" as we all come together as likeminded professionals to share our passion for the protection of worker health...and enjoy Perth!

**Dr Julia Norris**  
**AIOH President 2019**

## A NOTE FROM THE 2019 ORGANISING COMMITTEE CHAIR

### Welcome to AIOH2019

We are excited to welcome you to the 2019 Australian Institute of Occupational Hygienists 37<sup>th</sup> Annual Conference and Exhibition. To each and every one of you, thanks very much for joining us at Crown Perth. Our committee is delighted at the tremendous uptake and support from stakeholders across the profession.

### Snapshot of the conference structure

Over the next few days, you have the opportunity to draw insight and inspiration from our theme-driven presentations. Renowned occupational hygienists, health experts, leadership gurus, communication and influence specialists are ready to roll out leading-edge content across 3 sub-themes:

#### Re-Calibrate

- Embrace new technology
- Adapt to new opportunities
- Stretch our boundaries

#### Re-Synergise

- Reinvigorate our networks
- Enlist a multidisciplinary approach
- Embody a holistic perspective

#### Re-Brand

- Strengthen our reputation
- Communicate our contribution
- Invest in our brand footprint

You are invited to create your own personal conference experience by selecting from nine keynote presentations, 16 workshops and over 18 concurrent sessions showcasing the work of more than 40 speakers. *Oh yes, and don't forget to register at the Head Shot café to rebrand your LinkedIn profile.*

### Thanks so much to all our support groups.

A special thanks to all our generous sponsors who have made this conference possible. In particular, to our major sponsors, who have been with us over the years, we say a huge thank you for supporting the AIOH conference again this year.

Thanks to all our exhibitors for what promises to be an outstanding exhibition, showcasing world-class products and services. You ignite innovation and advancement within our profession.

It has been a pleasure to lead our passionate and hardworking conference organising committee. To each member of our team, I say this heartfelt thanks.... "There is no way that this world-class conference could have come together without your innovative ideas, your grinding hard work and your fun vibe – thank you!"

### Organisers' wish list

We'd be thrilled if, from Wednesday 4<sup>th</sup> December, each of you takes home and implements these three key value propositions:

1. Reenergise your passion, having engaged with world-class thought leaders
2. Refresh your world view and deploy your new skills
3. Reinvigorate and leverage your professional networks

We'll think back on the AIOH 2019 conference as the moment our profession switched on the 'The Power of Many'.

Candice Absalom  
2019 AIOH Conference Chairperson

**P.S. Have fun and soak up all the value we have packed into these three days!**

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<b>Strategic Advisory Committee:</b>	
<b>External Affairs Committee</b>	Martin Jennings

Enquiries should be directed to the AIOH Administration office.

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### BIO

René Rodriguez is entertaining, but he is NOT an entertainer. His clients describe him as “powerful”, “thought provoking”, and “authentic”. They say things like, “you could hear a pin drop as everyone was so captivated.” Rene’s engaging speaking style, backed by his scientific approach, makes him a top-rated speaker at every event. For the last 20 years, René has researched and applied behavioral neuroscience as a dynamic keynote speaker, leadership advisor, world class sales expert, and renowned speaker coach. Yet, he believes that we are only scratching the surface of what is possible and that every profession can benefit from fully engaging human mind/brain. His company has trained more than 100,000 people in applying behavioral psychology and neuroleadership methodologies to solve some of the toughest challenges in leadership, sales and change. Rene will advance your personal power with tools that you can unpack immediately.



### ABSTRACT

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*Dr. Max Lum*

Senior Advisor e-Communication and Research Translation | National Institute for Occupational Safety and Health (NIOSH)

### BIO

Dr. Lum was responsible for the National Institute for Occupational Safety and Health's initiatives in health communication, media relations and the Institute's international program portfolio for over fifteen years until his retirement in 2011. He currently serves as senior advisor to the Office of the Director, on communication and research translation issues. Dr. Lum began his career as a White House Fellow serving as a technical writer and community involvement specialist. Before moving to NIOSH, he served with the Agency for Toxic Substances and Disease Registry, in Atlanta Georgia, as the Director of the Division of Health Education and Promotion, responsible for the Agency's activities in community and health professions' education.



### ABSTRACT

Utilizing digital media is at the very heart of the changing approach to communication for delivering evidenced-based information that our audiences need for good decision-making. We now have the convenience of reaching out and connecting to our audiences, family and co-workers virtually instantaneously with a few clicks. This new constant connection approach requires that we must be agile and alert to utilizing better strategies and techniques that will help deliver our OSH information. However, we need to be alert and cautious to the fact there is potential ugliness in the digital world. This case-based presentation using globally derived data will discuss the use of a variety of the most popular digital communication platforms- Facebook, Twitter, Blogs, Wikipedia, and apps and their potential for expanding information reach and delivering on the promise of engaging the public and our community of practice as part of an overall health and safety communication strategy.

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Group Lead: Occupational Health and Hygiene | Anglo American plc.

### BIO

Cas is the Group Lead Occupational Health and Hygiene at Anglo American plc. He is a Certified Occupational Hygienist working in the field of occupational health and hygiene for more than 20 years. He is appointed as Extraordinary Associate Professor in Occupational Health and Hygiene at the North-West University, South Africa and is an Honorary Fellow at the University of Wollongong, Australia. He is a Past President of the Southern Africa Institute of Occupational Hygiene (SAIOH) and the current chair of the Health Working Group of the International Council of Mining and Metals (ICMM).



### ABSTRACT

Traditional modes of managing occupational health have focused on managing consequences (the disease itself) rather than the cause i.e. the control of exposure and prevention of the disease. Within Anglo American we've embarked on a journey to apply critical control risk management principles to reduce exposures across our business. We've realised that as occupational hygiene professionals we need to reinvent ourselves to prevent occupational disease – we need to re-imagine occupational hygiene. In this key note the Anglo American occupational hygiene Framework and Strategy will be shared with the audience. The presentation will look back at the occupational hygiene journey of Anglo American and how we are moving from a 'Zero Exposure' policy to a proactive, integrated, and sustainable control at source strategy. The application of technology to support our journey is critical and we'll explain how real-time monitoring and digitalization is supporting our strategy.



## ADVOCACY AND INFLUENCE: THE HYGIENISTS CENTRAL ROLE

*Dr Julia Norris*

Medical Director and Certified Occupational Hygienist | Occuhealth Pty, Ltd.

### BIO

Dr Julia Norris, is an advocate of preventative health with a unique combination of qualifications and experience in both Occupational Hygiene and Medicine. Throughout her career as both an occupational hygienist and medical doctor, she has demonstrated a passion and commitment to protecting and promoting worker health.

Julia is the Director of Occuhealth Pty Ltd, an Australian occupational hygiene and medical consulting company. As well as being a General Practitioner, Julia is also a Certified Occupational Hygienist, a Fellow of the Australian Institute of Occupational Hygienists and the current President of that body. She is also a fellow of the Royal Australian College of General Practitioners and a registered medical review officer. Julia has over 20 years of experience in occupational health matters, having worked across many industries including mining, refining, oil and gas, construction and agriculture.



### ABSTRACT

As occupational hygienists, our role is to advocate on behalf of the workforce and influence workplaces to provide healthy work environments for all. In this role we often work alongside other health professionals but traditionally the different health disciplines have operated quite separately, with defined theoretical boundaries and unfortunately, a culture of competition. However, as occupational health professionals, we are all working towards the common goal of better health in the workplace.

Our challenge in providing effective and comprehensive workplace health strategies is to appreciate the importance of our expertise as occupational hygienists, while also recognising our potential synergies with other health disciplines. There is a wealth of expertise and knowledge that we can all access by fostering closer working relationships with likeminded professionals. Using accelerated silicosis as a case study, Julia's address will highlight the importance of engaging occupational hygiene in early response to emerging issues and the success that can be achieved through a systematic culture of collaboration.

## THE HEALTH BENEFITS OF GOOD WORK - ACHIEVING BETTER HEALTH OUTCOMES

*Dr Peter Connaughton*

Consultant Occupational Physician | Australasian Faculty of Occupational and Environmental Medicine

### BIO

Dr Peter Connaughton is the immediate Past-President of the Australasian Faculty of Occupational and Environmental Medicine. He serves on the Faculty Policy and Advocacy Committee and the Executive Group for the 'Health Benefits of Good Work' campaign. He is a Consultant Occupational Physician working in private practice in Perth, consulting to the mining sector. He is an Adjunct Associate Professor at the School of Medicine, the University of Notre Dame, and also at School of Public Health, Curtin University. He is a member of Executive of the International Occupational Medicine Society Collaborative (IOMSC) and Co-Chair of the Coal Mine Dust Lung Disease Collaborative Group. Peter studied occupational medicine at the Institute of Occupational Medicine in Edinburgh and has a MBA from the University of WA. His special interests include workplace mental health strategies, vocational rehabilitation for complex cases and the evaluation of occupational health interventions.



### ABSTRACT

This presentation challenges occupational hygienists to join the Health Benefits of Good Work Campaign, as an excellent way to achieve the Conference goals to re-calibrate, re-synergise and re-brand. The HBGW Campaign is the highly successful policy of the Australasian Faculty of Occupational and Environmental Medicine. It is leading a paradigm shift to focus on creating good work to improve the health and well-being of workers. It is based on compelling evidence that good work is beneficial to health and wellbeing and that long-term work absence and unemployment have a negative impact. The campaign brings together over 200 organisations to encourage employers' continuing support for workers' health and to advocate for improved policies on work and health. The steering group includes statutory authorities, healthcare organisations, insurers and national employers. HBGW enables you to "reinvigorate your networks, enlist a multidisciplinary approach and to embody a holistic perspective."

## LEV TEST EQUIPMENT

*Adrian Sims*

Director | Vent-Tech Ltd

### BIO

Founded Vent-Tech in 2001, BOHS approved to teach P601 (LEV Testing) & P602 (LEV Design) modules. Currently Vice Chair of the Institute of LEV Engineers & working with Health and Safety Executive on multiple LEV based projects inc. Competency, Recirculating Filters & TExT. Since founding Vent-Tech in 2001, it has been Adrian's mission to help reduce preventable deaths and illness from the hazardous substances emitted during industrial processes.



Working with companies across the UK, Vent-Tech is involved in the design, installation, testing and commissioning of specialist local exhaust ventilation systems.

Over the years he has worked with clients such as Anglo American, Airbus, Rolls Royce, The Royal Mint, Toyota, Bombardier, Marshall Aerospace, Premier Foods, Johnson Apparelmaster, Mission Foods and Aunt Bessies to name a few.

### ABSTRACT

We will look at the various pieces of LEV test kit available to us and assess which we are going to rely on to enable us to make a judgement as to whether adequate control is being achieved.

## OCCUPATIONAL SURVEILLANCE PROGRAMS - LIFESTYLE FRONTIERS

*Christine A. Kennedy*

Consultant Occupational Physician University of Calgary, Departments of Community Health Sciences and Family Medicine, and the Public Service Occupational Health Program- Ontario and Nunavut, Health Canada

### BIO

Christine A. Kennedy MSc MS DPhil MD CCFP FCFP FRCP(C) CCBOM PGCEBP, is currently practicing as an occupational physician for the Canadian Public Service Occupational Health Program- Health Canada. She formerly served as the chief medical officer for Syncrude Canada Inc. (until Dec 2018). She completed her doctorate in health economics from the University of Oxford, UK, in 2000, and has continued to work in the area of the economics of cancer prevention, including occupational cancers prevention, and surveillance. She practices in the Northern Alberta oil sands region, and also practices preventive medicine, public health, and primary care in various indigenous communities in Treaty 8 lands. She is a clinical lecturer at the University of Calgary, Department of Medicine, Family Medicine and Community Health Sciences.



### ABSTRACT

Medical surveillance is about informing prevention: it is designed to identify, characterize, and mitigate risks before health effects can occur. We design and implement occupational medical surveillance programs in order to keep workers healthy, and ensure that employers are meeting standards in Occupational Health and Safety Code regulations and legislation. Current medical surveillance programs include specific exposures such as for silica, benzene, beryllium, laser, and noise, and more generally for regulated occupations: such as for firefighters, sea going occupations, and others. Programs have been designed and active for many years, however, in two industries (mining and refining), there has been an increasing incidence of "findings" of possible occupational disease, resulting in intensive clinical follow up which found non-occupational conditions/disease in all cases. Specific clinical cases were reviewed in this study for silica, beryllium, benzene and noise, which show a trend of increasing rates of disease (respiratory and hearing loss) due to non-occupational exposures such as cocaine and fentanyl drug use, tobacco use, and other lifestyle toxins/risks (ethanol, obesity). The rate of "lifestyle diseases" found by occupational surveillance programs now far outnumber any "true" occupational condition cases identified. The implications of such changes in fundamental occupational medicine and industrial hygiene practices of medical surveillance programming are explored, and suggestions for rationalizing scarce resources and optimizing monitoring and surveillance practices are presented in this paper. Two illustrative medical cases will be presented. Multidisciplinary discussion of the challenge presented by increasing numbers of "lifestyle" diseases and exposures to current surveillance and monitoring practices is encouraged.

## MAKING WORDS COUNT - CHANGE COMMUNITY BEHAVIOUR

*Clare Arthurs*

Senior Trainer | Red River Strategic Communication

### BIO

Clare Arthurs is a public speaker with a background as a broadcaster and journalist. She has spent more than 20 years in global news media, working in Australia, Europe and South East Asia. Clare has:



- Worked for the BBC as a Foreign Correspondent, East Asia Editor, news producer and senior in-house trainer as well as held senior roles at the ABC. She's worked in print, radio, TV and global news agencies around Australia and in Britain.
- Communication advice to Cabinet Minister in Canberra and in the Prime Minister's Department.
- Consulted with the United Nations on presentations and message development throughout Asia and Europe.
- Presented at national and international forums
- Teaching experience at Australian universities to Masters level in journalism, broadcasting, safety and social media

### ABSTRACT

It's not enough to be highly skilled and know your stuff. If we want to influence people and create change, which for many of us is about saving lives, we need to be able to communicate with clarity, impact and cut-through. In this session Clare Arthurs of Red River Strategic Communication will give us an insight into why it's so important to build the influence of Occupational Hygienists as well as an give us some foundational communication skills which we'll be able to apply immediately.

## TO THE MOON AND MARS: EXPLORING THE EFFECTS OF IONIZING RADIATION BEYOND EARTH'S ORBIT AND DEEP UNDERGROUND

*Dr. Doug Boreham*

Division Head, Medical Sciences; Northern Ontario School of Medicine and the Bruce Power Research Chair in Radiation and Health

### BIO

Dr. Boreham is currently a professor at the Northern Ontario School of Medicine (NOSM) as the Bruce Power Research Chair in Radiation and Health and is Division Head for the Medical Sciences Division. Dr. Boreham is a recognized leader in the field of radiation health and environmental effects. He was selected as an expert Canadian delegate for the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) in 2012. He has earned several awards including: McMaster President's Award for Excellence in Instruction (2004), Canadian Nuclear Achievement Award for outstanding Education and Communications (2005), Canadian Radiation Protection Association – Distinguished Achievement Award in Recognition of Outstanding Contributions in the Field of Radiation Protection (2009), Radiation Research Society – Mentor of the Year Award for Scholars in Training (2010). The International Dose-Response Society selected Dr. Boreham as recipient of the 2015 Outstanding Leadership Award in the field of Dose Response. Dr. Boreham currently conducts research on low dose impacts from natural and man-made radiation. Low dose cancer risk and radioprotection is a primary focus of his research. He has supervised numerous graduate students and Post-Docs and has over 120 peer reviewed scientific publications



### ABSTRACT

In space, galactic cosmic radiation (GCR) is ionizing radiation which causes damage to biological life, e.g. astronauts. We are collaborating NASA scientists on several projects aimed at understanding the consequences of space radiation exposure and possible countermeasures to protect organisms from the damage. BioSentinel is a NASA Ames astrobiology research project which aims to detect and measure the impact of deep space radiation on living organisms. The BioSentinel project is currently utilizing genetically modified mutants of the yeast *Saccharomyces cerevisiae* as a biosensor model to study the effects of deep space (40,000,000 km) on DNA damage and repair. In our lab, the BioSentinel yeast along with a human cancer model will be grown in a novel research laboratory (SNOLAB) 2km (6,800 ft) underground in a mine. The rock burden above SNOLAB shields virtually all GCR. Specialized shielding eliminates external terrestrial radiation coming from the rock walls in the mine, and an innovative growth chamber eliminates naturally occurring radioactive radon gas in SNOLAB. Consequently, we can study how life processes deal with the absence of ionizing radiation or reintroduce controlled quantities to test for biological responses. Occupational exposure to high doses of ionizing radiation and CGR can increase the risk various pathologies including cataracts, cancer, and cognitive decline. We have developed a complex dietary supplement to be used as a protective countermeasure. The supplement has been shown to reduce cataract formation, reduce cancer risk, and dramatically improve cognition. The research is aimed to better understand the molecular mechanisms underlying how humans can adapt to ionizing radiation (and other stresses) and how dietary countermeasures could protect humans in workplaces on the earth, moon and Mars.

## CONCURRENT SESSIONS

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### DIESEL AND WELDING FUMES – ‘CANCER-CAUSING’ DECLARATIONS BY IARC AND THEIR IMPACT ON EXPOSURE STANDARDS

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*Gregor Riese*

Principal Consultant, Giant Hygiene Services | School of Medical and Health Sciences, Edith Cowan University

#### BIO

Gregor Riese has over 25 years' experience in the waste management and material recycling industry and completed his Master of Occupational Hygiene and Toxicology with Edith Cowan University in 2018. Gregor has been part of a team at Edith Cowan University working on a major Commonwealth government project looking at complex mixtures and compliance with GHS requirements. These reviews included examining over 500 recent papers on the health effects of diesel emissions and welding fumes, both of which have been declared "known carcinogens" by the International Agency for Research on Cancer.

#### ABSTRACT

The International Agency for Research on Cancer (IARC) declared diesel engine emissions and welding fumes Category 1 carcinogens in 2012 and 2017 respectively. Many exposure standards currently in use are based more on acute effects (eg metal fume fever) rather than long-term carcinogenic effects. Exposure standards based on acute health-effects may not be protective in relation to long-term chronic exposure and risk of cancer. These complex mixtures may also contain chemical substances such as carbon monoxide and nitrogen oxides in diesel emissions, or heavy metals of Ni, Mn, Cr and Zn in welding fumes, that each have their own exposure standards. There is a relative scarcity of exposure standards internationally in relation to diesel engine emissions, compared to welding fumes, despite the 2012 IARC declaration. This reflects the rapid evolution of diesel engines and the increasing use of biodiesel fuels which power them. A number of international jurisdictions have seen fit not to use historical epidemiological data for diesel exposure because they represent old technology and do not reflect current exposures. This paper examines what weight should be placed on a "known carcinogen" declaration by IARC in establishing and/or reviewing exposure standards for complex mixtures.

*Thomas Mitchell*

Principal Consultant EHS Risk & Compliance | Jacobs Engineering

## BIO

Thomas Mitchell is a career Environmental Health & Safety (EHS) leader with extensive executive level experience and demonstrated success servicing multi-national organisations. He has held academic positions of Lecturer and Senior Research Officer with University of Ballarat (Victorian Institute of Occupational Safety and Health) generalising in Safety Engineering, Safety in Design, Industrial Hygiene and Ergonomics and specialising in Risk Management, Compliance and Management Systems, Training and Education.

Thomas has worked across government, business and industry sectors providing consultancy, training and auditing services.

Thomas has also undertaken commissioned EHS research projects for the National Occupational Health and Safety Commission, Coal Industry Research Program, Mining and Quarrying Association and WorkCover equivalent programs in NSW, Victoria and South Australia.

## ABSTRACT

The architecture, engineering and construction (AEC) sector collaborate to design our built environments and in doing so, carry responsibilities to anticipate, recognise, evaluate, communicate and control hazards even before soil is broken on a building or infrastructure project. In Australia, the WHS Act (S.22) imposes duties on designers to ensure that structures are designed to be without risks to health and safety of persons. Designers' responsibilities to maintain and transfer WHS risk information are also prescribed. Constructors of structures (including to install, commission and demolish) also have WHS duties to deliver their respective function associate with a structure, so it is without risks to health and safety of persons (S.26). The emergence of Safety in Design (SiD) principles have connected WHS professions with the AEC sector to develop processes for investigation, evaluation and communication of WHS risks associated with built environment design, constructability and operability. However, with no standardised mechanism to transfer SiD information progressively from Designer to Constructor and to the Operator, often the chain of custody may be weakened or broken and critical WHS risk treatment information may be lost over time. As SiD was becoming regular practice in the AEC sector, digital asset design management processes were gaining momentum (Engineers Australia, 2005). Since, Alomari (2012) suggested improvements in safety performance and Ganah (2015) improvements in safety communication attributed to the use of Building Information Modelling (BIM) in the construction industry. Towards 2020 all states and territories will have a digital engineering strategy following BIM principles. It is inevitable that occupational hygienists and other WHS professions will have increasing involvement with digital asset design/engineering, with many seeking new opportunities to adapt BIM to improve environmental, health and safety management.



*Jane Whitelaw*

Co-ordinator of the Occupational Hygiene Program | The University of Wollongong

### BIO

Jane is a Certified Occupational Hygienist, Certified Industrial Hygienist and Fellow of the AIOH. She had over 25 years' experience in Corporate roles in heavy industry before moving into teaching and research at the University of Wollongong; where she is Co-ordinator of the Occupational Hygiene Program. She is a member of the AIOH PD&E committee, the Respiratory Protection Fit Testing Steering Committee and is the AIOH representative on the Australian Occupational Health and Safety Accreditation Board.

She is the Safety Institute of Australia representative on SF 10 Australian Standards Committee publishing "AS/NZS 1715 Selection, Use and Maintenance of Respiratory Protective Equipment". Jane's research interests are in Protecting Worker Health from Chemical and Physical Hazards, and her major grants and research have been in evaluating the Efficacy of Respiratory protection. She is currently a PhD candidate at the University of Wollongong in the Faculty of Medicine.

### ABSTRACT

Respiratory Protection is the last line of defense in control of exposures to hazardous substances, yet often the only viable choice in the workplace. Standards Australia has advised their intention to adopt the ISO 16976 suite of standards with their next revision; incorporating Human Factors such as anthropology and ergonomics as well as the individual's physiological response to the use of respirator which will have ramifications for every workplace using respiratory protection.

Smelter workers wore their normal negative pressure respirators and performed their usual work duties across their 12hr shifts whilst their breathing rates, heart rate and core temperature was monitored for comparison with the recommended limits in ISO/TS 16976-1.

This research was enabled by the recent development and validation of new technology to measure breathing rates through a respirator whilst workers perform normal work activities.

Not surprisingly, it was found that the higher the work rate experienced, the more pronounced the effects of RPD use were; and the more distinct the changes in breathing pattern became. The physiological effects and perceived burden of use were also more pronounced.

The results provide the first real time analysis of breathing rates of negative pressure RPD wearers performing normal duties in a smelter workplace. Interestingly, they were not always consistent with those specified in ISO standards that had been primarily determined from laboratory tests.

Whilst laboratory tests give an indication of the use of respiratory protection, they are no substitute for real time in-workplace evaluation. Studies which use simulated activities and non-industry cohorts may not be representative of the workplace use of Respiratory Protection.

Wearers of Respirators at higher work rates are under additional strain, and the individual's physiological capacity, as well as the work rates and environmental conditions should be considered in respirator selection.

## ABSTRACT

### Objective

Prevalence of non-communicable diseases (NCD) is growing among workers globally, causing 71% of all premature deaths. We determined baseline prevalence of risk factors among mine workers.

### Method

1169 employees were randomly recruited to a cross sectional study. The study focused on key risk factors of hypertension, obesity, alcohol use and smoking status. These factors are known key contributors to NCD risk.

### Results

Results of the study showed prevalence's of hypertension 12.9%, obesity 64.1%, alcohol users 22.1% and smokers 38.8%. The general population prevalence's are 27.5%, 56.8%, 15.5% and 24.8% respectively.

### Conclusion

Prevalence of hypertension for the study cohort was lower than general population which may be the healthy worker effect. Obesity, alcohol use and smoking rates however, were slightly higher in the study cohort. Reducing the prevalence of risk factors will require significant resources.

**Keywords:** Non-communicable disease, Hypertension, Obesity, Alcohol, Smoking, Public Health, Mongolia.

## 1. INTRODUCTION

This paper will discuss collection, analysis, results and conclusions resulting from data collected as part of a wider Health Impact Assessment (HIA) conducted at a remote mine site in Mongolia. This location was selected due to its remoteness and the availability of access to the site and the selected study cohort. Data analysed were selected to identify public health markers that are known risk factors for the development of non-communicable (NCD) or 'lifestyle' disease. These factors are consistent in much of the developed world and not specific to the study location. The selected public health markers used in this paper are hypertension, obesity, alcohol use and smoking status, these are known risk factors for the development of NCD, which are a global issue among workers and non-workers<sup>1</sup>.

A Health Impact Assessment is a research project conducted to identify current health status, predict future potential health issues and gauge the effectiveness of current interventions<sup>2</sup>. The results of HIA are used to identify the health risk prevalence of a population. The risk prevalence is able to be used to select, classify and implement further intervention to manage the risk.

Prevalence of NCD is growing among working populations globally. The World Health Organization (WHO) estimates NCD are responsible for 71% of all premature deaths<sup>1</sup>. Cardiovascular disease, cancers, respiratory disease and diabetes are the four most prevalent causes of death from NCD, accounting for 80% of all recorded deaths associated with NCD<sup>1,3</sup>. Smoking (tobacco use), physical inactivity, alcohol use and diet are all known associates with an increased risk of the development of NCD and premature death<sup>3</sup>.

The primary aim of this study was to provide an overview of the general health of the workforce (using a confidence interval) and to determine a baseline level of NCD risk factors. Following a critical review of the data collected, the results were also compared with a 2013 Health Impact Assessment conducted on the general population of Mongolia<sup>4</sup>. This enabled the researchers to determine if there were any significant similarities or differences in the two populations.

A critical analysis of the implemented interventions was conducted to ascertain effectiveness. These critical analyses were also used to quantify and identify areas where intervention strategies needed to be introduced, improved or increased based on the quantifiable data.

There are many general health interventions in place currently; the secondary the aim of the study to assess their effectiveness and relevance for the people working on site and to assist in targeting future interventions based on quantitative and qualitative data.

The study findings have shown us that current interventions, while successful, do require a re-assessment and improvement to mitigate the risk of NCD development in the future.

## 2. METHOD

The Health Impact Assessment study team used a cross-sectional study design for this study. The cohort included employees and contractors employed by a large scale open pit mining and mineral processing company in Mongolia. The study team defined inclusion and exclusion criteria for study cohort based on the target population. These criteria were:

### *Inclusion criteria:*

- Geographical location: Cohort inclusion based on work location at the mine site.
- Employment type: Cohort inclusion based on Operational Mining or Mineral Processing workers.
- Nationality: Cohort inclusion based on Mongolian nationality.
- Employment term: Cohort inclusion based on length of service of more than one year.

### *Exclusion criteria:*

- Nationality: Cohort exclusion on all nationalities other than Mongolian.
- Employment term: Cohort exclusion based on project based or short term workers.

Four parameters were selected as a measure of the risk of future development of NCD (if no lifestyle changes are made) in the study cohort. These parameters were hypertension, obesity, alcohol use and smoking status. The collected data were assessed individually and then compared with the Mongolian population using data collected in a 2013 study<sup>4</sup>.

The representative sample size for the mine worker population (n=4985) was determined at 95 percentage confidence level using Formula 1. The ideal sample size was calculated at 1658. This calculation was conducted to show the cohort we studied were representative of the site population and that we could demonstrate confidence in the results

### **Formula 1: Representative sample size calculation formula**

$$n = \frac{Z^2 \times P_0 \times (1 - P_0)}{e^2} * def * rr$$

In the calculation of the sample size, we assumed:

- Z - t statistic's distribution in 95% confidence interval was assumed by 1.96 or probability that the data set is normally distributed;
- P<sub>0</sub> – probability value is given as 0.05 when null hypothesis is true;
- e - in order to minimize statistical error, relative and absolute errors are assumed at 0.085% and 0.114% respectively;

- deff – we used random sampling method, then design effect is assumed as 1.0;
- rr – probability of not participating in the study is assumed as Zero, then  $rr=1.0$ .

Participation of personnel in this study was voluntary, participants who met the inclusion and exclusion criteria and who were recruited to the study were fully briefed on the study aim, the data collection tools, participant input required and what would be done with the results. All participants involved in this study gave written informed consent to be involved in the study and gave permission for their data to be used in the subsequent reporting. A copy of the signed informed consent form was given to the study participant, and another copy has been filed together with other study documents. Ethical approval for the study was given by the Mongolian Ministry of Health, which enabled us to proceed with data collection.

The assessment and questionnaire were designed using a cross sectional study across a large group of employees based at a mine site in remote Mongolia. 1169 personnel were randomly recruited to the study based on previously identified inclusion and exclusion criteria. The study group utilised a data capture tool modelled in the WHO STEPS questionnaire<sup>5</sup> to collect information about demographics, anthropometrics, health behaviours, lifestyle, smoking status, alcohol use, non-communicable disease status and work related information. This paper focusses on four key public health (non-work related) risk factors, which are hypertension, central obesity, smoking status and alcohol intake and habits. These factors are known key contributors to NCD<sup>3</sup>.

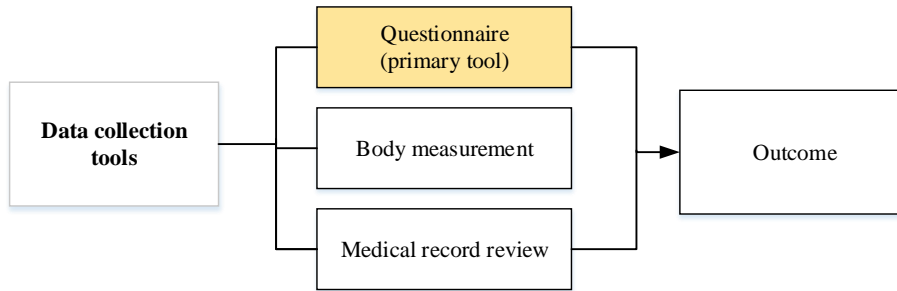
During the initial data collection period, 61% of target sample size (n=1698) was reached. As a result of this, the data collection period was extended a further two weeks in order to increase the study participation rate. At the completion of the data collection phase, 70.5% of the target sample size (n=1169) was reached. Some of the selected employees were unable to be contacted due to the absence of leave or scheduled work in other divisions/units at the time of data collection, this contributed to the lower than expected sampling size.

A stratified random sampling method was used to select individuals into sub-groups of the total study cohort. The stratification kept characteristics of participants (age and gender) as similar as possible across the study groups.

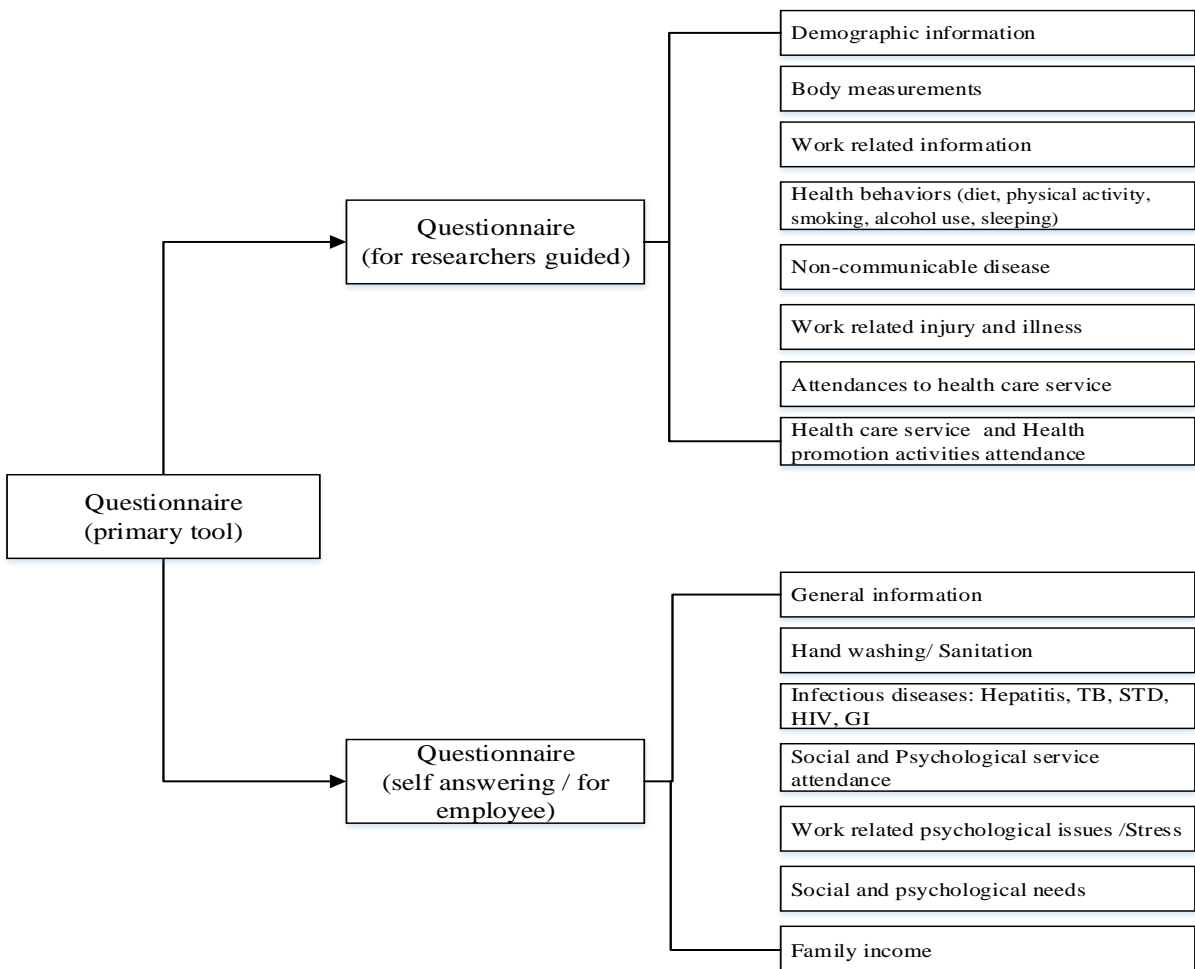
The primary tool used for data collection was a targeted questionnaire. The questionnaire was developed based on similar studies conducted using WHO STEPS Instrument for Non Communicable Diseases Risk Factor Surveillance<sup>5</sup> and The Mongolian National STEP Survey for Non Communicable Diseases Risk Factors<sup>4</sup>. This method was selected as it mirrored previous HIA and a NCD Policy Analysis<sup>6</sup> conducted in Mongolia. This enabled a direct data comparison which was required to complete the research objectives. The questionnaire contained questions about demographic, health behaviours, alcohol consumption, smoking, non-communicable diseases and work related information. The interviewers used a direct questioning technique which was validated within the framework of interviewer training and pilot data collection. Using the WHO STEPS<sup>5</sup> technique enabled a direct comparison between the study cohort and the general population survey.

Figure 1 shows the data collection tools used for this study and Figure 2 shows a detailed explanation of the data we collected through the questionnaire used for this study.

**Figure 1: Overall data collection method flow chart**



**Figure 2: Detailed primary tool (questionnaire) flow of information**



As well as a questionnaire, the research team collected anthropometric data in the form of blood pressure using sphygmomanometers and waist and hip circumference (converted to ratio). Parameters used to determine conformance were taken from leading authorities and associations. The American Heart Association<sup>7</sup> defines hypertension stage 1 as >130 / >90. Waist to hip ratio (WHR) determines central obesity as<sup>8,9</sup> of the employees and the WHO<sup>10</sup> state that there is a substantially increased risk of metabolic

complications at waist to hip ratios greater than 0.90 for Men and 0.85 for Women. The study team used these parameters as our measurement baselines.

The research team retrieved data from employees medical records, from pre-employment and periodic medical check-ups in order to triangulate and confirm self-reported health and disease data. Study participants provided their consent to use their individual identification number to access their latest medical check-up records for the retrieval of data. Medical records of 1,050 out of 1,169 study participants (89.6%) were accessible for data retrieval. The rest of the records could not be accessed.

The study team were selected from experienced members of the Mongolian National Association of Occupational Hygienists (MNAOH) and the Mongolian National University of Medical Science (MNUMS). The research team were selected based on their educational and research background and all members were approved by the Mongolian Ministry of Health. The team converted the survey questionnaire into an online questionnaire using the 1KA survey application<sup>11</sup>. The research team used an internet connected laptop and tablet for conducting interviews with study participants at the mine site as this enabled the immediate upload of the collected responses. Data collection was conducted on site between December 2018 and February 2019. Each interview was completed over approximately 15 minutes in an isolated area to maintain privacy of the respondents. The timeframe of the interview was important to limit the disruption to normal duties. Prior to data analysis, the collected and collated data was downloaded into Microsoft Excel, cleaned and organised into a user friendly format.

Through the publicly available HIA study conducted by the Mongolian Ministry of Health<sup>4</sup>, the study team had access to only the statistical calculations from the study and not the raw data points; therefore, we were unable to calculate the confidence intervals between the data sets (only having two (2) data points to compare).

### 3 SELECTED STUDY PARAMETERS

#### 3.1 Hypertension

Hypertension is the medical term for high blood pressure. Blood pressure is the measure of pressure (force) exerted against the walls of blood vessels when the heart pumps and is measured in two stages of the heart beating, systolic blood pressure; the force exerted when the heart pumps out and diastolic blood pressure; the force exerted when the heart rests between beats<sup>7</sup>.

Hypertension increases the workload on the heart and the circulatory system, which can lead to a range of health problems including heart disease, cardiac infarction, stroke, aneurysm and kidney function decrease<sup>12</sup>. These can all be life-threatening conditions. It is estimated by the World Health Organisation that 40% of people worldwide have hypertension<sup>12</sup>.

Risk factors for developing hypertension are varied, as genetics do play a part. Lifestyle however, is also a significant contributor to this risk factor<sup>7</sup>. Some more common risk factors however are age, weight, tobacco use, alcohol use, diet (high sodium) and stress<sup>13</sup>.

There are medications available to lower blood pressure; this treatment coupled with lifestyle change, such as an increase in exercise, quitting smoking and change in diet can significantly reduce the risk of adverse health outcomes rising from hypertension.

#### 3.2 Obesity

Obesity is defined by the World Health Organisation as abnormal or excessive fat accumulation that presents a risk to health<sup>10</sup>. Obesity is a measure of size and weight, this is generally assessed by the Body Mass Index (BMI), by which is a person's weight is divided by the square of their height. A person with a BMI of above 30 is considered obese<sup>9</sup>. While there are outliers (genetics, body type, and muscle to fat ratio), the BMI is the general indicator used to determine obesity with the WHR used as an indicator of cardiovascular risk<sup>8</sup>.

Obesity increases the pressure put on the whole of the body including the heart, circulatory system, joints, muscles and bones. This can limit mobility significantly, which in turn reduces the ability and likelihood of

exercising. Obesity is major risk factor for a number of chronic diseases, including diabetes, cardiovascular diseases and cancer<sup>10</sup>.

Diet and exercise are the simplest control measures for reducing potential for obesity. There are medical interventions available for those who choose to lose large amounts of weight, however, these are not without risk<sup>14</sup>.

### 3.3 Smoking

Worldwide, smoking is the leading cause of preventable death, being responsible for more than four million fatalities every year; this equates to approximately one death every eight seconds<sup>15</sup>. Smoking is an issue at all levels of the socio-economy; however, it tends to affect the lower end of the spectrum more than the upper class<sup>16</sup>.

Smoking a cigarette immediately exposes the body to carbon monoxide and nicotine. Nicotine reaches the brain around seven seconds after inhalation; the result of this is an increase the workload of the cardiovascular system, which also can raise blood pressure<sup>17</sup>. Nicotine, found in cigarettes is highly addictive<sup>15</sup>.

Cigarettes contain around 600 ingredients and when burning, over 7000 chemicals are emitted, including carbon monoxide, toluene, cyanide and arsenic<sup>18</sup> of these 7000 chemicals, 69 are known to cause cancer<sup>19</sup>. There are numerous life altering health effects that can be directly attributed to smoking, including cardiovascular issues, stroke, aneurysm, foetal development issues, fertility issues, a range of cancers and many others<sup>13</sup>.

There are many options for assistance (both chemical and therapeutic) in quitting smoking. These include a range of diverse support mechanisms including nicotine replacement therapy (gum, patches, and mouth spray), hypnosis, counselling, peer support and others. There is no single quit smoking intervention that is effective as it depends on the individual. A combination of methods is recognised as the most likely to succeed<sup>20</sup>.

### 3.4 Alcohol

Alcohol is a widely used, legal drug (in the depressant family) which acutely affects the brain and central nervous system. While use of alcohol in moderation is generally not considered harmful, long term and heavy use of alcohol is<sup>21</sup>. When consumed, alcohol is absorbed into the bloodstream through the stomach and small intestine. Alcohol remains in the system until the liver is able to break down, process and excrete it<sup>21</sup>.

Alcohol acutely affects the entire body, in particular the brain and central nervous system (slowed reflexes, altered levels of consciousness). Secondary chronic effects are seen in the liver and kidneys which are made to work harder to process, biotransform and excrete<sup>22</sup>.

Long-term use or abuse of alcohol can cause chronic physical and mental health problems. These include hypertension, stroke, liver cirrhosis or failure, ulcers and multiple forms of cancer<sup>21</sup>. Alcohol is addictive and along with the associated health effects of long term use, can also lead to crippling social problems<sup>23</sup>.

Alcoholism is an addiction, which like any addiction, is a very hard habit to break. A treatment program, which includes a variety of interventions such as inpatient and outpatient treatment, medication, cognitive behaviour therapy and willpower<sup>24</sup> is recognised as the most likely to lead to success.

## 4 RESULTS

Results of the study were arranged and assessed to understand health risks and to ascertain whether the intervention strategies are effective in demonstrating a reduced risk when comparing the study cohort to the general population. Table 1 shows the total population (n=4895), the sample population (n=1169) and the distribution of age and gender. Table 2 shows the general characteristics of the study cohort. Total study cohort results for the four selected parameters and comparative data collected throughout the general population of Mongolia<sup>4</sup> in a similar study are included in Table 3.

**Table 1. Study cohort and sample size by gender and age groups**

Age group	Male		Female		Both genders	
	Total population	Sample population	Total population	Sample population	Total population	Sample population
<=24	374	64	170	26	544	90
25-34	1683	428	607	127	2290	555
35-44	975	291	370	69	1345	360
45-54	468	117	150	23	618	140
>=55	86	21	12	3	98	24
Total	3586	921	1309	248	4895	1169

**Table 2. General characteristics of the study participants**

Gender	Number of study participants		Mean age	Mean total employed years	Mean worked years on the mining site
	Freq.	%			
Male	921	79%	35.4	12.1	5.7
Female	248	21%	33.7	8.8	4.5
Total	1169	100%	35.0	11.4	5.4

**Table 3. Prevalence of NCD risk factors in the study and the general population**

	Gender	Arterial hypertension	Central obesity	Daily smokers	Weekly Drinker
<b>Study cohort (2019)</b>	Male	12.5%	73.2%	45.9%	24.5%
	Female	14.5%	30.1%	10.9%	12.9%
	Total	12.9%	64.1%	38.8%	22.1%
<b>General population (2013)</b>	Male	30.5%	44.4%	45.4%	21.1%
	Female	24.5%	69.3%	4.5%	9.8%
	Total	27.5%	56.8%	24.8%	15.5%



Measurements of the NCD risk factors showed that in the total study cohort of 1169 participants, 12.9% were classified as hypertensive, 64.1% have high central obesity, 22.1% drink alcohol weekly and 38.8% smoke daily.

Differences between gender for central obesity (men: 73.2%, female: 30.1%), smoking rate (male: 45.9%, female: 10.9%) and alcohol consumption (male: 24.5%, female: 12.9%) were statistically significant ( $p < 0.05$ ). The differences in the hypertension rates were insignificant.

When compared with the health impact assessment conducted on the population of Mongolia<sup>4</sup>, the total combined male and female results showed a positive result when comparing hypertension rates (study cohort: 12.9%, general population: 27.5%). However, other three comparisons were not as positive, which is consistent with qualitative opinions of mining populations globally. In the study cohort, the rate of central obesity is higher (study cohort: 64.1%, general population: 56.8%), the study cohort smoke more (study cohort: 38.8%, general population: 24.8%) and drink more (study cohort: 22.1% general population: 15.5%).

The differences in the study cohort and the general population are in some areas significant and in others insignificant. The data did show us quite clearly that the current intervention strategies require re-assessment and improvement.

## 5 CURRENT INTERVENTION STRATEGIES

Currently at the mine site, there are a range of lifestyle intervention strategies in place. Below is a list of the strategies in place that directly or indirectly influence the selected study parameters.

### 5.1 Hypertension and Obesity

The intervention strategies for hypertension and obesity are the same. The mine site has a wellness committee which meets regularly to drive programs and activities which promote healthy lifestyle and educate the workforce about good choices. The wellness committee has implemented an education area in the main dining area (seen by approximately 5000 people per day) named the 'Wall of Wellness.' This wall contains health promotion posters and information on gym activities, upcoming health related events, general health information sheets for take away and a range of other information directly related to health and wellness. The mine site has multiple exercise options (basketball, football, tennis, and running tracks) and fully equipped weight and cardiovascular exercise rooms. There are full time staff in the gym to develop individual programmes, run group classes and supervise.

Recently, an eight (8) week healthy lifestyle challenge was run which encouraged those who signed up ( $n=102$ ) to make lifestyle changes (increase exercise, reduce risky behaviour such as smoking and alcohol) and make better and informed choices when selecting food. The group of people who completed this challenge all saw positive outcomes.

For those who are hypertensive or have other identified NCD (usually discovered as part of the periodic medical program), there is a monitoring and medication program in to which they are enrolled to ensure that their health status does not affect their fitness for work.

### 5.2 Smoking

At the mine site during 2018 and 2019 a Smoking Cessation Programme (SCP) was developed and implemented to assist those who wanted to quit smoking to achieve success. This program was a first for Mongolia and from the start had great participation with over 800 people signing up.

As a direct result of this program, 208 people have successfully quit smoking and remained smoke free. The SCP used medically and scientifically proven methods in combination to assist personnel to quit smoking. The programme utilised preparation, counselling, nicotine replacement and peer support to assist and motivate those who enrolled. Final numbers showed results of 25% long term success rate (long term is defined as six months smoke free) for those who enrolled and completed the program.

### 5.3 Alcohol

While alcohol is available on the mine site, there are strict controls in place to manage intake. The bar is managed by bar staff and security staff to ensure access and behaviours are controlled. The bars are open only three of each seven days. Further, to purchase alcohol, each person must swipe an identification card, which ensures each person can only purchase up to four alcoholic beverages on nights the bar is open. This gives a maximum of 12 alcoholic beverages per week. Alcohol sold at the bar is also limited to beer and wine.

## 6 DISCUSSION

Health promotion and intervention strategies are most effective when they are targeted to areas that have quantitative or qualitative research data to demonstrate risk. This enables the development of specific intervention strategies based on data. Having a health promotion calendar is a great idea, and the results can be very useful, however, having meaningful data from the results of a Health Impact Assessment give the information needed to target site wide health challenges that need to be addressed.

The aim of the study was to provide baseline data to understand NCD risk factors affecting the study cohort. The reasons for this were two-fold; firstly to ensure health interventions were targeting the right health challenges and secondly to compare the mine workers with the general population of Mongolia.

Due to raw data access restrictions from the 2013 study, we were not able to calculate a p-value (using a t-test) for the two data sets to show a comparative confidence interval. However, a qualitative comparative assessment of the study cohort versus the Mongolian Ministry of Health data does show differences in the study cohort and the general population that are in some areas significant and in others insignificant.

The study found that the general health of the workforce is in much better condition than the general population for hypertension, but slightly below the national average when compared to the other parameters of central obesity, alcohol use and smoking status. The findings for hypertension may be due to the healthy worker effect and the age of the study cohort. The healthy worker effect is a known phenomenon which shows a lower standardised mortality ratio (SMR) for workers compared with the population, this is due to the worker cohort being in a condition of good health which allows them to pass pre-employment medical assessments which are a requirement for them to be employed<sup>25</sup>.

Hypotheses were developed to explain the reasons why, on comparison, the mine workers recorded lower than national average results for the three remaining parameters. The mine workers are able to eat three prepared, hot, carbohydrate and protein rich meals per day while at work, which is inconsistent with the diet of the wider population, the mine workers are also, mostly in a better socio-economic position due to the higher than average wages paid at the mine. This allows more disposable income that can be spent on non essential items such as tobacco and alcohol.

The study results and comparison show that our correct intervention strategies, while adequate and appropriate, do require re-assessment to ensure the workers are not only employed long term, but also have long term good health.

## 7 CONCLUSION

The results of the studies show that both of the study cohorts require lifestyle improvements to ensure long and healthy working and post working lives. Following the implementation of further targeted intervention strategies at the mine site, it is predicted that there will be measureable decreases in the public health and non-communicable disease risk factors. It is recognised and understood that interventions to date, while they have been implemented well, have not had the desired impact. The future interventions will be based on the quantitative data collected in this study and focus energy directly in areas which require improvement.

It is known that this will require significant resources to ensure that the interventions have the best chance of being successful. The measure used to demonstrate successful further interventions that are

expected to lead to a positive impact on the workforce, a decrease in medical centre presentations and time off work due to illness and / or injury. This study will be repeated in the future where a direct study cohort comparison will be available to be carried out. It is expected that with the review and update of intervention strategies, a reduction in the prevalence of risk factors will be demonstrated. The clinical significance of the research will be seen with a reduction both in on and off site medical centre attendance and overt NCD risk factors in the workforce.

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## BIO

Mark is an Occupational Hygienist whose current role at 3M Australia (Personal Safety Division) focuses on providing technical end user guidance and advice around the selection, use and maintenance of personal protective equipment. This is backed through his previous experience as a Occupational Hygiene/Property Risk Consultant, Masters in Science (Occupational Hygiene Practice), Cert IV in OHS, NSW Licensed Asbestos Assessor (LAA001242) and 15+ years in the safety equipment and training industry.

Mark is also the host of the weekly “Science of Safety Podcast”, which is available on all major podcast platform. He chats with expert guests on a range of WHS topics to provide practical advice and guidance for all workplaces.

## ABSTRACT

A significant aspect of the practice of occupational hygiene in certain industries is the management of respiratory protective equipment programs, including fit testing. There is clear evidence that real world respiratory protective equipment (RPE) protection factors are improved when there is an RPE fit testing as part of a respiratory protection program (RPP). The specifics of RPE fit testing are coming under increasing scrutiny with such high reliance in many workplaces on RPE as a control. However, there is currently no clear guidance in Australia on what defines a “good” RPE fit test and unfortunately, there are plenty of examples of poor fit testing practice and mis-information in many industries. Most industries/companies currently use their own definition/level of a “competent person”, but what is a “competent person” varies significantly between industry/companies.

The AIOH are implementing an industry self-regulated RPE fit testing training and accreditation scheme in close co-operation with many stakeholders to fill this gap in guidance and best practice to provide the means for improving the quality of RPE fit testing in Australian workplaces.

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## UTILIZING A HOLISTIC APPROACH TO 'BEATING THE BUILD UP BLUES'

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### ABSTRACT:

Heat stress and heat-related illnesses continue to be one of the most prevalent health issues facing the workforce in the tropical Northern Territory environment. During the 'build-up' season in the Top End (Oct – Jan), not only are the climatic conditions extremely hot and humid, other external stresses can affect the health and wellbeing of workers. The end of the year can bring about real or perceived deadlines, the holiday season can be stressful for some, particularly for those who work away from home. Anecdotally, a known phenomenon in the Top End is Mango Madness, high heat, humidity and stress tends to enhance negative behaviours such as anger, frustration and shortened tempers.

It is important to take a holistic approach to address all aspects of health and wellbeing at this time of year. Our workplace runs an annual campaign during the Build-Up and Wet Season (October – January) known as "Build up Blues." This program aims to educate our workforce not only in heat stress and hydration, but also in work life balance, mental health and fitness for work. We will provide an overview of the topics and initiatives covered in our Build Up Blues Campaign, including workforce and leader heat stress workshop presentations, online heat-stress symptom surveys, physiological monitoring, programs to empower personnel to self-manage heat stress risk, delivering education programs targeting fitness for work and work-life balance, promote resilience through peer support, and implementing mental health programs and initiatives.

### 1. INTRODUCTION

Our business operates a mine site located 250km east of Darwin in the Northern Territory (NT). The mine site is currently processing stockpiles of ore, while also preparing for the closure and rehabilitation of the mining lease. The tropical climate presents unique challenges to managing worker health as instead of the typical four seasons, there are three: the Wet season where rain is plentiful and a welcome reprieve from the stifling heat and humidity; the Dry season where the mornings are crisp and cool and the days warm with minimal humidity; and the dreaded Build Up season in between the Dry and the Wet, where the humidity and temperatures increase but with no reprieve from the clouds above (mean maximum temperature 37.7°C, (BOM, 2019)).

Research by McDermott et al. (2017) identified residents of the 'Top End' (the Northern Territory area north of Elliot) were 1.6 times more likely to die by suicide and 3.3 times more likely to die from assault-related deaths during the wet season (October – March). Anecdotally, the oppressively hot and humid conditions contribute to the coining of the phrase 'mango madness' which is a reflection of the altered behaviour and increased assault and suicide rates reported around this time of year (Brearley et al. 2015).

On top of this unique climate, The 'Build-up' occurs at a time of year (end of year and holiday celebrations) that brings about many real and perceived stressors to the workforce including perceived time pressures, workloads, work-life balance and fitness for work. To assist and encourage the workforce to be proactive towards managing their health and wellbeing, the business has been running a holistic program named "Beat the Build-Up Blues". This program runs from October through to January each year, with a different focus each month on a topic that resonates with the workforce around that particular time and therefore addresses not only environmental factors, but also other factors that can influence people's behaviour at this time of year.



Figure 1. Build Up Blues Banner

## 2. BUILD UP BLUES CAMPAIGN

### 2.1 Heat Stress and Hydration Management

Historically, as part of the hydration management strategy, the workplace conducts hydration testing using a refractometer to measure Urine Specific Gravity (USG). This method targets workgroups to provide a urine sample at the beginning of shift, mid-shift and post shift to educate the worker on their own hydration status during their workday. In 2017, the business trialed a self-testing regime with hydration strips to encourage the workforce to self-manage their hydration. A campaign interaction and handout of hydration strip packs was undertaken by leaders with the support of the health and safety team at the beginning of the Build Up season. These packs included three hydration test strips, a lollipop, and an instruction card (Figure 2). This is in addition to the routine USG hydration testing for targeted high-risk work groups, random Drug and Alcohol (D&A) testing and post-incident D&A testing.



Figure 2. Hydration Self-test Pack

Basic thermal risk assessments are completed for high-risk work areas and tasks where the potential for heat illness has been identified. Thermal work limits (TWLs) are calculated through monitoring with a Calor Heat Stress Monitor (HSM) utilizing work environment, work demands and PPE requirements.

A key aspect to our Build-Up Blues Campaign over the years has been engaging Dr Matt Brearley from Thermal Hyperformance to present workshops and training throughout the campaign period. These workshops have included education sessions for both the workforce and leadership teams on heat stress symptoms and awareness, hydration management, sources of electrolytes and effective methods for cooling the core temperature. Dr Brearley has also conducted physiological monitoring of high-risk work groups, which included measuring core temperature, heart rate, USG, workload and sweat rates. This physiological monitoring was able to demonstrate the effectiveness of ingesting slushies (slushed ice) on lowering the core temperatures of the participants. The use of ingesting slushed ice as a tool to effectively

decrease core body temperature has been measured by Walker et al. (2014). As a result of this engagement and demonstration, the workplace implemented slushy machines in their crib rooms.

Survey Monkey was trialled as an engagement tool for heat stress awareness. The workforce was encouraged to anonymously participate in an online questionnaire regarding their work environment, tasks, and controls they have available. This information was used to provide specific workplace feedback to the workgroups during workshops and training.

Each year toolboxes distributed to leaders for delivery to their teams. These include basic information on managing heat in the workplace, controls available to manage heat exposure, hydration, and the signs and symptoms of heat-related illness. During the Build-Up, targeted HSE interactions are scheduled including handing out water and distributing electrolyte icy poles during the day.

## 2.2 Work-Life Balance

We provide the workforce with the opportunity to attend workshops that are facilitated by the businesses employee assistance program (EAP) provider. These workshops are held monthly during the Build-Up period and are focused on achieving work-life balance. Examples of workshops that have been conducted in the past include: Managing money and financial stress, Prioritising and setting goals, maximising family/relationship time, establishing boundaries between work and home life, and knowing when to ask for help.

A health and lifestyle coordinator is another resource made available to all employees, and who can facilitate group exercise sessions and cultural excursions for those without access to a vehicle while on shift that would otherwise be confined to the immediate township and/or camp.

## 2.3 Mental Health and Fitness for Work

A Peer Support Program was launched in 2018, with another recruitment drive occurring in 2019. The Peer Support Program utilizes volunteers from the workplace who are trained in appropriate methods of assisting peers who are affected by stress. It is an initiative that aims to improve the mental health of the workforce through onsite support.

Volunteers self-nominate and are interviewed by the companies EAP provider. A Psychologist from EAP provides formal training to the volunteers to recognise the signs and symptoms of stress in their peers, and how best to provide support. Peer Supporters attend regular review meetings with the companies EAP Psychologist.

R U OK? Day activities are held each year with the intent of bringing the workforce together and encouraging conversations around mental health and wellbeing. Fundraising and support for Movember, a yearly event which aims to raise awareness to Men's health, is undertaken each year and all employees are encouraged to participate in the challenge.

In 2019, the company has collaborated with MindFit at Work to deliver resilience training to the workforce. This training aims to equip the workforce with the tools and 'hacks'. Training includes shifting mindset's from a negative to a positive approach through a structured workshop that addresses responding to change on an individual level, embracing ambiguity, interpreting self-talk by switching from a negative to a positive outlook, and building mental muscles through awareness around personal triggers to become more resilient.

The company has engaged external trainers to provide Applied Suicide Intervention Skills Training (ASIST) a two-day interactive workshop for both the general workforce and leaders. The training enables them to understand the ways personal and societal attitudes affect views on suicide and interventions; provide guidance and suicide first-aid to a person at risk in ways that meet their individual safety needs; identify the key elements of an effective suicide safety plan and the actions required to implement it; appreciate the value of improving and integrating suicide prevention resources in the community at large; and to recognise other important aspects of suicide prevention including life-promotion and self-care. All peer support officers are offered the same level of training in mental health and suicide prevention.



The business facilitates fatigue management workshops for leaders as well as toolbox talks for the general workforce. The workshops aim to upskill leaders in the effects of fatigue, how to identify workers who may be suffering fatigue, common signs and symptoms of fatigue, and the policies and processes in place to manage fatigue in the workplace. Toolboxes delivered to the general workforce deliver information that the workforce can put to use in both their home life and in the workplace to manage fatigue. This includes strategies to minimise fatigue such as aiming for adequate sleep, minimising stress, minimising screen time, and aiming for a healthy and balanced diet.

### 3. CONCLUSION

The business employs a wide variety of strategies to address hydration and heat stress, work-life balance, mental health and fitness for work in the form of our program “Beating the Build-up Blues”. We hope that sharing these strategies will assist other professionals and workplaces in implementing their own holistic approach to improving worker’s health, especially in temperate climates such as those experienced in the Northern Territory

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## RE-CALIBRATING DATA INTERPRETATION FOR EFFECTIVE STAKEHOLDER ENGAGEMENT – A TEMPLATE TO ‘RE-BRAND’ OUR COMMUNICATIONS

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### BIO

Mel has worked in the mining industry for the past eight years. Mel holds a degree in Health Science (BSc.) and is currently completing her Masters of Occupational Hygiene and Toxicology at Edith Cowan University in Western Australia. Mel is currently employed with Rio Tinto where she holds the position of Occupational Hygiene Advisor – East Pilbara Operations.

### ABSTRACT

One of the most important and often overlooked functions of the occupational hygienist is the ability to effectively communicate the work they undertake. The challenge of the hygienist in this regard is ‘how’ to distil complex data into an easy to understand message for the worker, given that this information is usually reported in a statistical language citing technical parameters, which can be perceived as both convoluted and confusing. Historically, the challenge has been effective stakeholder engagement when communicating such information, given significant latency periods in occupational health trends resulting in exposure risks often perceived as less of a priority when compared to acute ‘safety’ risks. In addition, hygienists need to be able to adapt their communications in order to ‘pitch’ their message to a particular audience, from shop floor to general manager. Referencing the need to ‘Re-brand’ ‘how’ we communicate as a profession, the paper aims to ‘Re-calibrate’ traditional occupational hygiene reporting through harnessing new technology and business intelligence software. Although not a new concept, the practice of analysing and reporting on business performance is deeply rooted in many organisations, and an opportunity exists to leverage this technology to promote stakeholder awareness of health risk. The paper provides a template for how to simply transform raw data to assist an outlook of providing an easy to interpret, interactive dashboard to communicate occupational hygiene trends and insights. The design principles discussed in the paper can be applied to any industry to improve health risk communication.

## PREFACE

### Background and Motive

Atmospheric particulate matter (PM) pollution has been a major public issue in urban areas, because of the significant impact of particulate matter on human health (WHO, 2013). Particulate matter involves two categories including PM<sub>10</sub> able to pass through the respiratory system and PM<sub>2.5</sub> able to enter gas-exchange region in the lungs. In particular, PM<sub>2.5</sub> may reach bronchi and affect the respiratory system, which indicates these fine particles may result in various health issues (Environmental Protection Agency, EPA).

### Objective

This study collected atmospheric PM fine particles using the standard high-volume sampling procedure from the Environmental Protection Administration for analysis and conversion of ambient PM concentrations by weight method, analyzing type and content of the heavy metals in these fine particles. Meanwhile, the effect of PM<sub>2.5</sub> exposure on lung cancer cells or normal lung cells in the expression of vascular endothelial growth factor (VEGF) was also investigated.

## LITERATURE REVIEW

### 2.1 Characteristics of Particulate Matter

An aerosol is a suspension of a solid or liquid particle in the air. In human living environment, aerosol particles originate from natural sources and excretion of human activities, both having significant impact on atmospheric chemistry and air quality (Sisler and Malm, 1994).

### 2.2 Effect of PM on Human Body

Aerosol particles play important roles in the atmospheric processes, in addition to the affected air quality, decreased visibility, and altered atmospheric conditions, posing significant risk to human health (Seinfeld, 1988; Charlson et al., 1992). Based on study results in epidemiology, exposure to PM is strictly associated with human respiratory morbidity and mortality (WHO, 2013). The Air Quality Criteria for Particulate Matter established by the National Air Pollution Control Administration indicates the different deposition in three regions including nasopharynx, tracheae/bronchi, and pulmonary alveoli based on various diameters of particulate matters, particles with a diameter greater than 10  $\mu\text{m}$  mostly deposit in the nasopharyngeal region completely, 10% of particulate matters with a diameter between 2 and 5  $\mu\text{m}$  deposit in bronchi, about 20 to 30% of them deposit in alveoli, and particulate matters with a diameter less than 2  $\mu\text{m}$  mostly deposit in alveolar tissue, which manifests that different particulate diameters involve various health risks.

PM<sub>2.5</sub> involves a mixture of solid particles and liquid droplets, including airborne particles from black carbon, metal, nitrate, sulfate, polycyclic aromatic hydrocarbons (PAHs) and traffic waste gas (Bell ML, et al., 2007). The inflammatory response in pulmonary airways may be induced or aggravated in healthy and asthmatic subjects exposed to PM pollutants (Alexis et al., 2014; Janssen et al., 2015). Moreover, research suggested exposure of PM<sub>2.5</sub> induced lung inflammation and fibrosis in mice (Farina et al., 2011; Ogino et al., 2014; Jin et al., 2016). These studies prove high hospitalization rate and mortality of cardiovascular diseases and respiratory tract diseases in cities with high level of air pollution which involve consumption of medical resources and economic growth may be further encumbered in the long run.

#### 2.2.1 (Vascular endothelial growth factor) Function and Change in Pathological Mechanism of Vascular Endothelial Growth Factor

The primary function of vascular endothelial growth factor (VEGF) involves activation of intracellular tyrosine kinase by binding VEGF receptor (VEGFR), triggering downstream signaling molecules to activate angiogenesis (Figure 2.2.1-1). Nevertheless, when VEGF is overexpressed, it can contribute to disease, e.g., promoting the growth and metastasis of tumor cells.

As a tumor grows to greater than 2  $\text{cm}^2$ , the existing cell proliferation becomes inadequate in nutrient supply, associated angiogenic factor (e.g., VEGF) is then secreted because areas of the tumor become hypoxic, stimulating angiogenesis among surrounding blood vessels processed toward tumor site to support nutrient supply required for rapid growth. Meanwhile, tumor enters blood circulation through these blood vessels, metastasizing in tissues and organs. VEGF plays very important physiological roles in both normal or tumor cells.

## METHODOLOGY

### High-Volume Sampling Method

Based on Method for the Determination of Suspended Particulate Matter in the Atmosphere – High-Volume Method (NIEA A102.12A) established by the Environmental Protection Administration, R.O.C. TAIWAN, the sampling was conducted on the top floor (4<sup>th</sup> fl.) of the Center for Testing of Respiratory Protective Equipment using Volume Air Sampler. (The sampling site was selected among locations that assure atmospheric pollution without influence from any specific origin or other factors such as traffic conditions. In determination of air quality, the sampling site should be basically 2 to 15 meters above ground level, the sampling is conducted for a duration of 24 consecutive hours with the sampler not affected by other measuring instrument.)

In this study, flow rates of 1.1 to 1.7 m<sup>3</sup>/min was used to collect ambient PM within 24 consecutive hours for weighing.

### Sampling and Preservation

Inspection was performed to assure the error between calibrated flow rate and actual flow rate of the sampler within  $\pm 7\%$ .

### Sampling Devices

The US TISCH TE-6070 PM10 High Volume Air Sampler (Figure 3.2-1) and TISCH Series 231 High Volume Cascade Inertial Impactor (Figure 3.2-2) were used as sampling devices, allowing to perform sampling for PM with various diameters (2.5 to 10  $\mu\text{m}$ , and < 2.5  $\mu\text{m}$ ).

The PM10 High Volume Air Sampler collects ambient particulate matter through a PM10 size selective inlet. The larger particulates are trapped inside of the inlet as the smaller particulates continue to travel through the PM10 inlet and are collected on the 8" x 10" quartz filter paper. (U.S. EPA Federal Reference Number RFPS-0202-141)

### Materials

#### PM Collection

The PM sample was collected between August 2017 and May 2018 in South District of Taichung City. The air was sucked through inlet of the sampler operated with a constant flow rate, particulates with an aerodynamic diameter  $\leq 10 \mu\text{m}$  and particulates with an aerodynamic diameter  $\leq 2.5 \mu\text{m}$  were separately collected on the quartz filter paper through an inertial particle separator. The filter paper was weighed with a high precision micro analytical balance (Mettler Toledo XS105) previously to sampling and then after sampling under a condition with specific temperature and humidity for net weight conversion of the PM sample collected, which was further divided by the total volume sampled in sampling period to determine the average PM mass concentration in ambient air within sampling period.

PM sample solution was prepared according to the method described by Imrich et al., the filter containing PM sample was immersed in deionized water and sonicated for 30 min using a sonicator for extraction of PM sample solution from the filter. The extracted PM sample was then stored at  $-4^{\circ}\text{C}$ . Blank sample (unexposed filters) was prepared in the same manner as PM sample to be a control throughout the experiment. The PM sample solution was processed for 1 min using a sonicator before analysis for the homogeneity of the solution for decreased variance and reduced error.

#### MTT assay

The lung cancer stem cell H1299 is characterized as metastatic cancer cell found after lymph node metastasis, which involving non-small cell lung cancer (NSCLC). Meanwhile, the lung cancer cell A549 is a cell of carcinoma in situ, which is categorized as NSCLC too. Human lung cancer cell lines including H460 (p53 wild-type), H1299 (p53 null) and A549, as well as normal lung cell line MRC-5 were selected to perform the experiment.

Based on the method described by Qiuli Fu et al.,  $1 \times 10^6$  cells/ml of lung cancer cell lines H460, A549, H1299 and human normal lung cell line MRC-5 were incubated in 12-well culture dishes. Various concentrations of medication were first prepared prior to the processing with or without PM2.5 1.5 hours later, after incubated in the incubator at 37°C with 5% CO<sub>2</sub> for 12 or 24 hours, observed with microscope the cellular morphology, collecting the supernatant liquid; after that, 10 µl of the Cell Counting Kit-8 (CCK-8) reagent was added to each well of the plate and put back in the constant-temperature incubator at 37°C with 5% CO<sub>2</sub> for incubation of about 1 to 3 hours until the discoloration appears. Finally, the values of absorbance between wavelength 450 and 595 nm (OD 450/630) were measured using an ELISA Reader. The Cell Counting Kit-8 reagent is ready to conduct a simple and accurate assay to measure cell proliferation and cytotoxicity, which is used for analysis of inhibitory effects of medications on cell proliferation.

### 3.3.3 ELISA (Enzyme-linked Immunosorbent Assay)

Based on the method described by Qingjie Zhao et al., 100 µl of diluted (250x, coating buffer used) cytokine capture antibodies was added in each well of the 96-well dish, allowing to stand overnight at 4°C. Rinse with wash buffer three times after removal of excessive capture antibodies, adding the assay diluent reagent enclosed in the Kit for reaction at room temperature for 1 hour and followed by rinse three times using wash buffer; the abovementioned collected cell culture solution, specimen and various cytokine diluent standards (100 µl/well) were then added in the specific area of the dish for assay, allowing reaction at room temperature for 2 hours and followed by rinse three times with wash buffer, 100 µl/well of detection Ab (250x diluted) was then added for reaction at room temperature for 1 hour and followed by rinse 5 times using wash buffer, after that, 100 µl/well of Avidin-HRP was added for reaction at room temperature for 15 min, followed by rinse 7 times with wash buffer; finally, 100 µl/well of substrate solution (1xTMB) was added for reaction at room temperature for 5 to 10 min, 50 µl of stop solution (2NH<sub>2</sub>SO<sub>4</sub>) was added for termination of the reaction. The OD value in absorbance at wavelength 450 nm was measured using an ELISA Reader, concentration of tested sample is calculated by use of the standards.

### Western Blot (Analysis for Associated Protein Expression)

After incubation of various prepared cell lines using the method described by Qiuli Fu et al., the cells were collected and rinsed with phosphate buffered saline (PBS) followed by centrifugation at 3000 rpm for 5 min, the precipitated cells were collected, rinsed with PBS and centrifugalized, cell lysis reagent was added after removal of supernatant, performed sucking and ejecting 20 times using a 1 ml syringe, removing the supernatant after centrifugation at 18000 rpm for 20 min at 4°C. Part of the supernatant was used for quantitative determination of protein concentration using the Bradford Protein Assay Kit (AMRESCO, Inc., USA), the remaining was added with equivalent volume of sample buffer, shaking well the cell suspension followed by heating with dry bath incubator at 95°C for 5 min and immediately placed on ice, stored at -20°C for further use. Equivalent content of protein was added to the prepared cell extract solution in each well for vertical electrophoresis using 10% sodium dodecyl-sulfate polyacrylamide gel electrophoresis (SDS-PAGE). After electrophoresis completed, the gel tray was removed and the protein on it was then transferred onto the polyvinylidene difluoride (PVDF) membrane using the semi-dry electrophoretic transfer cell (Bio-Rad). After that, the transferred PVDF membrane was soaked in Tris buffered saline with Tween 20 (TBST) (buffer with 5% skimmed milk) for 1 to 2 hours to reduce non-specific binding and followed by adding primary antibody for 24 hours of reaction at 4°C, washing to remove the unbound primary antibody using TBST (3 times, 10 min/time), allowing reaction for 50 to 60 min using Horseradish peroxidase (HRP)-conjugated goat anti-mouse/rabbit antibody, washing nitrocellulose (NC) paper in the same manner, the Western Blot Chemiluminescence Reagent Plus was finally added for reaction before conducting the quantitative image analysis using the LAS-1000 plus System.

Phosphoinositide 3-kinase (PI3K) is categorized in the family of intracellular phosphatidylinositol kinases, the activated protein kinase B (Akt) mediates downstream signaling events through phosphorylation of a series of intracellular proteins, including cell viability, cell growth, proliferation, cell

migration, and angiogenesis, while phospho-extracellular-signal-regulated kinase (p-ERK1/2) mediates cell multiplication and division, the abovementioned proteins are positively associated with the production of VEGH; glyceraldehyde-3-phosphate dehydrogenase (GAPDH), an enzyme involved in glycolysis, is extensively distributed in various tissue cells, which has been commonly used as an internal reference for Western Blot because of the stability in gene expression.

#### Statistical Analysis

Statistical data analysis was performed with one-way analysis of variance (ANOVA), using the least significant difference (LSD) test to evaluate the difference between the groups,  $p < 0.05$  was considered with significant difference (Freud and Wilson, 1997), all data were processed by analysis using SAS software (SAS Institute, Inc., 2002).

#### 3.4 Sampling Location

Based on the data from ambient air quality monitoring stations of the Environmental Protection Administration and meteorological information in Taichung area, a comparison was conducted with the sampling results from the study. The relative locations of other ambient air quality monitoring stations in Taichung area were identified as shown in Figure 3.4, including Dali Station with a distance of 3.08 km, Zhongming Station with a distance of 3.83 km, Xitun Station with a distance of 6.02 km, Shalu Station with a distance of 14.59 km and Fengyuan Station with a distance of 17.16 km.

## RESULT AND DISCUSSION

### Analysis for Sampling Results

Information analysis was performed with the sampled data. The comparison between data from five ambient air quality monitoring stations and the sampled data in the study was used to investigate the seasonal changes in the concentrations of PM<sub>10</sub> and PM<sub>2.5</sub>, as well as the association between ratios of PM<sub>10</sub> and PM<sub>2.5</sub> in different measuring locations. The result analysis is shown as follows:

The peak PM concentrations are found from winter (October to December) to the next spring (January to April), because impact of sand and dust storm (SDS) in East Asia on air quality in Taiwan involves regional phenomenon, the elevated PM concentrations are gradually found in monitoring stations in the central and southern areas in Taiwan when the southbound high-pressure cold air mass with sand and dust occurred, and the concentration increments show degressive trend from the north to the south.

The sampled data are found consistent with that from ambient air quality monitoring stations with values mostly within the ranges from various monitoring stations, without significant difference (Figure 4.1-1 and Figure 4.1-2); the values change with the climate variance and are close to the trend of data found from various stations. The lower PM concentration are found during seasonal change when the monsoon blows, afternoon thunderstorms frequently occur with the vigorous summer convection, the PM concentration also decreases due to the rain wash resulted from frequent impact of typhoons in Taiwan region during summer and autumn. The circled sampling dates in Figure 4.1-1 indicate the precipitation at sampling, which is found to be consistent with the theory that precipitation can decrease the ambient PM concentrations. The results show relatively higher PM concentration due to the impact of SDS from East Asia in winter.

The ratio comparisons of PM<sub>2.5</sub> to PM<sub>10</sub> among all data sampled and from various monitoring stations are mostly found between 0.38 and 0.62. The average ratios of sampled data in this study are found to be higher than that from the remaining stations, the elevated concentration of PM<sub>2.5</sub> may be resulted from the factors such as the location of sampling site near railway traffic, difference in density of traffic routing and fugitive dust at nearby construction site. The higher health risk from PM<sub>2.5</sub> is found with its share of about 60%, which indicates the higher amount and ratio of PM<sub>2.5</sub> produced than that from PM<sub>10</sub>.

In the analysis for 13 metallic elements, relatively significant concentrations of Pb, Fe, Zn, Cu, Mn, V, Cr, Ni and As in the sampled PM<sub>2.5</sub> were found. The metallic elements such as Pb, Zn, and AS primarily come from traffic exhaust emissions and fuel combustion; the combustion of mining and metallurgy, as well as fossil fuel is the major release origin of Cu. The metallic element Pb has been ubiquitous in the environment, which is mostly produced by human activities such as combustion of fossil fuels, mining industry and industrial manufacturing.

Nevertheless, compared to associated literature data, the concentrations of Pb measured were found to be significantly higher in the sample investigated in this study. The inferred causes can be human error in sampling or the sample contaminated by other sources of interference, the detailed causes are to be identified. But lead has been ubiquitous in the environment, which is mostly produced by human activities such as combustion of fossil fuels, mining industry and industrial manufacturing. Lead has been established by the US EPA as a potential human carcinogen. The International Agency for Research on Cancer (IARC) has identified inorganic lead as a potential human carcinogen. Research found that VEGF was induced by Pb (2+) in the incubated astrocyte cultures (Chem, et al., 2000). Subacute exposure to lead may upregulate vascular endothelial growth factor in the bone marrow, enhancing angiogenesis (Barbeito, et al., 2007; Saghiri MA, et al., 2016).

Inhaling high concentration of copper can irritate the nose and throat. Ingestion of high concentration of copper leads to liver and kidney damage. Pulmonary diseases are found to be induced by high dose of nickel in dogs and rats, the stomach, blood, liver, kidney and their immune system, as well as reproduction and growth are also affected. Nickel can be transferred from mother to fetus through the transportation in breastfeeding and placenta. It causes lung cancer and sinus cancer too, the IARC has also identified



some nickel compounds as potential human carcinogens. The study suggests the induction of VEGF in human NSCLC cell line H460 in subjects exposed to NiCl<sub>2</sub> (Wang JC, et al., 2016).

### Cell Exposure Analysis

Previous research indicated the higher health risk caused by PM < 2.5 μm than PM10, based on the acute damage to lipid, protein and nucleic acid resulted from the reactive oxygen species (ROS) rapidly produced after PM2.5 entering the lungs, PM2.5 is thus selected for further investigation in the study.

In this study, no any significant difference in effects on cell viability was found among lung cancer cell lines H460, A549, H1299 and normal lung cell line MRC-5 exposed to PM2.5 (concentration: 100 μg/ml) for 24 hours, which was inferred as no any acute death in lung cell lines occurred and beneficial for the proceeding of comparison in the study (Figure 4.2-1). Nevertheless, some elevated cell vitality with the increased exposure concentration was found in normal lung cells, which is probably associated with inflammatory response, further relevant solid evidence is required to prove it. Moreover, the significantly elevated intracellular VEGF expression was found after PM2.5 exposure (concentration: 50~100 μg/ml) in both lung cancer cell lines and normal lung cell line (Figure 4.2-2). In analysis of various proteins using Western Blot, the levels of relevant proteins inducing VEGF were also found to be elevated with the increased concentrations of PM2.5 exposure (Figure 4.2-3). It is found that expression of relevant protein inducing VEGF increases, and the VEGF secretion also significantly increases in lung cancer cell lines (H460, A549, H1299) and normal lung cell line (MRC-5) exposed to PM2.5 sample solution for 24 hours. When the remarkably increased amount of VEGF far exceeds the activity of anti-VEGF, extensive angiogenesis occurs resulted from the mass growth in vessels mainly composed of blood vessels.

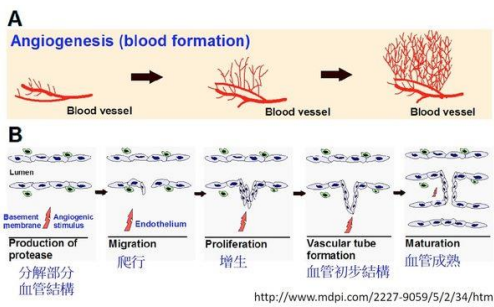


Figure 2.2.1-1 Angiogenesis process.



Figure 3.2-1



Figure 3.2-2

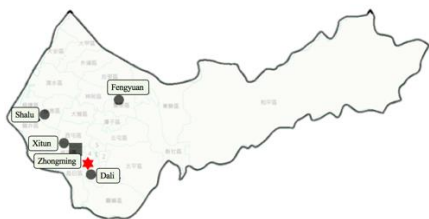


Figure 3.4 Locations of the Ambient Air Quality Monitoring Stations in Taichung City

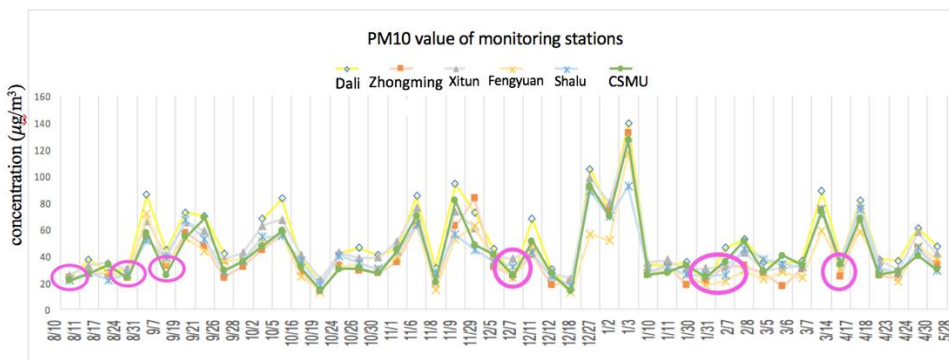


Figure 4.1-1 Result comparison between PM10 sample and distribution variance of data from various ambient air quality monitoring stations

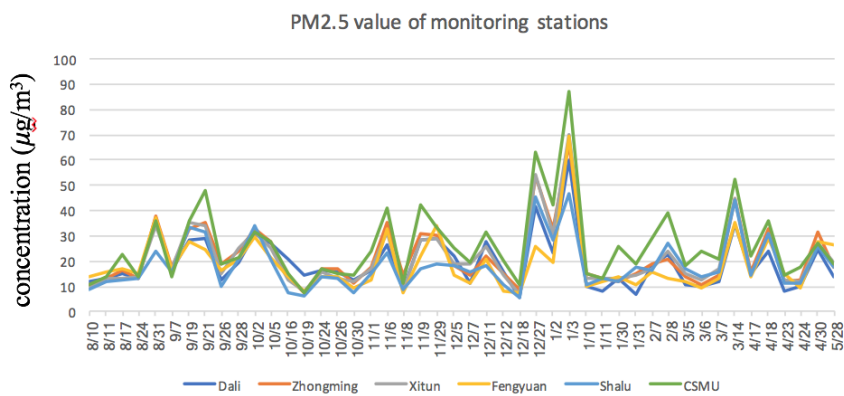


Figure 4.1-1 Result comparison between PM2.5 sample and distribution variance of data from various ambient air quality monitoring stations

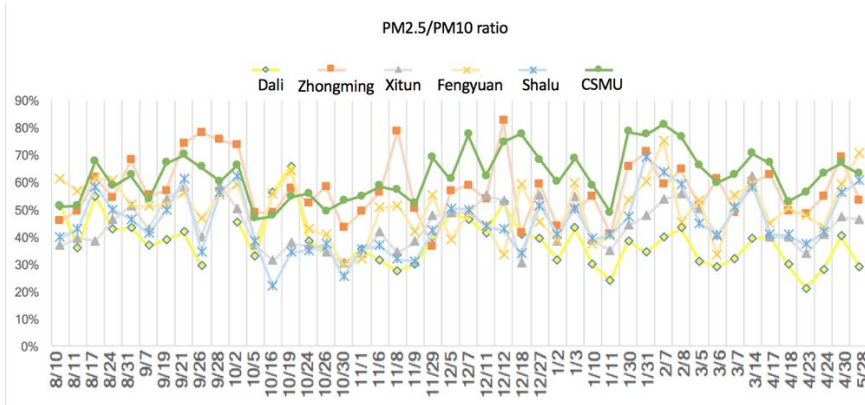


Figure 4.1-3 Result comparison between PM2.5/PM10 ratio sampled and data from various stations

	blank	10/5	11/8	12/7	
(V)	mg/L	N.D.	0.069	N.D.	0.031
(Cr)	mg/L	N.D.	N.D.	N.D.	0.031
(Mn)	mg/L	N.D.	0.202	0.104	0.162
(Fe)	mg/L	0.113	2.45	0.752	1.26
(Co)	mg/L	N.D.	N.D.	N.D.	N.D.
(Ni)	mg/L	N.D.	0.030	N.D.	N.D.
(Cu)	mg/L	N.D.	0.398	0.387	0.157
(Zn)	mg/L	N.D.	1.07	0.499	0.783
(As)	mg/L	N.D.	0.020	N.D.	N.D.
(Se)	mg/L	N.D.	N.D.	N.D.	N.D.
(Cd)	mg/L	N.D.	N.D.	N.D.	N.D.
(Hg)	mg/L	N.D.	N.D.	N.D.	N.D.
(Pb)	mg/L	N.D.	94.1	N.D.	55.1

Table 4.1-4

metal	Conversion result of metal content in ambient PM2.5 (ng/m <sup>3</sup> )		
Pb	5888.684	ND	3538.259
Fe	153.319	44.826	80.911
Zn	66.960	29.745	50.281
Cu	24.906	23.069	10.082
Mn	12.641	6.199	10.403
V	4.318	ND	1.991
Cr	ND	ND	1.991
Ni	1.877	ND	ND
As	1.252	ND	ND

Table 4.1-5

Result of metal content in PM2.5 sample solution

Conversion result of metal content in ambient PM2.5

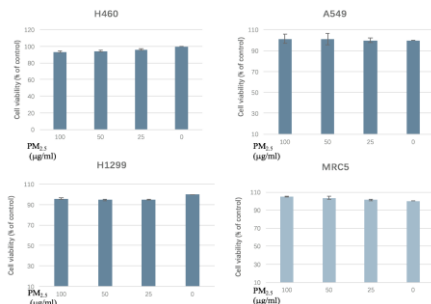


Figure 4.2-1

Various effects on cell viability after PM2.5 exposure

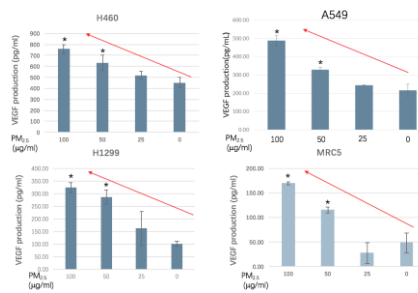


Figure 4.2-2

VEGF expression in cells after PM2.5 exposure

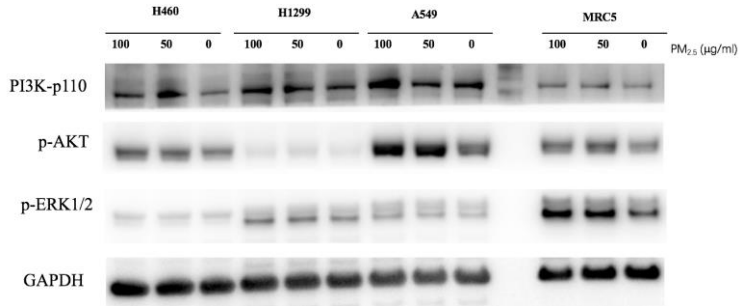


Figure 4.2-3 VEGF expression induced through PI3K/Akt/ERK pathways in the exposed H460, A549, H1299 and MRC-5

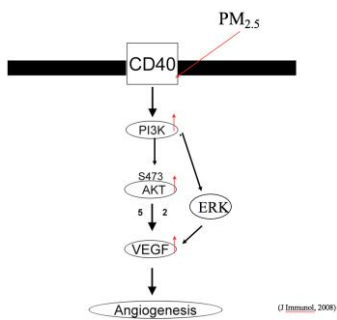


Figure 4.2-4 Signaling pathway

## CONCLUSION AND SUGGESTION

### Conclusion

The similarity between the PM concentrations in sample collected using high-volume sampling method and the concentrations surrounding ambient air quality monitoring stations represents the sampling reliability in this study.

The PMs collected in the study are composed of various heavy metals such as Pb, Fe, Zn, Cu, Mn, V, Cr, Ni and As, these metallic elements can develop significant impact on cells.

After exposure to water-soluble PM<sub>2.5</sub>, significantly elevated expression of VEGF is found which can further induce angiogenesis, it is inferred that metastasis is more likely to occur in patients with lung cancer when they exposed to ambient PM<sub>2.5</sub>.

### Suggestion

\*Analysis of type and content for heavy metals in larger size of sample, evaluation of ambient annual average concentrations, and reduction of errors.

\*Further investigation of the associated impact on cells from exposure to PMs.

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## BIO

Nathan has been an Occupational Hygiene and Environmental Health Professional for over 18 years, providing expert risk assessment and toxicological services to a broad range of industries and government bodies. Nathan is a recognised Registered Professional in the field of Toxicology and Health Risk Assessment by the Australasian College of Toxicology and Risk, a Licensed Asbestos Assessor and a trained Public Health Professional. Holding senior level positions in both the private and public sectors, Nathan has managed and successfully delivered multiple high-profile projects ranging from assessment of exposures to contaminants in our environments to national level policy development and advice. Nathan has considerable experience in sourcing, collating and interpreting epidemiological and toxicological hazard information to better determine health risks.

## ABSTRACT

This paper discusses an investigation into reports of worker adverse health effects experienced during abnormal operations at a power generation site. The objective of this paper is to discuss use of toxicological and site specific information to narrow the list of potential hazards for investigation. Employees reported adverse health effects manifesting after exposure to spilled ash slurry or water resulting from abnormal operation such as ash pit overboarding or pipe malfunctions. The reported health effects were compiled and a review was undertaken of the circumstances of exposure at the Site along with relevant literature in relation to upper respiratory physiology, the adverse health effects and related toxicological information. Of importance was knowing what symptoms were not experienced. Based on the available information, a list of potential hazards with potential to cause the reported health effects was created, greatly reducing the need for extensive monitoring.

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## RE-CALIBRATING HEALTH RISK ASSESSMENT IN BUSH FIRE FIGHTING

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### BIO

Zach has worked in the field of Occupational Health and Hygiene for the past seven years, working across the Oil, Gas, Construction, Mining and Agriculture industries. Zach holds degrees in Health Science (BSc.), Occupational health and Safety (Grad Cert.) and is currently working toward gaining a Master's degree in Occupational Hygiene and Toxicology at Edith Cowan University, Western Australia. Zach is currently employed with Rio Tinto where he holds the position of Occupational Hygiene Advisor – West Pilbara Operations

### ABSTRACT

The atmospheric exposure profile that accompanies the work of a firefighter is known to be complex and dynamic. Much of the literature to date illustrates a myriad of contaminants encountered by firefighters, mainly due to products of structural, vehicle and chemical combustion to which a firefighter is regularly exposed. For this reason, firefighters adopt specific controls in response to these 'structural' fires. Structural firefighter personal protective equipment (PPE) typically includes a self-contained breathing apparatus (SCBA) which aims to protect and account for the numerous compounds liberated during these fires.

Conversely, bush firefighting is a separate discipline with limited research available in the literature assessing and quantifying hazardous compounds released due to the combustion of native vegetation, with bush firefighters typically employing a lower level of respiratory control than that of structural firefighters.

The aim of the paper is to 're-calibrate' the atmospheric risk profile associated with bush firefighting, given that it is anticipated bush firefighting would involve an atmospheric risk profile which differs to that of a structural fire. The research hypothesis is that an array of compounds, in addition to particulate matter, are released during combustion of vegetation. The paper will aim to identify and quantify selected compounds released during combustion of native vegetation including Formaldehyde, Acrolein, Polycyclic Aromatic Hydrocarbons (PAHs) and Volatile organic compounds (VOCs). The paper will provide guidance on how Occupational Hygienists can 're-synergise' and align the health risk assessment approach to bush firefighting through the adoption of a multidisciplinary approach.

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## DEVELOPMENT OF A PREDICTION MODEL TO ASSESS COSTS FOR COMPLYING WITH OELV'S.

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*Steven Verpaele*

IH manager | Nickel Institute

### BIO

Mr Verpaele currently works as manager Industrial Hygiene at the Nickel Institute and had senior roles at Mensura and the University College of Ghent. He is founder and president of the Belgian Centre for Occupational Hygiene (BeCOH), board member of the Belgian Society for Occupational Hygiene (BSOH), extraordinary member of the Belgian High Council for Prevention and Protection at Work and the Belgian representative in the EU OH platform. With a Master's degree in Environmental Chemistry – Industrial Hygiene, he has more than 10 years' experience as an expert in different ISO and CEN workgroups, with primary focus on workplace atmospheres.

### ABSTRACT

EU authorities launched the process of deriving EU wide occupational exposure limits for nickel and nickel compounds. The Risk Assessment Committee (RAC) of the European Chemicals Agency (ECHA) launched activities to scientifically derive OELVs for nickel and nickel compounds. The European Commission also committed to put nickel compounds under the 4th wave of substances to be included into the Carcinogens and Mutagens Directive (CMD) which is currently under review. Under the CMD, socio-economic and technical feasibility factors are also considered, and the Commission will carry out an Impact Assessment covering Nickel compounds. An important and mainly difficult part of the impact assessment is the compliance cost. Feedback received by companies and sectors showed that deriving compliance cost data for a range of different limit values is challenging. Therefore, guidance how to derive compliance costs for different OELV levels for Nickel compounds should be available. The Nickel Institute therefore decided to develop a cost prediction model. Exposure scenarios are the basis of the model, especially the different workers contributing scenario's in the registration dossiers for Ni compounds. A questionnaire is designed to gather retrospective cost data related to the RMM's in relation to the exposure concentration. The total cost output of the model is depending on common processes, workplaces and company size and considers the existing Risk Management Measures and Operational Conditions and is providing information on additional measures needed to comply with a certain OELV. The developed tool can also be an important help for occupational hygienists to estimate the costs to lower exposure at certain workplaces.



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## RE-ENERGISE OCCUPATIONAL HYGIENE FOCUS IN A GLOBAL MINING COMPANY

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*Portia Weeks, Naree Carton and Penny Rose Baldo*

Corporate Occupational Hygienist, Corporate OH&S Mgr., Didipio OH&S Manger

### ABSTRACT:

Identifying trends in data across multiple sites and countries can be extremely challenging, especially when viewed against a background of varying regulatory requirements, reporting formats, collection methods, and management objectives. Years of data nested in multiple layers of mixed collection and reporting techniques can overpower the value of such data and obscure the risks of worker exposures.

OceanaGold (OGC) is a mid-tier multinational gold producer with primary operations in New Zealand, the Philippines and the United States, and offices in Australia and Canada. Until 2019 occupational hygiene management had largely been guided by various consultants they contracted with limited corporate oversight.

In order to facilitate effective and systematic OH management across the group OGC committed to extending and customising the capabilities of its existing health data management system – InHealth. This involved getting back to basics to ensure all sites had (or would) adopt a consistent approach to identifying, evaluating, controlling, and reviewing hazards at each site across the group.

Using Didipio in the Philippines as a test site, the InHealth project team has implemented InHealth as a data management, trending, and reporting tool. The InHealth system has enabled a shift to holistic risk management by incorporating Occupational Health and Hygiene into the company's existing risk management strategy and reporting framework. The InHealth tool facilitates this by reporting trends across the organisation and storing data for all aspects of the risk management process in one central location.

This presentation will discuss the challenging and rewarding aspects of introducing new management systems across different cultures, navigating established perceptions and methods, to provide a comprehensive method of risk management for OH risks to workers.

### INTRODUCTION

OceanaGold (OGC) is committed to providing safe and healthy working conditions for the prevention of work-related illness, injury, and occupational disease across all our business activities. This includes the health of workers throughout all stages of the mining lifecycle, from exploration, the project development cycle (pre-feasibility, feasibility and construction), mining, processing, exports and closure.

OceanaGold are making a valuable contribution to exposure management and improving health outcomes for all employees and contractors. An extensive on-site education and awareness program has facilitated this, and we continue to work towards our goal of reducing the burden of occupational disease, particularly in the Philippines, where existing occupational health and hygiene knowledge amongst the workforce has been extremely poor. These efforts are promoted through the involvement of the Board of Directors and championed by all members of the Executive committee, which is essential for the sustainability of the occupational health and hygiene program. With significant existing health issues there have been substantial challenges implementing this program, particularly at Didipio Operations in the Philippines.

At Didipio Operations, immediate safety impacts have successfully been the focus of the initial years of operation, resulting in an impressively low Total Recordable Injury Frequency Rate (TRIFR) of 1.3 (12 monthly moving average (MMA)). Injury and time-off work impacts the worker and their families immediately which is heightened by already strenuous economic conditions. Occupational Health and Occupational Hygiene impacts are typically longer term and less visible and therefore require increased education and awareness. Through a combination of the role of a Certified Occupational Hygienist (COH®) and the correlation of the impact on the individual, we have increased the focus on the prevention through a combination of monitoring and medical testing.

## PROJECT OBJECTIVES

Our goal was to successfully customise and implement an integrated OH data management system with high user acceptance. To achieve this the system had to be simple to use but with enough complexity to integrate with other organisational systems and provide informative oversight on exposure assessment, and management.

In the short-term, the goal of OceanaGold was to implement 'InHealth' as the standard tool for managing and reporting potential employee/contractor work and non-work-related health and hygiene risks. The process needed to standardise reporting of employee and contractor work related health risks, and streamline data input. This has enabled OGC to have secure, reliable and accessible information on Occupational Health and Hygiene for the workforce. The new system facilitates quick and simplified information summaries, as well as the tracking of actions, adherence to the recommended monitoring regime, and compliance with corporate standards and local legislation.

OceanaGold engineered the implementation of InHealth as a sustainable business process to ensure maximum current and future benefit. The aim was to embed the necessity of a sustainable occupational hygiene program and reduce the reliance on the software provider. OGC provided an in-house systems expert to understand the workings of the software and to liaise with the consultant occupational hygienists to ensure customisation and maximise benefits to the workforce and the company.

The key benefits and Return on Investment (ROI) are expected to be visible via:

- Standardisation in the way sites manage occupational exposures;
- Removal of inefficient manual processes and numerous variations of spreadsheets;
- Enabling accurate data capture, storage and retrieval for legislative and compliance purposes via automatic upload;
- Productivity in terms of long-term storage of uniformly structured data;
- Support of sustainable IH program;
- Timesaving and reliability of information retrieval;
- Understanding of production and product exposure risks;
- Employee quality of life improvement;
- Cost of injury and illness claims avoided as exposure scenarios are better identified and managed; and
- Shared opportunities for health and production improvements across the group.

In order to streamline the implementation, process the roll-out of InHealth was planned sequentially across the group, starting with Waihi in New Zealand, closely followed by Didipio in the Philippines, with all sites to be fully functional by the end of the year.

## InHealth operational site roll out sequence and planned cutover dates (TBC)

All dates pending confirmation with sites

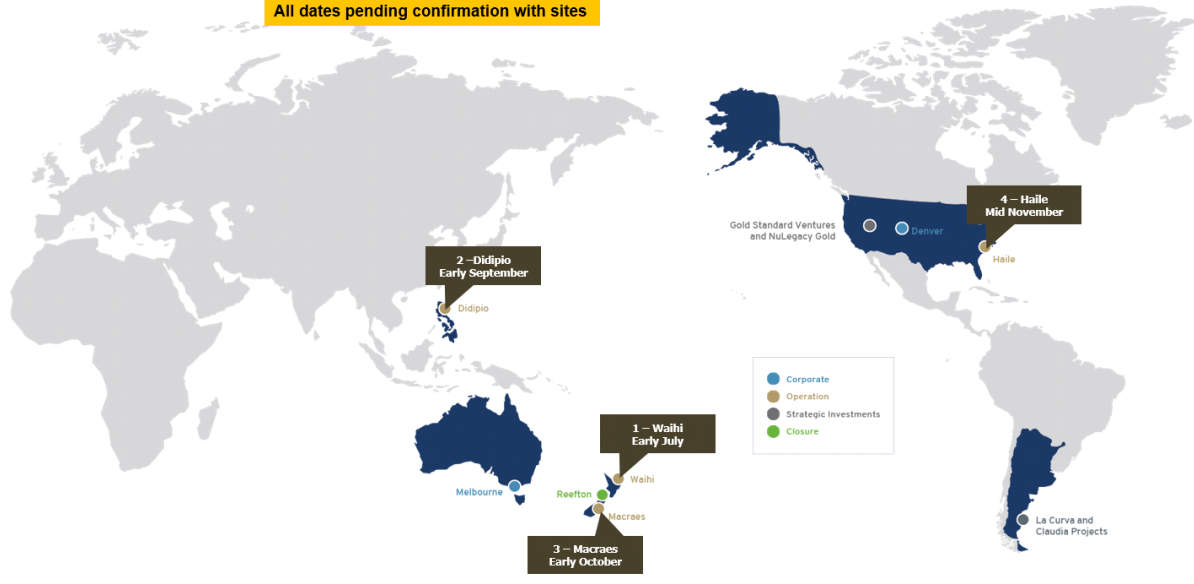


Figure 1 OGC InHealth Implementation Plan, March 2019

In order to ensure standardised occupational hygiene management techniques across all operations, the corporate standard was updated and extended to include the following process (Figure 2).

Following the simultaneous implementation of the standard and the roll-out of InHealth, a gap analysis was performed to assess the status of each site, and to enable a customised strategy to align all sites by the end of 2020.

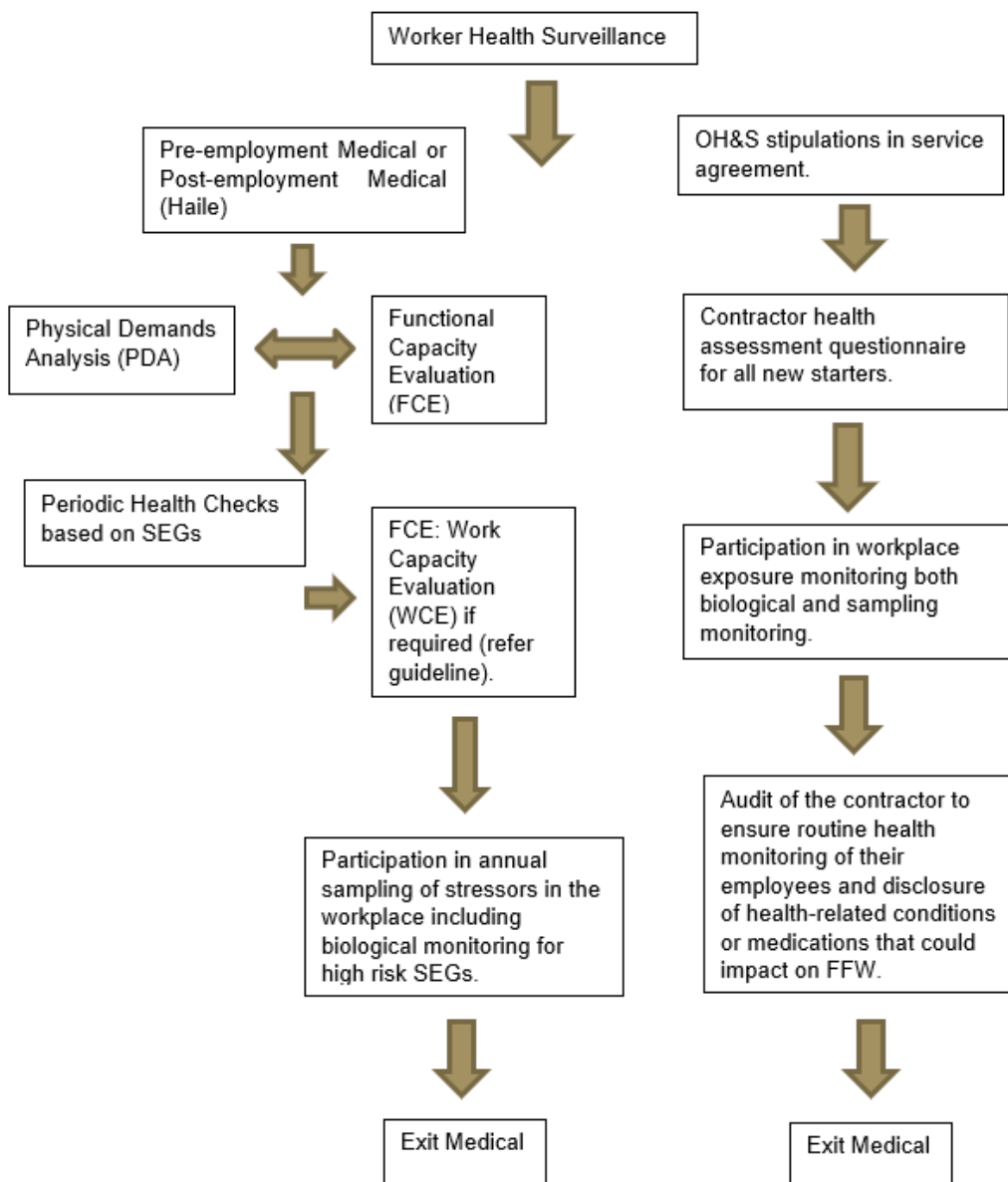


Figure 2 Process flow

### WHAT DOES IN HEALTH DO?

Until 2019 the process adopted for Occupational Hygiene monitoring across our four operations was disconnected and relied heavily on various consultants providing information to the company. Data was required to be manually input into the system and documents were prepared and sent to the site once the consultant had completed the final report.

Historically data for all sites have been stored locally on servers and have been collected according to the methods of the contracted site occupational hygienist. With the simultaneous implementation of a corporate standard and InHealth it has been possible to connect this data and provide valuable knowledge on exposure profiles across the

group. Data, when connected, provides information, and when linked by a competent occupational hygienist, becomes invaluable when managing and mitigating exposures.

The main benefit from InHealth in the short duration of its implementation, is the ability to have corporate oversight on planned vs completed monitoring and immediate notification of exposures of concern (above 50% of the OEL). Integration with medical data allows a holistic understanding of the health impact on the individual which is significantly more proactive and allows increased oversight for at-risk individuals and SEGs.

As well as providing immediate value, the system provides a lot of future value, owing to the latency of many workplace hazards. The improved storage and retrieval capabilities of the system further protect the business and any future operations.

Functional requirement of the system was to:

- Maintain exposure histories
- SEG analysis
- Interface with incident management
- Link to health surveillance
- Automate lab analysis results upload
- Reporting
- Integration with rosters, PPE, hearing conservation
- Recommendations tracking

Cutover success criteria was to achieve the following:

- Medical Conditions and Medications Registers able to be updated in InHealth by nurses
- Medical Consultations being entered into InHealth
- WEM data process in place and able to be entered into InHealth
  - (Note July WEM data to be loaded in August)
- Some reporting provided for the above

### Best Practise OELS

OceanaGold are committed to providing the healthiest and safest working conditions by managing exposures to As Low As Reasonably Practicable. Where the occupational exposure limits (OELs) differ between host countries the lowest value has been implemented as the corporate standard. This process has enabled both legislative compliance as well as maintaining the organisation’s integrity and promoting worker health.

Similar Exposure Groups (SEGs) are entered into the InHealth system and the system is also integrated with HR to enable up-to-date roster and employee job title information, with the sampling strategies and quotas prepared by the occupational hygienists. Rosters, people profiles and work-related information are all captured in the system enabling a comprehensive overview all in the one location. The system enables us to define the various SEGs and the sampling strategy for the operation.

**Similar Exposure Group (SEG) Details**

Ref: 2      Name: 001 MANAGEMENT, ADMIN...      SEG Assessor: ABREU, Dorian

People   Risk Assessment   Documentation   Sampling Strategy   Exceedances

Statistics Report

Ref	Exposure	Start Date	End Date	Title	Description	Assessment Ph.	Risk Assessment	Priority	95 Percentile	% Above OEL
✖	Asbestos	27 Mar 2017		Asbestos post		Maintenan...	High (C4)	High	0.650	2.00

- Logged in as: DEMOD\INX\ECED
- SysAdmin
- INX Company
- Online Help
- Home
- Clinic Overview
- Health Monitoring
- Hygiene Register
- SEG Register**
- Sampling Schedule
- People
- Adhoc Reports
- Administration

### Similar Exposure Group (SEG) Register

Please make your selection and click search

Start Date:  End Date:  SEG Assessor / Person:  Exposure:

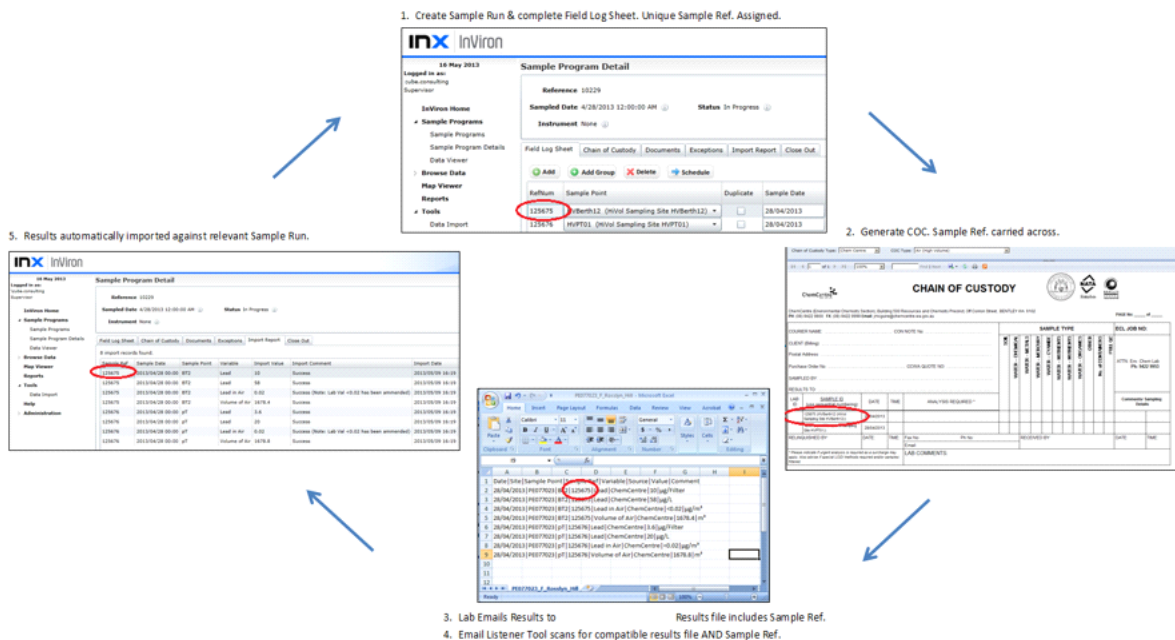
Site Security:  Search:  Show History:

	SEG Ref	Code	Name	Description	SEG Assessor	End Date	Scheduled Samples	Actual Samples
		1	001 Management & Administration	Perth based and site based	CORTIER, Anna		20	12
		2	002 Mining Engineering, Geology and Field Personnel	Occupations that spend tim			36	12
		3	003 Heavy Mobile Equipment Operators	Operate heavy equipment			36	12
		4	004 Maintenance	All maintenance personnel			42	12
		5	005 Processing Plant	Processing plant personnel			42	12
		6	006 Drill and Blast Crew	All personnel involved in dr			36	12
		7	007 Laboratory	All laboratory personnel			27	12
		8	008 Warehouse and Stores	All personnel that are pred			9	12
		9	009 Rail Operations	All personnel who provide r			18	12

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The hygiene data fields enable us to add the parameters of the sample and provides the ability to filter results by these parameters, e.g. DPM exceedances wearing appropriate RPE. The Quebec adjustment model is applied for each contaminant by the corporate occupational hygienist and is unable to be altered by technicians entering data. Results are automatically uploaded from the testing laboratory via an email listener to expedite reporting and reduce human error.

# Configuration – Lab Integration



## SITE EXAMPLE – DIDIPIO OPERATIONS, PHILIPPINES

Didipio is a high-grade underground gold and copper mine located on the island of Luzon in the Philippines. OceanaGold commenced commercial production at Didipio as an open pit operation in 2013. In 2016, the mine transitioned from an open pit to underground operation, with production from the underground commencing in early 2017.

The Didipio Mine delivers significant socio-economic benefits to the Barangay of Didipio, neighbouring communities, the provinces of Nueva Vizcaya and Quirino and the Philippines. It directly employs over 1,500 workers of which 97% are Philippine nationals and 59% are from local communities. It provides several thousands of additional livelihood opportunities and indirect jobs through partnerships with cooperatives and social development organisations.

Since beginning the operation, the mine has contributed extensively to local infrastructure in order to produce a significant and lasting positive impact on the lives of the local communities. Didipio has built (and maintains) roads, power, schools, hospitals, and continues to provide free medical care to local and remote communities throughout the Philippines.

Since beginning operations OceanaGold Philippines has generated over 3000 jobs as part of its economic contribution to the country. In the development of their host communities, they have the following accomplishments:

- a total of 119kms of road improved and developed
- 201 scholars graduated since 2007, 11 mining engineers produced
- trained and produced 114 local residents as globally competitive underground mine workers

- established a community-owned corporation that offers a multitude of services of OGPI
- financially and technically supporting 13 agricultural cooperatives and establishing local and regional markets

The mine is now fully underground, with production expected to continue until 2030.

Historically, occupational hygiene, or Work Environment Monitoring (WEM) as it is locally known, is an obscure and poorly understood field in the Philippines. Despite previous mining experience there was limited understanding by local management or the workforce, and there had been no previous experience with WEM. The legislation was confusing and largely ignored and the extent of the simple baseline monitoring program was staggering to most, including the regulators.

A qualitative risk assessment and walk-through survey was performed during December 2016 and January 2017. Over the past two - three years, with significant operational change, a baseline monitoring program has been implemented and in its final stages. A quantitative risk assessment will follow and will largely dictate the monitoring program for 2020.

One of the most challenging aspects of introducing an occupational hygiene program at Didipio has been adjusting expectations of the occupational hygienist. Whereas in most workplaces the program would have been completed within 12 months, it has taken almost three times as long. This is partly owing to the unfamiliarity with the field, as well as lack of full-time on-site support by an occupational hygienist. Visits were made quarterly and a local technician was trained to collect samples. This in itself was a long process in order to ensure sampling quality was maintained and consistent.

Implementing the current WEM program has been a slow, challenging process however ultimately worthwhile. With the implementation of InHealth, the WEM program will be sustainable due to its integration with other internal systems. By connecting InHealth with human resources we have perpetually updated SEG rosters, with in-built system tracking of an individual's SEG history for more accurate health information. Connection with the incident reporting and management system forces parity with safety metrics and continually highlights the importance of occupational hygiene within the company. The integration also allows tracking of incident actions, investigations, and report recommendations.

Another vital integration is with the on-site medical clinic, including a doctor, several nurses, and a dentist. Integrating SEG history and exposures allows the medical team to review symptoms through an occupational lens, which is a significant improvement in itself. This integration also facilitates the review of critical health surveillance information such as biological monitoring, respirator and hearing protection fit testing, spirometry and audiometric screening by individual, and also by SEG.

Ultimately the data management system allows quick retrieval of reliable information and, when combined with Microsoft Power BI, provides impressive reporting metrics as well as quick and reliable data retrieval and investigation.

## **LESSONS LEARNT**

The challenges that we have had and begun to overcome were both cultural and country specific. The level of understanding of the importance or implementing such a system varied across each site depending on the Safety and Health maturity of that specific operation. It also varied with the IT skills and ability of the administrative positions to adapt to change and move away from paper forms and locked cabinets.

The initial stages required thorough communication and onboarding of key influential people, i.e. GM and Site Nurse to drive and accept the change. Thorough communication and regular updates of the project assisted this along with a very patient system analyst/coach.

The security issues around personal health data were an issue just prior to implementation and this required detailed legal advice across the 3 countries in which we operate. The location of the server and two factor authentication was required to give OGC-the assurance that personal data was secure. Additional challenges along the way included a limited understanding of Occupational Hygiene, and host country legislative gaps.



*Megan Howitt*

Occupational Hygiene Advisor | Argyle Diamond Mine | Rio Tinto

## BIO

Megan has worked in the mining industry for 11 years across various businesses and operations in Western Australia. Megan holds a degree in Sports Science, Exercise Science and has completed the Basic Principles in Occupational Hygiene course. Megan currently holds the role of Occupational Hygiene Advisor with Rio Tinto.

## ABSTRACT

Mine closure is an important and inevitable part of any mine life cycle. The legacy a mining operator leaves post operational cessation is a key measure of their contribution to sustainable development, and fundamental to maintaining business reputation. The aim of closure work is to minimise the financial, social and environmental risks and liabilities associated with permanently ceasing operations, which requires a multi-disciplinary approach at all stages of the life of an asset. Closure planning has traditionally centred around environmental, heritage and community considerations, in addition to balancing any financial liability. Given these traditional focus areas, an opportunity exists to introduce health and hygiene consideration into the multidisciplinary closure framework. The paper focuses on the role of the occupational hygienist in ensuring that critical controls for the prevention of health exposures are identified, functioning as designed and verifiable during all stages of the mine closure process, in addition to managing legacy items that may present post-closure. The paper outlines three distinct pillars by which closure is delivered - Business as usual, Make safe, Demolition/De-construction – and details how the occupational hygienist is involved in each step of the closure planning and delivery process. In addition, the paper details the development of a specific health and hygiene management plan to address the changing risk profile within the context of closure, and steps out a process for integration of occupational hygiene considerations within the context of a multi-disciplinary mine closure team.

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## A WASTE MANAGEMENT PROJECT WITH LOGISTICS AND OCCUPATIONAL HYGIENE INTERACTIONS

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*Martin Jennings*

Private consultant | Martin Jennings & Associates

### BIO

Martin Jennings has over 40 years experience in the public and private sectors, over a wide ranges of industries including mining, chemicals, Defence and construction. He is a Fellow and past President of the AIOH and a COH.

### ABSTRACT

This paper describes synergies attained in a logistics project with occupational hygiene involvement. The project involved decommissioning and demolishing 3 large car manufacturing plants, which contained such regulated hazardous materials as asbestos, lead and PCBs. While compliance with relevant legislation was a given, the client's requirements for certain hazardous substances had to be managed, including their demand for cost recovery of designated scrap metals.

To meet these demands, a proprietary software program TracBASE, was used for cradle to grave tracking of 35 waste streams. TracBASE can be tailored to project requirements. For this project, with occupational hygiene input, it was configured to include decision points, communications, licensing, audits and records.

This gave a robust system which provided full assurance to the client of successful management of hazardous waste and met the key objective of ensuring minimal reputational risk to the client.

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## TOLL FOR TOIL

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*Holly Fletcher*

Regional Industrial Hygiene Manager - Asia and Middle East

### BIO

Holly Fletcher is a Certified Occupational Hygienist, and holds a Bachelor of Applied Science and a Master of Science, majoring in Occupational Hygiene Practice.

Historically, Holly has worked on major projects in various industries throughout Australia, the United Arab Emirates and Laos, including gas extraction, resource recovery, complex contaminated land remediation and large-scale tunnelling and underground mine expansion projects. Now in her Industrial Hygiene role with SGS, Holly governs the implementation of corporate compliance standards and subsequent occupational health performance in 38 countries across SGS's business lines in North East and South East Asia and the Middle East.

Currently, Holly holds a graduate research scholarship at the University of Wollongong and is midway through completing a PhD investigating health interventions that improve health outcomes in Chilean mine workers.

### ABSTRACT

Recent media publications are citing silica as “the new asbestos”, when in fact silica exposure and resultant occupational lung disease have deep foundations within Australia’s colonial history. Once termed “Tunnel Miners Disease”, silicosis has been the subject of multiple State and Commonwealth parliamentary inquiries, the earliest in 1902 and most recently in 2017.

The fundamental question is “Why do Australian workers continue to experience such disease outcomes”? To answer this question, a systematic literature review was conducted with the objective of identifying and evaluating evidence to support the historical attempts to control worker silica dust exposure, all while balancing the competing interests of stakeholders to achieve the development of critical infrastructure. The presentation “Toll for Toil” will communicate the systematic literature review findings and in particular will elicit the social, political and cultural factors that have influenced the historical repetition of occupational disease experienced by generations of workers to deliver critical infrastructure, required to support Australia’s ever-expanding population. What’s has changed? What hasn’t?

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## CHARACTERISATION OF RESPIRATORY HAZARDS DURING THE MANUFACTURE AND INSTALLATION OF ENGINEERED AND NATURAL STONE PRODUCTS

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Christian Madden<sup>1</sup>, Maggie Davidson<sup>2</sup>, Gregory O'Donnell<sup>3</sup> & Sue Reed<sup>4</sup>

1. Self Employed

2. Western Sydney University, Hawkesbury NSW

3. SafeWork NSW, Test Safe Australia, Chemical Analysis Branch

4. Edith Cowan University

**Abstract:** Due to concerns of recent cases of accelerated silicosis within the Australian masonry industry an exposure assessment was undertaken at a small NSW based business. Air sampling was performed for respirable crystalline silica (RCS) and solvent exposure in the factory that produced natural and engineered stone, kitchen benchtops and bathroom products, as well as funeral monuments. The assessment took place on two (2) occasions (July and November 2018) to investigate personal exposure to RCS across the factory and at an off-site installation location. The factory incorporated both remote operation cutting and polishing machines with integrated water suppression technology, as well as manual wet cutting and polishing. Respirable dust sampling was undertaken in accordance with AS/NZS2985:2009 and analysed for  $\alpha$ -quartz content by X-ray diffraction at a NATA accredited laboratory and exposure to solvents was assessed using passive vapour monitors. The RCS exposures measured across the SEGs (Wet Polish, Assembly, Line Production, Installation and Monument) were consistently below the current Safe Work Australia (SWA) workplace exposure standard (WES) of  $0.10 \text{ mg/m}^3$ , as were exposures to volatile organic compounds. The highest RCS measurement recorded occurred during cleaning in the monument production area and was found to be  $0.09 \text{ mg/m}^3$ . New controls were implemented to reduce RCS exposure in all areas including the offsite locations. This paper will report on the ranges of exposures and current controls in place, and the controls that were implemented to protect the health and wellbeing of the workers at the facility.

### 1. INTRODUCTION

Respiratory diseases such as pneumoconiosis (silicosis), chronic obstructive pulmonary and systemic scleroderma (SSL) are not a new occurrence in the stone masonry industry, but in the case of silicosis they are indeed a re-emerging one. (Leso et al. 2019; Yates 2018) Three centuries have passed since Bernardino Ramazzini wrote of the master stone-cutter who observed that fine "invisible" stone dust would "*gradually prove fatal to stone-cutters who took no precautions*" (Bogdonoff et al. 1983), and a little over a century since Bramwell published the first case studies of systematic scleroderma in two Scottish stone masons (Bramwell 1914), and the seminal publication *Dangerous Trades: A history of health and safety at work* described the pathology of phthisis and pneumoconioses in stone worker in 1902. In the early 2000s, silicosis was thought to be on the decline in industrial countries, although still problematic in developing nations, largely due to improved rigorous health and safety programs and regulation (Australian Safety and Compensation Council 2006). However, Frankel, Blake and Yates (2015) published an abstract describing a case of accelerated silicosis in a 52 year old stone mason who was exposed to respirable crystalline silica (RCS) during the cutting and polishing engineered stone kitchen and bathroom countertops (2015). This case study was the first documented case of the current Australian silicosis epidemic in the artificial stone/stone masonry industry. Although internationally reports of accelerated silicosis cases in the artificial stone industry had been published in the literature as early as 2012 (García Vellido, Gómez & Morillo 2011; Kramer et al. 2012; Martínez et al. 2010; Pérez-Alonso et al. 2014). To date, over 140 confirmed silicosis cases of have been reported in Queensland as of July 2019 (Hedges, Topping & Jenke 2019), including the death of a 36 year old male, and a large number of cases in young men, including at least 11 cases of severe progressive silicosis (Yates 2018).

Both natural and artificial/synthetic stone may be used in the production of kitchen and bathroom benchtops, splash and other decorative items such as fountains and monuments. The artificial stone products have become very popular because they are relatively inexpensive, can be made more uniformly in comparison to natural stone, and come in a diverse array of colours and textures with high strength properties. The stones are formed from a mixture of resins, pigments, fine dust, glass and/or feldspar, with a crystalline silica content that varies from 11-93% (Table 1). The artificial stone products have typically higher silica concentrations in comparison to natural stone, such as granite (25-40%), sandstone (67%) or marble that contains little or no silica (Safe Work Australia 2019) (OSHA 2015).

**Table 1: Artificial Stone Constituents According to Manufactures' Safety Data Sheets (SDS)**

Constituent	Manufacturer					
	Caesar Stone	Quantum Quartz*	Essastone	Dekton~	Silestone	Neolith^
Crystalline Silica	<93%	<90%	70-95%	<11%	70-90%	<25%
Cristobalite	<50%	-	-	-	-	-
Feldspar	<65%	-	-	-	-	-
Glass & Mirror	<43%	-	-	-	-	-
Polyester Resin	7.0-14.5%	-	5-15%	-	5-15%	-
Titanium dioxide	<4.5%	Trace	-	-	<5% (inc pigments & other)	-
Pigments	<4.0%	Trace	<5%	Trace	See above	<1%
Other	<4.0%	Trace	<5%	Trace	See above	-
Other	<1.0%	Trace	-	-		-
Styrene	-	-	Trace	-	-	-

\*SDS states not hazardous according to Australian WHS Regulations, includes resins and trace minerals including Al<sub>2</sub>O<sub>3</sub>, Fe<sub>2</sub>O<sub>3</sub>, TiO<sub>2</sub>, CaO, MgO, Na<sub>2</sub>O, K<sub>2</sub>O ~silico aluminate, amorphous silica, silicate zirconium, ^SDS "not classified as hazardous according to Safe Work Australia Criteria

The cutting and polishing of stone products generates aerosols of RCS, as well as slurries of water and dust that may become airborne when dried out. Investigations by Workplace Health and Safety Queensland have found personal exposures of stone workers ranging from 0.01 mg/m<sup>3</sup> to greater than 1.00 mg/m<sup>3</sup>, even in premises using wet processing methods (Hedges, Topping & Jenke 2019). Exposure to RCS can cause pneumoconiosis, lung cancer and autoimmune diseases including chronic renal disease, systemic scleroderma, systemic lupus erythematosus, rheumatoid arthritis (Harbison, Bourgeois & Johnson 2015; Jain et al. 2017; Mulloy 2003; Rees & Murray 2016). However, unlike their historical counterparts, today's stone masons can be exposed to a wider variety of chemical exposures including the nanosized particles, dyes, pigments and resins used to create the artificial stone, as well as the adhesives, paints, glues and other industrial chemicals and solvents used in the creation and installation of the products. A review of the published literature has found limited information on the chemicals that stone masons are exposed to, and predominantly focuses on their dust exposures. The aim of this project was therefore to evaluate worker exposures to both RCS and volatile organic compounds (VOCs) in the workplace, as well as to assess the efficacy of the current control methods in place at the facility.

## 2 METHODS

Full shift, personal sampling of worker exposure to airborne RCS was undertaken from the 17<sup>th</sup> to 19<sup>th</sup> July 2018 (winter), and between the 26<sup>th</sup> and 30<sup>th</sup> November 2018 (Summer, peak production). The November sampling also incorporated personal air sampling for VOCs and biological monitoring (urine) for toluene, xylene and styrene. The similar exposure groups (SEGs) that were observed at the workplace were:

- *Wet Polishers* who manually refine the final product by polishing with a water and high speed rotatory tool, cleaning and minor assembly (minimal solvent usage);
- *Mitre Assembly Workers* who manually do the initial fitting, assembly, and polishing of products (moderate solvent usage – including thinners and epoxy resins);

- *Line Saw Operators and Polishers* program and remotely operate the cutting and polishing machines (minimal solvent usage);
- *Monument Craftsmen* that design, sculpt, engrave, polish, paint and letter a variety of headstones and other funeral monuments. These workers were exposed to the greatest variety of aerosol and chemical hazards with tasks including sandblasting, spray painting and fine motor tasks such as gilding and lettering.
- *Field Technicians (Installers)* carry out the offsite installation, modification and repair of stone products. Their work can involve exposure to dust, solvents, glues/resins, noise and vibration as well as potential hazardous substance generated at the site (moderate solvent usage);
- *Warehouse Staff* oversaw the delivery, stocking and movement of stone slabs at the factory site. The staff do not engage in manual or remote cutting and polishing of stone, and minimal use of solvents.

Sampling and analysis of RCS was undertaken in accordance with AS2985:2009. Samples were analysed at the SafeWork NSW, TestSafe Chemical Analysis laboratory (NATA Accreditation #3726). SKC aluminium cyclone sampling heads were loaded with PVC filters, attached to Airmet SKC AirChek XR5000 or PXR pumps, and placed in breathing zone of participants. The pumps calibration was checked at  $2.5 \pm 5\%$  L/min, using DryCal Defender 510M, pre and post sampling. Samples underwent gravimetric analysis for dust deposition (TestSafe method WCA 191), followed by X-ray diffraction analysis for  $\alpha$ -quartz and cristobalite (TestSafe method WCA 220). The limit of quantification (LOQ) for both WCA 220 and WCA 191 is 0.01 mg/filter.

Personal sampling and analysis of VOCs was undertaken according to AS2986.2 using SKC diffusive badges (Cat No 575-001). The badges were attached to the lapel of workers at the beginning of shift, then collected, sealed and stored below 5°C prior to analysis. The analytical method used at TestSafe was method WCA 207 that screens for 73 VOCs including; aliphatic hydrocarbons, aromatic hydrocarbons, alcohols, chlorinated hydrocarbons; ketones, alcohols, acetates, ethers and glycols. A detailed list can be found in the laboratory handbook. The LOQ for the analytical method WCA.207 varies from 1µg/badge for aromatic compounds, 5µg/badge for aliphatic compounds and 25 µg/badge for oxygenated compounds. Pre and post work shift urine samples were collected and are to be analysed for toluene, styrene and xylene. Ethics approval was granted by the Western Sydney University human ethics committee, approval number H12930. Unfortunately, the biological monitoring results were not available at the time of presenting this paper.

Statistical analysis was undertaken using IHSTAT from AIHA and Microsoft Excel 2013. Geometric means (GM), geometric standard deviations (GSD) and Lands End lower confidence limit (LCL) and upper confident limit (UCL), 95<sup>th</sup> percentile, and minimum variance unbiased estimated (MVUE) for each SEG, as well as the workshop based cohort ( $n = 36$ ), excluding installer data ( $n = 4$ ) were determined. Data from the workshop based SEGs was log-normally distributed ( $W$ -test  $>0.05$ ,  $n = 36$ ). STATA v.15 was used to undertake further statistical analyse the workshop based data. Student's  $t$ -test of the natural log transformed RCS data was applied to analyse for significant difference between the seasons of the RCS exposure, along with one-way analysis of variance (ANOVA) and Fisher's least significant difference (LSD) test to evaluate for exposure variation between SEGs.

## RESULTS

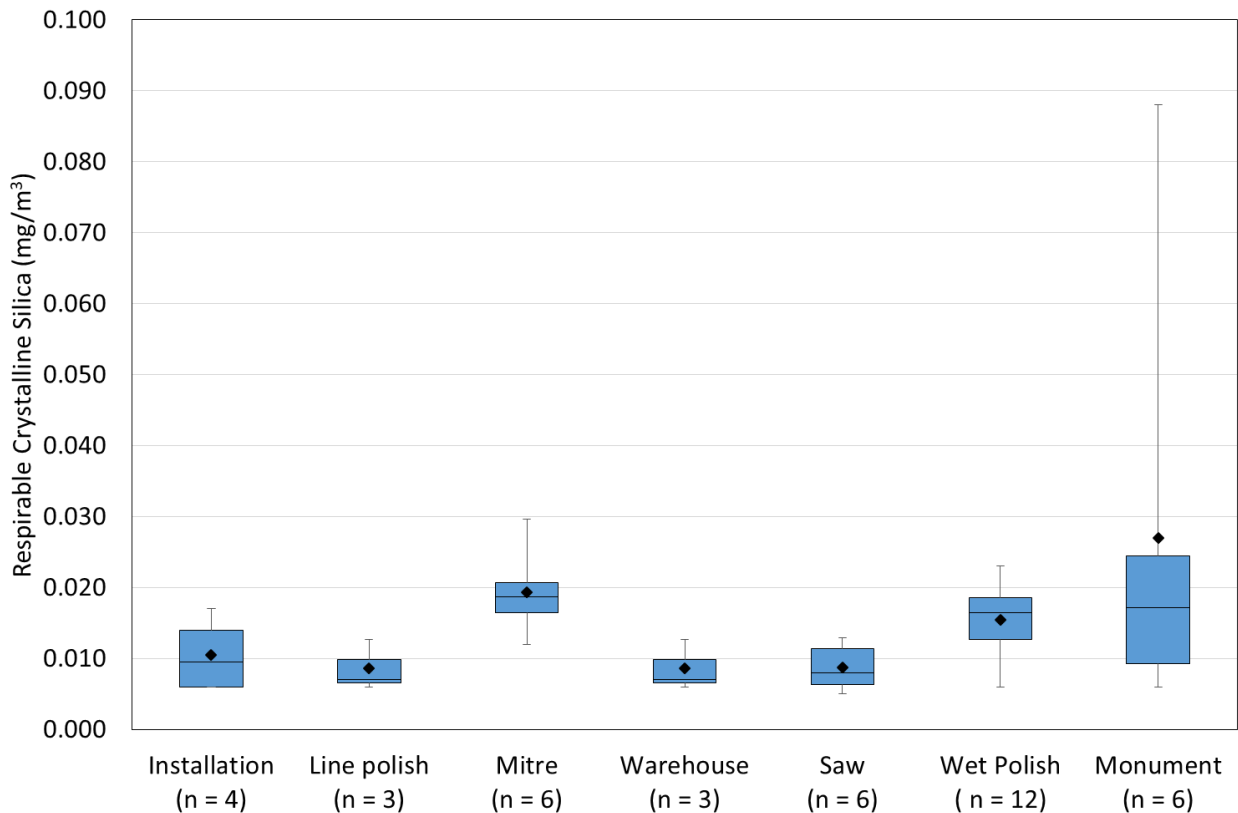
### 2.1 Respirable Crystalline Silica

The 95<sup>th</sup> percentile and MVUE RCS results were below the Safe Work Australia WES of 0.1 mg/m<sup>3</sup> measured as an 8-hour time weighted average (TWA<sub>8hour</sub>) (Table 2). The RCS action limit of 0.05 mg/m<sup>3</sup> was exceeded by the monument SEG on one occasion during winter monitoring, which elevated the GSD to 2.6, 95<sup>th</sup> percentile to 0.09 mg/m<sup>3</sup> and the MVUE to 0.03 mg/m<sup>3</sup>. Based on the 95<sup>th</sup> percentile and MVUE results, the monument, mitre assembly and wet polish SEGs had the highest RCS exposures (Table 2, Figure 1). A Student's  $t$ -test found no significant difference ( $t_{stat} = 0.17$ ,  $t_{crit} = 2.02$ ,  $p = 0.86$ ) between winter (July) and summer (November) RCS exposures for workers based at the factory site (Figure 2). The exposure ratio varied between 0.1 and 0.3 across the SEGs indicates that the minimum sampling frequency at the site should be conducted on an annual bases of 1 sample per 10 workers (Grantham & Firth 2014). One-way ANOVA indicated that there was significant difference between the SEGs RCS exposures ( $F_{stat} = 2.67$ ,  $F_{crit} = 2.39$ ,  $p = 0.03$ ), which the Fisher's LSD test attributed to the difference to the monument SEG and the other SEGs.

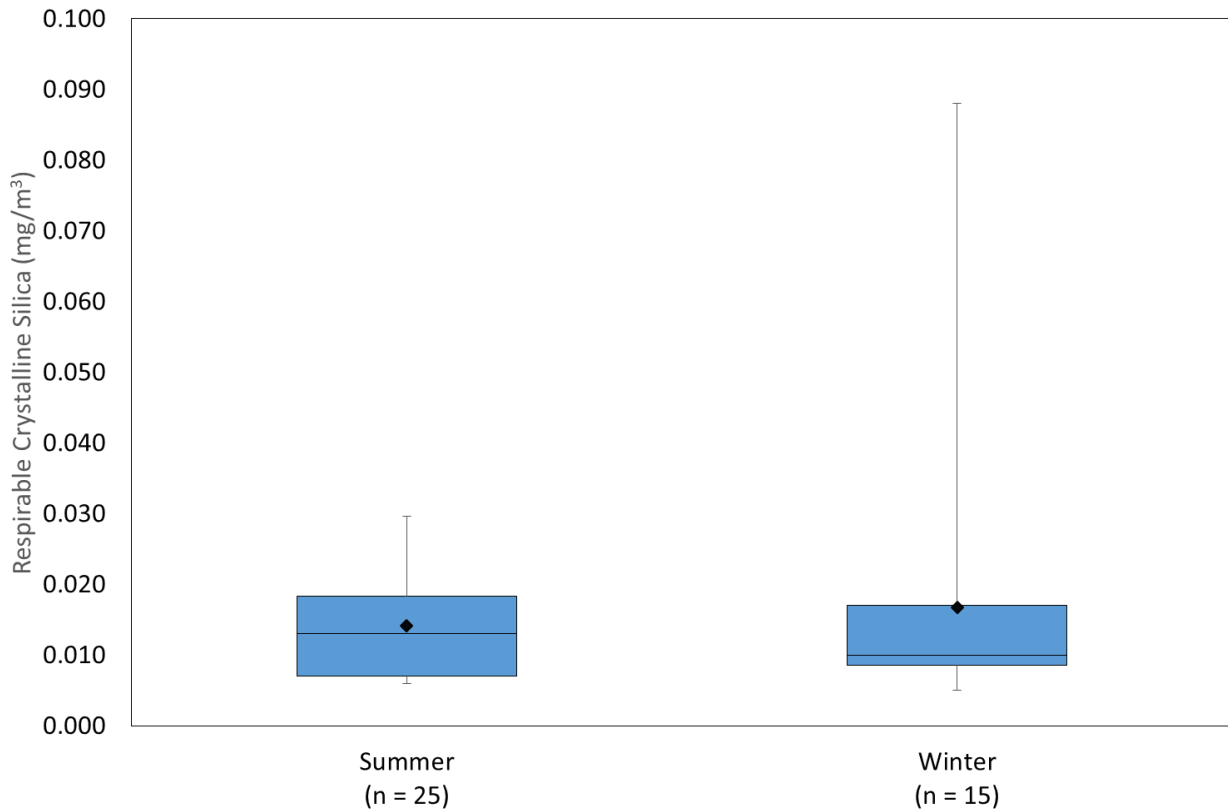
**Table 2. Respirable Crystalline Silica Exposures across Similar Exposure Groups, July and November 2018**

Similar Exposure Groups	Respirable Crystalline Silica Exposures (mg/m <sup>3</sup> )						
	Geometric Mean (GSD)	Minimum	Maximum	95 <sup>th</sup> Percentile	Minimum Variance Unbiased Estimate	Exposure Ratio (MVUE÷WES)	Measures Above Action Limit (0.05 mg/m <sup>3</sup> )
Monument (n=6)	0.02 (2.6)	0.01	0.09	0.09	0.03	0.3	1
Line Saw (n=6)	0.01 (1.5)	0.01	0.01	0.02	0.01	0.1	0
Wet Polish (n=12)	0.02 (1.5)	0.01	0.02	0.03	0.02	0.2	0
Mitre Assembly (n=6)	0.02 (1.4)	0.01	0.03	0.03	0.02	0.2	0
Installation (n=4)*	0.01 (1.7)	0.01	0.02	0.02	0.01	0.1	0
Warehouse (n=3)*	0.01 (1.5)	0.01	0.01	0.02	0.01	0.1	0
Line Polish (n=3)^	0.01 (1.4)	0.01	0.01	0.01	0.01	0.1	0
All Workshop Activities (n=36)#	0.01 (1.8)	0.01	0.09	0.04	0.02	0.3	1

\*November only, ^July only #excludes installer data



**Figure 1: Respirable Crystalline Silica Exposures by Similar Exposure Group. (WES = 0.100 mg/m<sup>3</sup>).**



**Figure 2: Comparison of Summer (November 2018) and Winter (July 2018) respirable crystalline silica measurements for factory based workers. (WES = 0.100 mg/m<sup>3</sup>).**

## 2.2 Volatile Organic Compounds

Table 3 indicates that all VOCs exposures were well below their regulatory and advisory WESs, with Xylene and 2-methylbutane were the most frequently detected chemicals across all SEG, with the exception of the warehouse. The monument and installation SEGs were exposed to the greatest variety of VOCs, as well the highest concentrations, followed by mitre assembly SEG. Analysis of samples for Warehouse staff were negative for all 73 of the VOCs. Other chemicals identified included *n*-hexane, 3-methyl hexane, *n*-heptane, *n*-pentane, 2-methyl pentane, 3-methyl pentane, methyl cyclohexane, ethylbenzene, styrene, toluene, acetone and ethyl acetate, which include both ototoxic chemicals such as styrene, toluene, xylene, *n*-hexane, *n*-heptane (Table 3). The exposure index was low for all SEGs at less than 0.15. Monument SEG has the highest exposure index of 0.15, followed by installation SEG of 0.14 and mitre assembly SEG of 0.07.



**Table 2. Presence of Volatile Organic Compounds by Similar Exposure Groups, 26-30 November 2018**

Chemical	WES (ppm) <sup>a</sup>	Monument (ppm)	Wet Polishing (ppm)	Mitre Assembly (ppm)	Installation (ppm)	Line Polish (ppm)	Line Saw (ppm)	Warehouse (ppm)	Ototoxic listed by SWA <sup>(Safe Work Australia 2018b)</sup>
2-methylbutane	1000 <sup>a</sup>	0.9-1.5	ND-0.7	ND-0.5	0.4-0.7	0.4-0.5	ND-0.6	ND	No
xylene	80 <sup>c</sup>	1.2-4.4	<0.1-0.2	0.1-0.6	0.4-3.7	ND-1.0	ND-0.4	ND	Yes
<i>n</i> -hexane	20 <sup>c</sup>	1.5-2.2	ND	ND-1.2	0.9-1.9	ND	ND	ND	Yes
3-methyl hexane	300 <sup>a</sup>	ND-0.3	ND	ND	ND	ND	ND	ND	No
cyclohexane	100 <sup>c</sup>	ND	ND	ND	ND-0.21	ND	ND	ND	No
<i>n</i> -heptane	400 <sup>c</sup>	0.4-1.6	ND	ND-0.2	ND-1.7	ND	ND	ND	Yes
<i>n</i> -pentane	1000 <sup>b</sup>	0.4-1.1	ND	ND	ND-0.5	ND	ND	ND	No
2-methyl pentane	500 <sup>b</sup>	ND-0.7	ND	ND	ND-0.5	ND	ND	ND	No
3-methyl pentane	500 <sup>b</sup>	ND-0.3	ND	ND	ND	ND	ND	ND	No
methyl-cyclohexane	400 <sup>a</sup>	ND-0.7	ND	ND	ND-0.7	ND	ND	ND	No
ethylbenzene	100 <sup>c</sup>	0.2-0.	ND	ND-0.5	0.1-0.7	ND	ND	ND	No
styrene	50 <sup>c</sup>	ND	ND	ND	ND-0.2	ND	ND	ND	Yes
toluene	50 <sup>c</sup>	ND-0.1	ND	ND	ND-0.5	ND	ND	ND	Yes
acetone	500 <sup>c</sup>	2.0-4.9	ND	ND-0.6	0.7-3.2	ND	ND	ND	No
ethyl acetate	1000 <sup>c</sup>	ND-3.8	ND	ND	20.5-45.1	ND	ND	ND	No
<b>Exposure Index</b>		<b>0.15</b>	<b>&lt;0.01</b>	<b>0.07</b>	<b>0.14</b>	<b>&lt;0.01</b>	<b>&lt;0.01</b>	<b>ND</b>	

<sup>a</sup> GESTIS <sup>b</sup> ACGIH <sup>c</sup> Safe Work Australia

## 4. DISCUSSION

Similar to other manufacturing operations, the stone mason's exposure to hazardous substances is not in isolation of other chemical, biological or physical hazards, and consideration to their potential for additive or synergistic responses with RCS exposure. Examples include the combination of RCS and irritant chemicals that increases the risk of chronic bronchitis, or how RCS can increase the susceptibility to infectious diseases such as tuberculosis. In addition, the wet production processes create a humid atmosphere that may be an effect modifier in presence of RCS and other biological and chemical agents in the environment.

Both RCS and solvents have been associated with the development of occupational autoimmune diseases including systemic lupus erythematosus (Cooper et al. 2010; Parks et al. 2017), systemic scleroderma (Miller et al. 2012; Walecka, Roszkiewicz & Malewska 2018), with high cumulative exposure to RCS a significant risk in the development of system scleroderma (Marie et al. 2014). Inventory of industrial solvents and chemicals used at the factory identified a range of products that were used for a variety of reasons in the assembly of units, cleaning and finishing of products, facility maintenance and cleaning, and water treatment chemicals used for the onsite recycling unit. The most common products identified at SEG work stations included all purpose industrial thinners (all SEGs), WD40 (majority of SEGs), surface bonders, sealants and adhesives (mitre assembly, installation and monument). The monument SEG had the most varied exposures due to the variety of processes used in the production of funeral monuments, sandblasting, spray painting, gilding and lettering. Of the SEGs monitored, the installers, monument and mitre assembly workers that had the highest and most variable VOC exposures, including aliphatic hydrocarbons, alcohols and aromatic hydrocarbons. However, their RCS and VOC exposures were well below current WESs and the total VOC Exposure Index of 0.15 for monument craftsmen, 0.14 for installers and 0.07 for mitre assembly is also below the Exposure Index standard of 1.0.

A variety of ototoxic solvents were identified in the personal passive samples. These included styrene, likely emanating from Tenax Solido adhesive used by the installers; *n*-heptane, *n*-hexane and xylene most likely from the thinners; ethanol and ethyl benzene. Safe Work Australia (Safe Work Australia 2018b) advises that workers exposed to ototoxic solvents should have daily noise exposure below 80 dBA.

### 4.1 Respirable Crystalline Silica

While RCS exposures at the facility were all below the current Australian WES for RCS of 0.10 mg/m<sup>3</sup> measured as an 8-hour time weighted average (TWA<sub>8hour</sub>), the WES is currently being reduced because it may not adequately protect workers. A TWA<sub>8hour</sub> of 0.02 has been proposed to protect workers from development of fibrosis, silicosis and the risk of lung cancer (Safe Work Australia 2018a). Under the revised limit, the estimated RCS (95<sup>th</sup> percentile) of 0.09 mg/m<sup>3</sup> for the monument SEG would be unacceptable, and would place workers at increased risk of lung cancer (Safe Work Australia 2018a). The result was significantly influenced by one specific activity, cleaning, including vacuuming of the monument facility, and exposures for this SEG varied significantly with the warehouse, installers, line polish and saw SEGs. This result illustrates how dry cleaning methods can potentially expose workers to high airborne concentrations of RCS. The slurry from wet processing methods can be transferred by spray and also through foot traffic into other spaces of facility, where it can later dry out and re-enter the atmosphere when disturbed. Observation of foot movement of the slurry was identified in many factory locations including the entrance to the business and administration sections, worker break rooms and factory show room. Housekeeping and cleaning to reduce surface accumulation of RCS has been highlighted by the Workplace Health and Safety Queensland's investigation of the artificial stone industry as an area of importance (Hedges, Topping & Jenke 2019).

The RCS exposures were unsurprisingly highest amongst the mitre assembly, wet polish and monument SEGs where there was direct contact with, and modification of stone through processes such as cutting and polishing. Control strategies were focused as a priority on reducing exposures amongst the workers engaged in manual processing of stone, followed by other factory workers. This is also reflected in the Workplace Health and Safety Queensland findings where exposures were highest for workers engaged in manual operations (Hedges, Topping & Jenke 2019). Excluding the monument worker undertaking cleaning activities, and based on the proposed WES of 0.02 mg/m<sup>3</sup>, the UCL/95<sup>th</sup> percentile for the mitre assembly SEG (*n* = 6) of 0.03 mg/m<sup>3</sup>, wet polish SEG (*n* = 12) of 0.03 mg/m<sup>3</sup>; and monument SEG (*n* = 6) of 0.04 mg/m<sup>3</sup>, would exceed the action limit. Based on the current estimated UCL/95<sup>th</sup> percentile for SEGs ranging from 0.01-0.09 mg/m<sup>3</sup>, the estimated risk of developing silicosis within 15 years of exposures varies from 0.25% for exposures below 0.02 mg/m<sup>3</sup>, to around 5-10% for exposures of 0.05-1.00 mg/m<sup>3</sup> (Buchanan, Miller & Soutar 2001; Health and Safety Executive 2002; Safe Work Australia 2018a). This finding indicates that as with the Queensland

research, wet processing methods are insufficient to maintain exposures below proposed new exposure limit, or action limit of  $0.025 \text{ mg/m}^3 \text{ TWA}_{8\text{hour}}$ . Further control methods are needed to keep exposures as low as reasonably practicable. Control measures implemented at the worksite to date include the supply, fit testing and training in the use of positive pressure air supplied respirators to SEGs with the highest exposures that meets the requirements of AS/NZS1715:2009 and AS/NZS1716:2009, complete moving towards a complete ban of cutting and polishing during field installation. Further control measures include investigation into a proposal to use similar materials with a reduced silica content and phasing out design features that at installation require fine and delicate finishing. To further limit the transportation of RCS from the factory all jobs are washed before transportation to site, and workers have received guidance on the importance of good personal hygiene in reducing RCS exposure at work and in the home, and on the health risk associated with RCS exposure, along with the health surveillance monitoring for all factory and installation workers.

#### 4.3 Limitations

The study was affected by the small sample sets ( $n = 3$  for some), collected over the 2 monitoring sessions (summer and winter). The research was only undertaken at a single facility and findings may not be reflective of broader industry, for either RCS or VOCs. However, the findings provide an indication of the various chemicals that may be encountered and other factories, and demonstrates the efficacy of engineering/isolation controls in minimising RCS exposure below the current WES.

Calculation of the RCS MVUE and 95<sup>th</sup> percentile for each SEG was limited by the small sample size, typically which ranged from 3-12 measurements per SEG. The estimated MVUE for warehouse, installation and line polish SEGs are therefore subject to greater uncertainty as the minimum recommend samples numbers for SEGs of less than 6 workers is 6 samples per worker. To address this, further sampling with the installation team is recommended. Additionally, the line saw and line polish SEGs could be combined as they both use remotely operate automated machinery ( $n = 9$ ), and are located with the same position in the workshop (between mitre assembly and wet polish SEGs). Further sampling with the warehouse SEG is required to confirm that the estimated 95<sup>th</sup> percentile remains less than 10% of the current WES for RCS.

Additional monitoring of worker exposure to aldehydes is recommended. Aldehydes may be present from use of industrial chemicals, epoxy resins, and even aerosolisation of stone binding resins during cutting. A sweet odour was frequently encountered around saws during monitoring, and by other workers on site.

#### 4.4 What this Study Adds

This study adds to the conversation on the relationship chemicals and stone masonry work, which if not properly controlled for, could potentially have additive or synergistic effects for the autoimmune disease when combined with RCS exposure. Noise and solvent combined exposure is another potential occupational hazard that may be encountered in the industry. The presence of ototoxic chemical means that worker noise exposure should be kept below 80 dBA ( $\text{TWA}_{8\text{hour}}$ ).

The estimated RCS exposures across the worksites, workshop and installation SEGs, indicates that the use of current best industry practices, including wet production methods and use of remotely operated saw and polishing machinery, business may not be sufficient to meet the proposed  $\text{TWA}_{8\text{hour}}$  RCS standard of  $0.02 \text{ mg/m}^3$ , or the action limit of the current WES of  $0.1 \text{ mg/m}^3$  (action limit  $0.05 \text{ mg/m}^3$ ).

Focus on material substitute (low quartz content stone), extraction and ventilation systems, premise housekeeping to minimise accumulation of dust slurry and dust resuspension, as well optimising of RPE will become key in further reducing employee exposure to RCS in the workplace, and in the prevention of occupational respiratory disease. Routine health surveillance for early disease detection, as well as employer and employee education on recognition of hazards associated with the creation of stone products, is needed and should include the potential health impacts, safe processing and control methods to protect their health, and the selection use, storage and maintenance of their RPE kit will also be key strategies in addressing and halting the current silicosis epidemic.

## 5. CONCLUSIONS

RCS exposures at the facility complied with current regulatory WES of  $0.10 \text{ mg/m}^3$ . However, in the event that the current WES was reduced to  $0.02 \text{ mg/m}^3$ , wet processing, including use of automated remote controlled saws and polishes would not be sufficient to control exposures below the proposed limit. Consideration should be given to using low silica content stone, mandatory wet cleaning methods and minimising dust residues in workshops were all recommended to help keep RCS exposures as low as reasonably possible.

This study also found that workers creating artificial stone products may be exposed to a variety of VOCs including aliphatic and aromatic hydrocarbons, ketones and alcohols emitted from thinners/solvents, glues/adhesives, resins and other industrial chemicals used at the premises. Some of the VOCs may have potential for additive or synergistic response in the presence of RCS because they have both been identified as risk factors in the development of the autoimmune diseases systemic scleroderma. However, it must be emphasised that exposure at the facility were significantly below current regulatory and recommended WES, with the exposure index of less than 0.015 across all SEGs monitored.

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## WORKING SAFELY WITH ENGINEERED STONE – A FABRICATOR PERSPECTIVE

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### 1. ENGINEERED STONE

#### A. GENERAL

All stone fabricating workplaces have numerous forms of chemical, physical and/or biological hazard or human stressors that may cause injury, illness, or impair workers' health or wellbeing. The main chemical hazard of concern is respirable crystalline silica (RCS). Occupational Hygienists are specifically concerned about the workers exposure to RCS in the workplace. For the purposes of this paper, other occupational health hazards for engineered stone worker are outside the scope of this paper. A systematic process for managing the RCS hazards at all stages of the fabricating operation is an integral part of an organisation's safety management system (AIHA, 2015) and complements other site hazard management plans for the site. It documents the agent, how hazards are controlled and what methods are used to verify that controls are effective.

The fabricating business needs a holistic, risk-based approach to managing RCS health and hygiene hazards that adopts changing technology, current scientific knowledge and encourages innovation. Fabricators should demonstrate an understanding of the fabrication industry, the specific operation's producing hazardous dusts. This is to be based on solid research and consultation with experts and workers. Objective guidance and instruction must be provided so both the employer and workers understand the RCS health risk profile of the workplace, what controls are in place and how the controls work. There should be the policies, procedures and reporting processes in place so that there is that verification that the health of workers is not being adversely affected.

#### B. INTRODUCTION & BACKGROUND

Engineered stone (ES) was first developed in the 1963 by Breton S.p.A. (ISFA, 2019). ES is formed by an aggregation of stone material, usually with a high percentage of quartz, which is bound together by a thermosetting resin using techniques pioneered by Brenton SpA. Since this initial production manufacturing plants across the globe have been established by several companies including, Caesarstone (1987), Costentino (1989) and others have produced similar and unique engineered stone products. The ES products contain a large percentage (up to 95% quartz) of silica-based minerals. Quartz-based products are much harder materials in comparison to natural stone (e.g. marble) Marble on the Mohs Scale (Britannica, 2019) scores a 3, quartz score a 7. This makes ES far more scratch resistant and therefore ideal for applications as kitchen bench tops and other similar surface products. Quartz countertops are more flexible making them less likely to chip or crack. Quartz is non-porous and usually does not require sealing. The ES products are stain-resistant however the quartz can discolor over time when exposed to direct sunlight. Seams can be seen with a quartz countertop but are less visible with darker colours.

### 2. PRIMARY' WORKPLACE

All works are generally completed at the primary workplace, which is the fabricator factory or workshop. The stone is cut to size at this location. There may be a need for some benchtops to include 'joinery' operations of the product/stone. This is to be completed also at this location. This may include the cutting, grinding and gluing smaller sections or pieces of stone to the main benchtop. The benchtops are then installed into the residential or commercial premises.

Small, Medium and Large Fabrication Sites - Small fabrication companies generally have between 1 to 9 employees in total; medium 10 to 29 and large; greater than 30.

Small sites are factories generally with a main fabricator workshop in an open plan area with multiple activities/workers happening in the one general work area such as saw operators, finishing, labourers, polishing and shapers. The supervisor, manager and/or business owner and office workers may be very close to the main operators in a small administration/office area. It is possible all these workers are being exposed to elevated to unacceptable levels of RCS.

Medium sites are factories generally with the main fabricator workshop in a large open plan or designated areas/rooms set up for the multiple activities happening in the one very large fabrication workshop, but sectioned-off parts of the main factory. These activities/workers may be computer numerical control (CNC) Router/water jet/saw operators, finishing, labourers, polishing and shapers. The supervisor, manager and/or

business owner and office workers may be separated from the fabricators workshop in a medium to large admin/office area so it unlikely that these workers are being exposed to elevated levels of RCS.

Large sites are factories generally are very large in size with the main fabricator workshop in a very large open plan or separated designated areas/rooms set up for the multiple activities happening in the multiple large/general work areas. These activities/workers may be CNC Router/water jet/saw operators, finishing, labourers, polishing and shapers. The supervisor, manager and/or business owner and office workers may be totally separated from the fabricators workshop in a large admin/office area so it highly unlikely that these office workers would be exposure to elevated levels of RCS.

### 3. SECONDARY' WORKPLACES

All works should be completed at the primary workplace, which is the fabricator factory or workshop. However, the product may be taken to a secondary (or more) location to undertake further fabrication at this next location. Some fabricators may choose to cut the benches slightly over size and then to the final cutting at the 'installation' point (onsite). There may be a need for some benchtops to go to another location for example to undertake the 'joinery' operations of the stone. This may include the cutting, grinding and gluing smaller sections or pieces of stone to the main benchtop in a location which is not set up with adequate controls as the primary workplace is. The benchtops may then be transported to site to be installed into the residential or commercial premises. At this point there may have been errors made at the fabrication stage which forces the installers to undertake further modifications to the stone onsite in a location which is not set up with adequate controls as the primary workplace is.

### 4. PRIMARY AND SECONDARY EXPOSURE SOURCES

Engineered Stone workers are expected to be exposed to primary exposures sources of RCS during fabrication due to their proximity to the main work areas/activities. There is a high possibility of secondary exposures due to settled dust from fabrication (e.g. housekeeping issues) to air movement from fabrication areas, staff movements in between spaces and inappropriate air handling systems.

### 5. THE STAGES OF THE FABRICATING OPERATIONS

Stone fabrication includes silica-containing materials from suppliers to fabricators for the specific purpose of fabrication as well as other silica-containing materials and silica-contaminated dusts associated with the fabrication process throughout the workplace. The Fabricators are sourcing stone from Australian and overseas suppliers and distributors who in turn source the stone from overseas organisations. This could be natural materials (e.g. granite) or engineered stone which the workers cut, grind and polish the stone as part of the fabrication and installation of the finished product. At small to medium fabrication sites stone slabs are cut to size by either the use of a basic grinder with a stone gutting wheel, with the medium to large fabrication sites utilising bridge saws or sophisticated CNC routers or water jet cutters. Joinery may be required at some stage of the process. The edges are then bevelled then benchtops are polished using handheld grinders, polishers, edge or surface polishing machines.

#### A. FABRICATION – MAIN WORK GROUPS

##### I. COMPUTER NUMERICAL CONTROL (CNC) ROUTER / WATER JET WORKERS

Workers who operate Computer Numerical Control (CNC) routers or Water Jet cutting machines utilise an automated cutting method to modify the ES into the appropriate dimensions and cut outs as required onsite. This work is generally conducted from a control point adjacent to the machine in the fabricators factory and does not require the worker to conduct the actual cutting process with the stone using hand tools for example. It may include controls such as isolation from the activity and engineering solutions such as water suppression and localised exhaust ventilation to prevent exposures.

##### II. SAW OPERATORS

Saw operators will cut the stone to the correct size. This work is generally conducted from a control point adjacent to the machine in the fabricator's factory and/or does require the worker to conduct the actual cutting process with the stone. It may include controls such as isolation from the activity and engineering solutions such as water suppression and sometimes localised exhaust ventilation (LEV) to prevent exposures.

##### III. LABOURERS

Labourers may be required to conduct activities and tasks which bring them into contact with RCS. This may be from primary-type exposures including work with stone, cleaning of stone products well as secondary-type

exposures such as cleaning equipment, assisting with those conducting cutting of stone, other housekeeping activities, etc.

#### **IV. SHAPERS**

Shapers conduct their activities by using power tools to shape the ES in the final required design for installation. This requires softer modifications of the ES to gradually change the shape as required which requires grinding and sanding modifications to the surfaces/edges. These activities may be conducted at the fabrication workshop or onsite as required. These individuals have high potential for exposure.

#### **V. FINISHING WORKERS**

Finishing of the ES may require sawing, cutting and shaping prior to installation of the stone onsite. This may require the use of power and/or hand tools, installation and housekeeping. This group is likely to be exposed to primary and secondary sources of RCS.

#### **VI. POLISHERS**

Polishers smooth the surfaces of the stone to provide the appropriate surface finish. The polishers are likely to use power tools with various exposures depending on the equipment and method used. Polishing may be conducted at the fabricator workshop and onsite as required. This group may have primary and secondary exposures.

#### **VII. SUPERVISORS**

Supervisors will have diverse roles which may have them enter the work areas and oversee activities with the potential to be exposed to RCS. They may be exposed to primary and secondary exposures dependent on the activities being conducted.

#### **VIII. OFFICES**

Office workers are considered personnel to be working within an office space and not tool or equipment based. They should not be exposed; however, it is expected that they may be exposed to primary sources of RCS due to their proximity to the main work areas/activities. There is a high possibility of secondary exposures due to air movement from fabrication areas, staff movements in between spaces and inappropriate atmospheric systems.

### **6. THE SILICA AGENT AND RISK PROFILES**

Silicon Dioxide (SiO<sub>2</sub>) is the most abundant mineral within the earth's crust with Quartz (crystalline) being the most common type. It is found in most igneous, metamorphic and sedimentary rocks. The three (3) main types of crystalline silica are Quartz, Cristobalite and Tridymite. There is also 'non-crystalline' silica called Amorphous silica (e.g. glass) which is a lower risk material when compared to crystalline silica. However, can be 'transformed' into more toxic crystalline silica when exposed to extremely high heat situations (e.g. foundries, furnaces, etc.). RCS is the very fine dust (respirable fraction – less than 10µm in diameter) which is generated by manufacturing, fabrication, processing, cutting, shaping and reworking of silica-containing products. Other activities that can produce silica include excavation, earth moving and drilling plant operations, clay and stone processing machine operations, paving and surfacing, mining, quarrying and mineral ore treating processes, tunneling, construction labouring activities, brick, concrete or stone cutting; especially using dry methods, abrasive blasting, foundry casting, angle grinding, jack hammering and chiseling of concrete or masonry, hydraulic fracturing of gas and oil wells and pottery making.

Silica can be found in quartz, sand, stone, soil, granite, brick, concrete, grout, mortar, bitumen, diatomaceous earth and engineered stone products. RCS can become airborne during fabrication and installation of composite (engineered or manufactured) stone countertops.

Higher risk work situations are where silica-containing materials are aggressively damaged, and the silica particles are 'fresh fractured' e.g. during tunneling of sandstone, cutting, ripping, grinding stone products. This gives the silica particle a greater surface area and therefore more toxic (e.g. biologically available) to the body. In comparison to this is working with 'aged silica' which is older (i.e. exposed to the air longer) silica products that have a lower particle surface area and therefore are less toxic to the body than freshly fractured silica. Examples of aged silica products are laying of concrete or excavation of clay soils which contain silica.

The RCS penetrates past the body's defenses and enters the lower regions of the lungs causing scarring of the tissue leading to silicosis. This damage to the lungs can form nodules and scar tissues within the lungs. The three (3) main type of silicosis are:



- Acute silicosis (very high exposures) – Latency period of weeks to 5 years;
- Accelerated silicosis (high exposures) – Latency period of 5 to 15 years; &
- Chronic silicosis (Moderate Exposures) – Latency period of greater than 15 years.

Continued exposure and advancement of the silicosis disease results in worker symptoms such as constant cough, shortness in breath and tiredness. This can lead to further conditions such as (but not limited to) renal disease, tuberculosis, heart disease, autoimmune diseases, chronic-obstructive pulmonary (Lung) disease (COPD) such as emphysema and then progressing to death.

A recent study by Noa *et. al.* (2016) examined the composition of natural and artificial stone material as to non-exposed workers and workers exposed to ES (see Table 5 [extract] below – units in parts per billion [ppb]). This study indicated that there was mainly silica present. There were also metals such as zirconium, titanium and aluminium present in significantly higher percentages than their content in natural stone. Those metals are well known to induce sarcoid-like granulomatosis which is a collection inflammation cells in the lungs (Newman, 1998). Importantly, the pattern of a high content of silica and metals contained in the material was reflected in the content of these metals in the induced sputum samples of humans. This also goes along with the reported radiological presentation of many of the artificial dust-induced silicosis cases that mimic sarcoidosis (Shtraichman, 2015).

TABLE 5 Chemical analysis by X-ray fluorescence in induced sputum particles retrieved from exposed workers and from raw material dust

	Nonexposed controls	Exposed workers	p-value	Natural stone	Artificial stone
Zinc	<LOD	160.2±97.8	<0.01	<LOD	1233.7±24.78
Copper	178.4±16.6	216.8±58.1	0.217	<LOD	57.8±13.92
Iron	293.4±59.6	1479.2±760.1	0.012	507.260.34	3574.0±80.8
Titanium	<LOD	603.6±268	0.064	<LOD	41 412.2±255.7
Calcium	4522±811.2	19 321.2±10 151	0.016	546 368.6±309	9058.2±245.9
Aluminium	<LOD	3192.7±2052	<0.01	899.1±170.3	20 146.9±430.2
Silica	<LOD	5739.6±1577	<0.01	4041.9±102	647 603.4±1198
Chloride	517548.7±136 374	18 634.9±7005	<0.01	<LOD	13 167.5±96.7
Sulfur	153316.3±57024	434 674.1±213 233	0.022	794.8±41.7	3350.4±89.7

Data are presented as the mean±SD of two measurements in three subjects for each group. LOD: limit of detection. p<0.05 (independent t-test).

Reference: Noa *et. al.*, 2019.

An in vitro study by Martinez *et. al.* (2010) and Pavan *et. al.* (2016) indicated that engineered stone dusts exhibited a higher reactivity in free radical production when compared to reference quartz. Pavan *et al.* correlated this result to the larger amount of metals suggesting that the different chemical features could play an important role with an increased severity of silicosis. Martinez undertook research into increased toxicity of ES which defined the hazardous properties of dusts contain chemical resins. This indicated specific toxicological properties of the stone powder and polymeric resins which may increase the toxicity of the dust and therefore change the occupational risk profile for workers that are employed in this industry.

#### A. SIMILAR EXPOSED GROUPS (SEGS)

The number of workers on a project may vary greatly and prediction of the exposure magnitude is vital for exposure assessment. The health hazard and control strategies are to be utilised so that there is efficacy and adequate coverage for workers and to protect them from adverse harm. Similar Exposed Groups (SEGs) are used as it is impractical to monitor all individuals as this is seen as an overuse of resources. The basic characterisation of activities, professional judgement and subsequent groupings of the SEGs are done using the workforce exposure profile. Similar materials and processes used by workers, the frequency of the tasks performed and the specific way they are performed can allocate workers into a SEG. A qualitative exposure assessment is undertaken on each SEG so that representative sampling is done. The findings from these assessments allow the SEGS to be better defined and characterised (see Table 1). Walk-through investigations and exposures assessments will then allow the SEGs to be expanded, if possible if exposure profiles becoming known. Once the Quantitative Exposure Assessment is undertaken then the below SEGs may be altered to include additional sub-SEG Groups (e.g. SEG 01A, 01B, 01C, etc.) to further categorise the work groups for larger workforces for example.

Table 1 – Similar Exposed Groups (SEGs)		
SEG No.	SEG Name	SEG Description
SEG 01	Stone Workers	This includes all personnel performing such tasks as CNC Router/water jet/saw operations, finishing, polishing, shapers and any other associated stone fabrication where there is a direct exposure to RCS dust. (i.e. Primary Exposure)
SEG 02	Support Workers	This includes all personnel supporting Stone Workers (SEG 01) and any associated works activities such labourers and other operations where there is an in-direct (e.g. working adjacent to SEG 01) exposure to RCS dust. (i.e. Secondary Exposure)
SEG 03	Office Workers	This includes all personnel not working in the fabrications areas where there is no direct or minor to no in-direct exposure to RCS dust. (i.e. Possible Exposure)

## B. EXPOSURE RATING

Exposure ratings are needed to group the exposure levels relative to the Workplace Exposure Standard (WES) and each of the SEGs as well (see Table 2).

Table 2 – Exposure Rating		
Rating	Exposure Category	Description
A	0 (Rare)	No exceedance of 0.01 of the WES (95th percentile < 0.01 x WES)
B	1 (unlikely)	No exceedance of 0.1 of the WES (95th percentile < 0.1 x WES)
C	2 (Possible)	>5% exceedances of 0.1 of the WES (95th percentile between 0.1x WES and 0.5 x WES)
D	3 (Likely)	>5% exceedances of 0.5 of the WES (95th percentile between 0.5x WES and 1 x WES)
E	4 (Almost Certain)	>5% exceedance of the WES (95th percentile > WES)
F	5 (Certain)	>5% exceedance 10 times of the WES (95th percentile > 10x WES)

Exposure Categories are used to link SEGs with a likely exposure rating relative to the WES (see Table 3). These are preliminary SEGs so depending on the specific situation there is a 'Possible' to 'Certain' exposure ratings applied to SEG 01, SEG 02 and SEG 03.

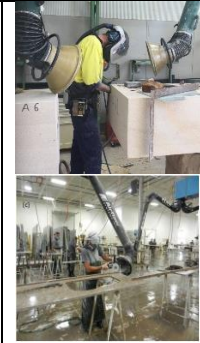
Table 3 – Hazard Identification and Exposure Category			
Hazard	SEG 01	SEG 02	SEG 03
CHEMICAL			
Respirable crystalline silica (RCS)	4 (Almost Certain)	3 (Likely)	2 (Possible)
	5 (Certain)	4 (Almost Certain)	3 (Likely)
Note 1: RCS WES based on SWA Level & Respirable Dust WES based on NSW Coal Mines (Coal Mine Health and Safety Act, 2002).			

## 7. HOW ENGINEERED STONE HAZARDS ARE CONTROLLED

Table 4 – The Hierarchy of Control

<p><b>A. ELIMINATION</b></p> <p><b>Elimination</b> of the RCS exposure hazard should be considered early in the design process of a workplace and in the manufacture of ES. Elimination can fail as a strategy if the hazardous process or material is reintroduced at a later stage in the design or production phases.</p>	
<p><b>B. SUBSTITUTION</b></p> <p><b>Substitution</b> can involve using a <b>less hazardous ES</b> which may not be an option. Substituting a more hazardous process for a less hazardous one is a very effective control to minimise exposures. Fabricators should not be dry cutting engineered stone, so this process substitution reduces massively worker RCS exposures from the fabrication process. Using processes that minimise RCS dust from becoming airborne such as wet cutting (instead of dry cutting) is essential in dust suppression. ES importers may wish to consider importing engineered stone with a lower silica content and producers may wish to explore developing stone with a lower silica content or selecting raw constituents for production with a safer mix of silica polymorphs (as an option mixing in a blend of amorphous silica products).</p> <p>The use of machines and <b>specialist lifting equipment</b> is a good control to transport stone in a safe manner, prevent damage to the stone and there reduce dust levels within the workshop areas for example. Changing processes to minimise the number of cutting frequency and slowing the cut speed down may assist with an overall reduction of dust within the air.</p>	
<p><b>C. ISOLATION/SEPARATION</b></p> <p><b>Isolation</b> relies upon separating the hazardous work process from the worker. In primary work sites where a dedicated work area has been designed into the workplace, isolation might be achieved by automating the fabrication process with workers directing the process from another location. The cutting equipment might also be isolated from the worker, by boxing or enclosing the cutting equipment. Secondary workplaces can be set up with barricades and warning signage to separate other workers from the stone cutting processes, thus minimising secondary RCS exposures.</p>	
<p><b>D. ENGINEERING CONTROLS</b></p>	
<p><b>Water Suppression</b> - Water cutting should be considered a standard requirement for the control of RCS. This can be achieved by selecting equipment with water suppression attachments designed into the equipment. The use water curtains built into fixed cutting equipment will also minimise the uncontrolled release of RCS. Handheld tools can be designed to spray water at the point of contact with the stone.</p>	    
<p><b>Brushes and guarding</b> - Brushes and guarding on the fabrication equipment can provide an effective way of reducing the uncontrolled release of RCS. The use of water is essential; however, some processes/tasks/activities produce excessive amount of very fine water mist that suspends in the air for a period of time. These brushes matting, and guarding is especially effective at minimising the level of overall very fine water mist in the air.</p>	   
<p><b>Extraction systems</b> can include slurry extraction and vacuum systems with H Class High Efficiency Particulate Air (HEPA) filtration systems attached to the cutting device.</p>	 

**Ventilation** should be designed into the workplace. Natural ventilation is important in outdoor situations, large open buildings with large air volumes or there is a large dust source that is very difficult to capture. Natural ventilation indoors is usually used with other forms of ventilation. Forced ventilation with the use of fans and large extraction systems are good for large air spaces. Local exhaust ventilation (LEV) is by far the most effective means of controlling large dust clouds from a specific or point source. For primary workplaces, a ventilation specialist can assist with this design. For secondary workplaces, doors and windows should be kept open to facilitate natural airflow. The three (3) LEVs types are an enclosure hood, an exterior hood and a high velocity low volume hood (HVLV). The enclosing hood is done within an air space (fully enclosed) or at the front for operator access so the dust is drawn away.



**E. ADMINISTRATIVE CONTROLS**

Very important to ensure that daily and thorough **housekeeping and cleaning procedures** for settled dust and water slurry/waste are implemented. Use of low-pressure water, wet sweeping, and use for H class rated vacuums to clean floors, walls and other surfaces.

**Decontamination** - Transfer of silica dust from work areas to break rooms, other onsite locations and off site (residential homes) is to be prevented. Worker clothes and uniform are to be cleaned frequently with industrial vacuums cleaners for access silica dust.



**Workplace monitoring** - Workplace monitoring is an effective way of determining whether the controls in place are effective at reducing workers' exposure to RCS. Such monitoring should include static monitoring or the working environment and exposure monitoring of workers conducting particular tasks. Exposure monitoring will allow for tasks to be adequately risk assessed and can be used to determine the level of respiratory protective equipment (RPE) required for each task.



**Health Surveillance** - Health surveillance is required under most state WHS Regs for workers who have been assessed as being at risk of RCS exposure. Where a worker is carrying out ongoing work at a workplace using, generating or storing a hazardous chemical and there is a significant risk to health due to exposure. Such surveillance should be organised and paid for by the employer. Examples to be used are Mobile Lung Screen (Lung Bus), Medical Clinics and/or Local doctor.

**Communication and Consultation** - Procedures for dealing with communication and consultation with the workforce and with other stakeholders must be developed in accordance with WHS Act and Regs.



**Waste** - RCS waste shall be taken directly to a sealable container located adjacent to the work/decontamination areas periodically throughout the fabrication process. The container shall be lined with a bag. RCS dust is not classified as a prescribed industrial waste. RCS waste can be disposed of as solid inert waste. Prior to transporting waste, the waste facility must be notified to ensure they have the capacity to receive the waste.

**F. PERSONAL PROTECTIVE EQUIPMENT**

Under the WHS laws, PCBUs must put control measures in place if it is not reasonably practicable to eliminate a health and safety risk in the workplace.

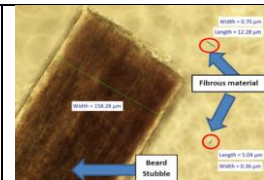
The Fabricator must ensure that the provision of **PPE** is managed in accordance with relevant WHS Act and WHS Regulation, AS 1715 Selection, use and maintenance of respiratory protective equipment & AS/NZS 1716 Respiratory protective devices. The Fabricator is to ensure that workers wear the appropriate PPE suitable to the nature of the work and potential hazard/s associated with the work. The Fabricator is to ensure that worksite WHS inspections conducted by management include an assessment of compliance with PPE requirements and the condition of PPE in use. The Fabricator must make available clean, serviceable PPE for the use by visitors.



**Respiratory Fit Testing (RFT)** - Quantitative test methods use equipment to measure the efficiency of a respirator in preventing materials in the atmosphere from entering a user's breathing zone. The measured leakage is expressed as a percentage of the outside concentration. The numbers generated by quantitative fit tests may not reflect the protection factors likely to be achieved in the workplace. The advantage of a quantitative test is that it does not rely on a subjective response.



**Clean Shaven Policy** - It is strongly recommended to the Fabricators that they adopt a strict 'clean shaven' Policy at their workplace. Where the regular use of respiratory protection is required the minimisation of risk of exposure to RCS is paramount to ensure exposure are below the WES as mandate by the relevant WHS Regulations.



**8. PROCESS OF LIAISON DIRECTLY WITH THE FABRICATORS AND OTHER STAKEHOLDERS**

Challenges of communication with the majority of Fabricators:

- English as second language or very low English-speaking skills or no English-speaking workers and/or supervisors
- Low to very low educational background (e.g. workers and supervisors)
- Lower to very low understanding and historical compliance with work, health & safety (WHS)

Other stakeholders may include project management teams, subcontractor hygienist, site safety committees, unions, EPA, State-based regulators, Safe Work Australia, the general public, etc.

**9. SITE -SPECIFIC UNDERSTANDINGS FROM THE FABRICATION INDUSTRY LEADERS**

Fabricators understand that:

- Dry cutting is not acceptable and will be seen as an automatic high-risk non-conformance, will not be tolerated and may be legislated against.
- All fabricators must be fully aware of the risks of working with ES and be open to the process of strict dust control such as water suppression systems, slurry storage systems and waste containment.
- There is a gap to ES Health & Hygiene Guideline & regulatory compliance.

- Wash-down of equipment and other work areas is a vital operating improvement as well as the prevention of the transportation of RCS dust outside of the work area.
- Containment to change rooms where laundry systems are offered is a solution and is being demonstrated by some fabricators.
- RPE should be mandatory in all areas of stone fabrication/polishing/cutting/handling plus respirator fit testing.
- Fabricators need to reach out to attain example resources in Guidelines and templates for silica management and record keeping to legislative standards.
- Personal (and static) air monitoring must be carried out on a regular basis depending on exposure levels.
- Gap analysis completed on management systems, training records, risk assessments, health records and safety plans.
- Develop a relationship with a consultant that knows their business for future improvement opportunities.

#### 10. RECENT FINDINGS FROM INVESTIGATIONS

- Employees engaged in the stone cutting and polishing process were observed to be wearing
- Respirators only 25 to 50% of the time in the fabrication areas.
- Water suppression was the primary engineering control used. On-tool water suppression was installed to the equipment including bridge saw, edge polisher, cutting saw and powered hand tools (grinder and polisher) and most sites.
- Local Exhaust Ventilation (LEV) is generally not used as wet dust suppression is incorporated into all stone cutting and polishing aspects of the fabrication.
- There was significant amount of slurry from powdered stone and water on the floor of the Production Shed from the wet method. The slurry is to be channelled from the floor to the outside for containment and removal.
- The floors were usually regularly washed down as the shift progressed.
- There was a staff member dedicated to washing down the floors, allowing the slurry to be channelled via floor drains through to the recycled water filtration system.
- Other personal protective equipment (PPE) used by the workers include long-sleeve shirt, apron, gumboots, gloves, goggles and earmuffs or ear plugs.
- Laundry facilities were generally not provided on site, employees not have a dedicated Change Room Area, RPE storage area and Lunchroom.

A summary of the personal exposure and static monitoring results for RD and RCS is presented in Table 5 below. Table 5 withheld due to client and intellectual property issues. - Refer to Table 5 in Presentation.

#### 11. WHAT METHODS ARE USED TO VERIFY THAT CONTROLS ARE EFFECTIVE TO ENSURE PRACTICAL AND REAL REDUCTIONS IN EXPOSURES

The fabricator organisations need to ensure their RCS work, health and safety program (including Engineering, Administrative and PPE controls) are verified as being effective. Examples of verification could include:

- Inspections of the workplace during operations to ensure that SWPs, SWMS or other procedures are being followed.
- Visual inspections/walkthroughs to visually ensure that equipment and controls are operating satisfactorily.
- Review of documentation and records.
- Regular equipment maintenance is occurring as required.
- Discussions with workers to identify ongoing RCS hazards and ensure controls are working effectively.
- It is recommended that each organisation has some form of action plan that documents scheduled future plans for minimising exposure to RCS.
- Conduct health surveillance of all employees and ensure that future
- Employees have pre-employment health surveillance checks;
- Ensure that Respirator Fit Testing is conducted on a regular basis (as per Management Plan);
- Ensure that regular exposure assessment monitoring is conducted as per the Plan; and

- Consider ways of improving the change room areas, lunchroom area and staff amenities to improve the in-house occupational hygiene management of RCS.

## 12. CURRENT SCIENTIFIC KNOWLEDGE IN THE INDUSTRY AS WELL AS CHANGING TECHNOLOGY AND ENCOURAGEMENT OF INNOVATION FOR FUTURE ADVANCEMENT OF THE INDUSTRY

- Utilising sheet-flow wetting methods indicated by David *et al.*, (2015) and on-tool local exhaust ventilation (LEV) has been shown to reduce respirable dust (RD) exposures greatly during the use of various powered hand tools on ES products. This includes tasks such as edge grinding with a diamond cup wheel and a silicon carbide abrasive wheels. The large reductions in exposures were occurring when they were utilised in combination. Sheet-flow-wetting with LEV reduced exposures as much as 95%.
- Personal optical aerosol monitors can be used simultaneously with the RD samples for rapid assessment of controls for such processes as polishing, blade cutting, and core drilling. Exposure monitoring with Video surveillance assists in dust source identification and rapid response with recommendations.
- NIOSH have a database that you can access and predict approximate exposures to silica hazards using this exposure control database. It will help to anticipate and control worker exposures to silica, this is a free online tool which allows you to enter a task, proposed controls, and other variables and obtain a predicted exposure level based on exposure data from trusted sources. People can then contribute to the database, which will make the database even more powerful and accurate.
- NIOSH (Chaolong *et al.*, 2016) have confirmed that larger amount of water through a central water feed sources for grinders (or example) can lead to superior dust control technologies. As well combinations of engineering control measures will be needed for these tasks to reduce the exposure to levels consistently below the Workplace exposure standard (WES). Alternative ways of cleaning and drying stone countertops other than using compressed air need to be considered and implemented.
- Guidelines to be available in Greek, Vietnamese, Mandarin, Arabic and any other language as required. The use of induction videos and large workplace safety signage with increase understanding and ongoing compliance.
- Language translation services (e.g. - Linguistico) can provide guidelines for non-English-speaking workforces.
- Thorough audit reporting including fabricator responses to Audit Tool, detailed onsite observations, recommendations and action plans to assist the fabricators in conforming with compliance.

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## ARE YOU INDEPENDENT AND COMPETENT?

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**Abstract:** Importation, manufacture, supply, storage, transportation, sale, use, reuse, installation and replacement of asbestos was prohibited from 1<sup>st</sup> of January 2004 in Victoria however it is still insitu in many homes, workplaces and vehicles. Asbestos removal jobs occur daily throughout Victoria of varying sizes and complexity many of which require an independent competent person to undertake relevant functions. Building owners, employers, employees and the community expect that asbestos is safely managed and removed safely every time. This paper will discuss Victorian legislative requirements for asbestos management and removal and how occupational hygienists can add value in this field. The final question is how does the profession of occupational hygiene set themselves apart from others in this area and rebrand themselves as the leader in asbestos related matters?

### LEGISLATIVE REQUIREMENTS

The objectives of the Occupational Health and Safety Act 2004 (Vic) (Act) are:

- To secure the health, safety and welfare of employees and others at work; and
- To eliminate, at the source, risks to the health, safety or welfare of employees and others at work; and
- To ensure the health and safety of members of the public is not placed at risk by the conduct of undertakings by employers and self-employed persons; and
- To provide for the involvement of employees, employers and organisations representing those persons, in the formulation and implementation of health, safety and welfare standards.

Further to this asbestos management and removal are specifically covered under the Occupational Health and Safety Regulations 2017 (Vic) (Regulations) under Part 4.4 – Asbestos. Victoria moved to risk based OHS legislation in 1985 however the significant risks associated with asbestos are well understood and as such Part 4.4 of the Regulations are both risk based and specific in nature.

Regulation 207 details who an independent person is in carrying out a relevant function in relation to asbestos removal work.

They must be independent from the following people if relevant:

- The employer or self-employed person performing the asbestos removal work;
- The persons who commissioned the asbestos removal work;
- The asbestos removal licence holder performing the asbestos removal work; and
- Does not have a conflict of interest in carrying out the relevant function.

They must also have the requisite knowledge, skills and experience to carry out the relevant functions.

The relevant functions are:

- The determination of airborne asbestos fibre levels under regulation 250 (determination that airborne fibre levels due to the removal of asbestos contaminated dust is likely to be less than one half of the asbestos exposure standard);
- The visual inspection of an area for visible asbestos residue under regulation 294 (Class A and B removal jobs); or
- The issuing of a clearance certificate under regulation 297 (to the person who commissioned the work).

### NON-LEGISLATED SUPPORT

Occupational hygienist are used for support on a range of asbestos related matters that are not legislated. The two Compliance Codes related to asbestos in Victoria are 'Managing asbestos in workplaces' and 'Removing asbestos in workplaces'. Both of these documents discuss that for various tasks a person with the requisite knowledge, skills and experience should undertake the activity. Further to this, the codes state that an example of a person with the requisite knowledge, skills and experience is an occupational hygienist.

The tasks specified which should include guidance from a competent person are:

- Atmospheric monitoring for airborne asbestos fibres
- Determination of what level of respiratory protective equipment must be worn for specific tasks
- Determination if fire damaged non-friable asbestos has become friable
- Management of heat stress during asbestos removal tasks that require disposable coveralls to be worn
- Determination of level of personal decontamination required
- Inspection of items taken out of an asbestos removal area for reuse
- Requirements for transporting asbestos waste through a building
- Visual inspection and smoke test of asbestos removal area enclosure (bubble) prior to use
- Paraoccupational air monitoring
- Asbestos identification
- Determination that non-friable asbestos in soil may become friable due to work processes
- Guidance for the development of Asbestos Control Plan
- Guidance for the design of a bubble
- Sampling of suspected asbestos containing material
- Reviewing asbestos register
- Development of Division 5 and 6 asbestos register
- Development of risk control measures

Further areas of engagement not specified in the codes but regularly performed by occupational hygienists are:

- Development of asbestos management procedures
- Asbestos awareness training
- Guidance of removing asbestos so far as is reasonably practicable prior to demolition
- Guidance on storage of asbestos
- Guidance on asbestos related activities meeting compliance with the regulations

#### INDEPENDENT

The Cambridge English dictionary defines independent as 'not influenced or controlled in any way by people, events or things'.

Independence may seem like a simple concept for example you can't be related to or have financial interest in the person or organisation that independence is required from. However this simple term can become confounded when occupational hygienists are engaged as part of a large asbestos removal job or work in a rural communities where relationships may influence an occupational hygienists' decision or non-decisions.

#### COMPETENT

The word competent is not present within the Regulations however it is commonly used to describe the requirement for the independent persons to have the requisite knowledge, skills and experience.

Within the Compliance Codes an occupational hygienist is given as an example of a person with the required competencies within the two compliance codes. Within industry occupational hygienists or 'hygienists' are known as the key person in regards to providing advice and managing asbestos removal jobs safely and compliantly.

Competency should be an easy requirement for occupational hygienist to meet as the Australian Institute of Occupational Hygienists (AIOH) has a professional membership structure.

A professional member of the AIOH is either a provisional, full or fellow member and shall have at a minimum:

- A first degree in science or engineering (or an equivalent acceptable to council); and
- Working in the field of occupational hygiene or one of its specialised branches; and
- To have worked at least for one year in a professional capacity, and
- Demonstrate to the council that a satisfactory level of professional competence has been achieved.

Do a science or engineering degree suitably cover the aspects of asbestos required to meet the requirements of competency under the Regulations? As the holder of an Engineering degree I cannot remember being taught about the hazards of asbestos, the risks associated with it or even any control measures to eliminate or reduce the risks associated with asbestos. So where can you learn this important information? Occupational hygiene qualifications cover the hazard and risks associated with asbestos in Australia today. These courses are provided to students from across Australia and the world so the legislative details may not truly reflect Victorian requirements. The AIOH provides asbestos related education seminars including the very popular asbestos in soil training. Registered training organisations provide Class B, Class A, supervisors and licenced assessor training courses. Australian organisations have also started providing the British asbestos surveying and sampling course. But where do you learn how to design and test a complicated bubble as this is one of the areas that the WorkSafe Victoria Removing Asbestos in Workplaces Compliance Code states that an independent competent person should provide guidance on. Do you learn this key skill at an AIOH conference? A review of AIOH conferences shows that only four asbestos related concurrents have been given in the last four years. This year there are four asbestos related concurrents, however when reviewing the abstracts only one may provide details on the bubbles built during the asbestos removal works.

The legislative requirement associated with asbestos are complex and varied. Part 4.4 – Asbestos is the largest part of the Regulations with 113 separate regulations, in comparison Part 5.2 – Major hazard facilities only has 42 separate regulations. One key competency that an occupational hygienist requires when working in the asbestos field is a clear understanding of these regulations as well as the overall requirements from the Act including the definition of reasonably practicable. There are many subtle differences between the states and territories' asbestos related legislative requirements and it is important that occupational hygienist working in Victoria understand the Victorian requirements.

As an occupational hygienist you must ask yourself if you have the competency to complete the required task. You maybe competent in regards to understanding and managing the risks associated with welding fumes or you may have a large amount of experience conducting asbestos audits in commercial buildings but do you then have the competency to oversee large and complex asbestos in soil removal jobs where clearances must be given whilst removalists screen the soil?

#### RESPONSIBILITY

Can you be held responsible for giving unprofessional advice? Yes you can. Section 23 and 24 of the Act relate to duty to others. Even if you have no employees Section 24 states that: A self-employed person must ensure, so far as is reasonably practicable, that persons (e.g. home owners, workers in the buildings, demolition workers, other contractors, the public) are not exposed to risks to their health or safety arising from the conduct of the undertaking of the self-employed person. This is an indictable offence with a penalty duty of 1800 penalty units which equates to \$297,396 in 2019 – 2020. Section 23 is the same except that it applies to employers detailing that a body corporate can be fined 900 penalty units or \$1,486,980 in 2019 – 2020 for breaching this duty. In regards to occupational hygienist and asbestos related works a breach of this duty could mean providing an insufficient asbestos register, providing a false clearance certificate or performing air monitoring in a manner that provides an incorrect result. The impact of these actions are more than the fine, and could result in persons being exposed to airborne asbestos fibres, subsequent significant cleanup costs, media attention and cease works. All of this leads to the brand of occupational hygienist being compromised.

#### REBRANDING

'Hygienists' are known in asbestos related work as the independent competent person who provide expert guidance and clearance certificates. There are key skills required to do this work which professional occupational hygienist have due to their ability to understand the hazards associated with the work, skills in risk assessing the potential outcome and the identification of controls to eliminate or minimise the risk. However, do occupational hygienists have the knowledge and experience required to conduct these tasks and how are they gained? Asbestos has historically been a hazard which occupational hygienist have predominantly been involved with however due to the magnitude of asbestos related activities being undertaken other persons are now providing guidance in this area. The way the profession sets itself apart is by taking ownership of our brand in this area and upskilling occupational hygienists in the key areas where guidance is sought.

Occupational hygienists need to ask themselves, is Asbestos the new Silica: a hazard that is well understood by the profession however, it is thought to be under control and maybe we are losing our competency in this area?

#### ACKNOWLEDGEMENT

WorkSafe Victoria's head office is based on the sacred land of the Traditional Owners, the Wadawurrung people.

I respect the history, culture and Elders of all Aboriginal and Torres Strait Islander People, both past, present and emerging.

#### REFERENCES

1. Occupational Health and Safety Act 2004 (Vic)
2. Occupational Health and Safety Regulations 2017 (Vic)
3. WorkSafe Victoria, Removing Asbestos in Workplaces, Compliance Code, Oct 2018
4. WorkSafe Victoria, Removing Asbestos in Workplaces, Compliance Code, Oct 2018

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COMPLIANCE FOR OCCUPATIONAL HYGIENE: WHSQ'S ENFORCEMENT CAMPAIGN OF THE STONE BENCHTOP  
FABRICATION INDUSTRY IN QLD

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*Carolyn Topping*

Acting Director Occupational Health and Hygiene Unit | Office of Industrial Relations Workplace Health and  
Safety Queensland

**BIO**

Carolyn Topping is the Acting Director of the Occupational Health and Hygiene Unit within Workplace Health and Safety Queensland. She is a workplace health and safety inspector, full member of the Australian Institute of Occupational Hygienists and a Certified Occupational Hygienist. Carolyn has worked for Queensland government safety regulators for twenty years including the Office of Industrial Relations and Department of Natural Resources and Mines. Her team is leading significant interventions in occupational exposure to respirable crystalline silica in Queensland.

**ABSTRACT**

The emergence of cases of accelerated silicosis in Queensland workers from exposure to respirable crystalline silica during the fabrication of stone benchtops prompted an industrywide audit campaign during 2018. A team of workplace health and safety inspectors and occupational hygienists worked together to carry out 138 compliance audits within a 4-month period. This was the largest occupational health compliance focussed campaign in Queensland since the introduction of the Work Health and Safety Act 2011 and resulted in over 600 statutory notices being issued.

The audits identified significant health and safety issues across the industry, and highlighted an immature understanding of health risks posed by respirable crystalline silica by both businesses and workers. This presentation will provide information about the methods used, current regulatory compliance requirements, findings and lessons for other industries.

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BASIC OCCUPATIONAL HYGIENE SERVICES FOR SMALL ENTERPRISES

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*Mahinda Seneviratne*

Chair, Scientific Committee on Occupational Health in Small Scale Enterprises and the Informal Sector  
| International Commission on Occupational Health (ICOH)

**BIO**

Mahinda Seneviratne is a certified occupational hygienist with over 25 years' experience as an occupational health professional involving research, teaching, consulting, regulatory enforcement and policy development. Mahinda is currently chair of the International Commission on Occupational Health (ICOH)'s scientific committee on improving occupational health among workers in small enterprises and informal sectors. He has facilitated several multi-disciplinary workshops to deliver basic occupational health services in Asia and Africa.

**ABSTRACT**

Occupational Hygiene is a powerful tool in preventing work-related illness & disease but only a minority of workplaces have access to this critical occupational health service. Most workplaces in Australia and in many other regional economies are micro or small to medium sized enterprises (MSMEs) with less than 30 workers. MSMEs are known to have greater exposure to workplace hazards and subsequent risk of illness to its workers but have little or no access to the resources required to identify and address them.

Delivering Basic Occupational Health Services (BOHS) such as occupational hygiene assessments & advice to control hazardous exposures and health monitoring for early detection and prevention of illness & disease are a global priority for ICOH which is taking some practical steps to address this challenge.

One of ICOH's scientific committees SCOHSEIS\* has focussed on two approaches: (a) building capability among OH professionals and social partners to deliver basic occupational hygiene skills & knowledge to MSMEs and (b) engaging with medical practitioners to improve occupational health monitoring of vulnerable workers.

This will be an interactive session involving the "power of many disciplines" and participants. It aims to explore some of the unseen barriers as well as unexplored opportunities, including using novel tools, in providing basic occupational hygiene practice to protect workers in MSMEs. Is this a very timely climate for the occupational hygiene profession to ReCalibrate its coverage of service delivery? To ReSynergise its engagement with fellow occupational health practitioners for a more wholistic approach to workers' health? Can we ReBrand the profession as an accessible and equitable community to serve a larger sector of the workforce?

\* Scientific Committee on Occupational Health in Small Scale Enterprises and the Informal Sectors (SCOHSEIS)

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## HARNESSING THE POWER OF MANY

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*Dr Steve Dix*

Director of Learning and Teaching, School of Marketing | Faculty of Business and Law, Curtin University

### BIO

The golden thread that connects Steve's career is his passion as practitioner and mentor in brand building, digital marketing and advertising. Steve's experience spans across borders. He established and developed brand value at Global School of Business in South Africa, led the re-branding of market leader David Forman Ltd in New Zealand and has informed brand management campaigns in Australia.

Steve is Director of Learning and Teaching in the School of Marketing at Curtin University. Moreover, he consults to SME's and is engaged across several entrepreneurial ventures in industry. Steve's sweet spot is where creative, rigour and passion converge. He is hard-wired to think more deeply than his competition, work smarter than his peers and engage better with his audiences. Tortured soul?

### ABSTRACT

An insightful exploration into the underbelly of the brand. In this highly visual presentation, Steve sets out to share how the world outside of the AIOH sees the world inside. What can we learn from the great brand stories of the past to leverage the lessons of branding for our discipline?

Find out why AIOH faces an 'interesting' re-branding challenge. What path might we go down in our quest to build brand image and profile around Occupational Hygiene? Explore what you can do to bring the power of many to the new brand story for AIOH.

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## CONTROLLING EXPOSURE TO RESPIRABLE CRYSTALLINE SILICA IN SYDNEY DEMOLITION WORKERS: A CLIENT-LED INTERVENTION

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*Kate Cole*

MAIOH Certified Occupational Hygienist (COH)<sup>®</sup> & Michael Fisher, Occupational Hygienist | Sydney Metro

**Abstract:** Sydney Metro is Australia's biggest public transport project and has served a unique opportunity to leave not only a world class transportation system, but also a legacy for future generations. A strategic element of our legacy is the development of a client-led system to enable us to positively influence better outcomes for worker health protection.

Demolition is one of the many activities required to deliver Sydney Metro. Demolition can produce respirable crystalline silica (RCS) as numerous building materials such as concrete and tiles contain quartz. Given Sydney Metro's contractors are demolishing more than 65 buildings to make way for a new world-class transport system, demolition workers may be exposed to RCS at quantities that could result in occupational lung disease if not adequately controlled. Expectedly, RCS exposure was identified as one of the highest health risks for demolition activities during the planning stage.

Sydney Metro instilled specific contractual requirements with regards to the management of health during demolition activities across multiple Principal Contractors (PCs). These included the need to engage a Certified Occupational Hygienist (COH)<sup>®</sup>, perform health risk assessments, exposure control planning, health monitoring, exposure monitoring, ongoing verification and incident reporting. Over a two-year period to June 2019, six PCs engaged numerous COHs to meet these requirements which resulted in the collection of 313 personal exposure samples for RCS from workers performing demolition activities.

Statistical evaluation of exposure data demonstrated that demolition workers with the highest measured exposures, including those with a 95% Upper Confidence Limit (UCL) above their respective shift-adjusted Workplace Exposure Standard (WES) were demolition labourers performing activities involving strip out and the dismantlement of scaffolding, in addition to heavy plant operators in machinery without an enclosed cabin performing structural demolition activities. The 95% UCL was above Safe Work Australia's proposed draft WES of 0.02 mg/m<sup>3</sup> when shift-adjusted, for all remaining assessed similar exposed groups with the exception of workers erecting scaffolding.

In many cases, the Sydney Metro project was the first time that demolition contractors had engaged a COH, put specific control measures in place to control RCS exposure, and had completed health monitoring for crystalline silica for their workforce. Over time, there were many examples of positive work practices being applied to protect the health of demolition workers. Opportunities to improve the control of RCS exposure were identified to include the need for more widespread use of misting dust suppression and dust extraction, and greater management of fit testing and clean shaven requirements when using respiratory protection.

In contrast to other industry sectors where high-quartz containing materials are encountered such as kitchen benchtop manufacture and tunnel construction, the proportion of quartz in exposure samples collected was relatively low (an average of 7%). The level of exposures to RCS recorded however demonstrates that RCS presents a significant risk to health for demolition workers.

While the level of awareness of the extent and magnitude of RCS exposures in this industry is improving; it is evident that further intervention to address the level of RCS exposure to those servicing the demolition sector would benefit this industry. This may be addressed, at least in part, through the inclusion of this risk and associated practical control measures in a revised edition of the existing Code of Practice for Demolition Work (1), which currently does not include the risk of RCS exposure.

### 1. BACKGROUND

In broad terms, "*demolition*" is defined as the demolition or dismantlement of "*structure or part of a structure that is load-bearing or otherwise related to the physical integrity of the structure...*" with some exceptions. It is considered to be "*high risk construction work*" and is regulated under the NSW Work Health and Safety Act 2011 and associated regulation and supported through a Code of Practice for Demolition Work (1). Among the many safety risks listed in the Code, such as the risk of falls, contact with electricity and the risk of dropped



objects, the health risks of performing demolition work are stated to include exposure to asbestos, lead, polychlorinated biphenyls (PCBs) and synthetic mineral fibres.

The risk of occupational exposure to RCS in demolition workers has been investigated in several studies globally including those in Finland (2), The Netherlands (3), Tehran (4) and the USA (5) (6). Such studies have repeatedly demonstrated that workers are exposed to RCS at levels above the current Australian Workplace Exposure Standard (WES) of 0.1 mg/m<sup>3</sup> as an 8-hour time weighted average (TWA). Closer to home however, there is a paucity of readily available scientific literature or documentation on the extent or risk of RCS exposures to demolition workers in Australia, including this cohort not being identified in the Australian Work Exposures Study (7) and the risk of RCS exposure being omitted in the Code of Practice (1). Notwithstanding, numerous guides have identified that demolition workers may be at risk of RCS exposure including those documented by SafeWork NSW (8) and the Cancer Council (9).

In 2016, SafeWork NSW published a Work Health and Safety Roadmap (Roadmap), which included a strategy to enable a continued decline in fatalities, serious injuries and illnesses with a specific focus on key priority areas (10). The Roadmap committed to work with all NSW Government departments to support work health and safety initiatives. It committed to work to identify and reduce workplace exposures to hazardous chemicals through the implementation of the *hazardous chemical and materials exposures baseline and reduction strategy* with a specific focus on RCS (11). The strategy included numerous measures of success, one of which was a, “*reduction in number of workplaces with non-compliant (unacceptable) exposures to crystalline silica*”.

In 2018, SafeWork NSW published the *Building and Construction Work Health and Safety Sector Plan to 2022* (12). The goals of the plan were an improvement in respiratory health; supporting, protecting and intervening where workers are at greatest risk; a marked decrease in serious injuries and illnesses; and identifying and targeting high-risk workplaces for proactive compliance and interventions. RCS was identified in that plan as a priority health harm in the demolition industry.

In 2018 Safe Work Australia (SWA) announced that they would undertake an evaluation of the WES (13) with RCS selected as the first chemical under review. The draft evaluation report from SWA released for public consultation recommended a WES of 0.02 mg/m<sup>3</sup> as a TWA (14). At the time of writing this paper, the WES had not been finalised. Notwithstanding, this paper provides context to the impact and relevance of a lower exposure standard on the demolition sector.

## **2. AIM OF A CLIENT-LED OCCUPATIONAL HEALTH STRATEGY**

Sydney Metro activities significantly depend on contracting companies, of various sizes, to conduct a wide variety of works, the majority of which are carried out in and around high-risk work environments. Historically, approaches for managing contractor occupational health performance has focused effort and resources on monitoring and controlling health and safety activities after contracts are awarded. While such has contributed to minor improvements in contractor performance, such approaches typically result in significant effort being focused towards reacting to incidences and non-conformances. These reasons prompted Sydney Metro to take a proactive approach to better manage occupational health risks.

Demolition activities commonly produce RCS as numerous building materials such as masonry, bricks and tiles contain quartz. Demolition activities such as breaking up, dismantling, cutting, hammering, and transferring materials, sweeping and loading out can result in exposures to RCS above the WES if they are not adequately controlled. Breathing in RCS can cause incurable diseases such as silicosis and lung cancer (15). As part of the delivery of Sydney Metro, more than 65 buildings needed to be demolished to make way for a new world-class transport system. Exposure to RCS was identified early on in the planning phase by Sydney Metro as a significant health risk that would require control during demolition. Because of this, an occupational health strategy was prioritised and implemented by Sydney Metro, as the government client organisation, to address this issue.

In 2016, Sydney Metro launched a Health and Safety Strategic Plan which included a specific occupational health initiative to ensure effort applied to health risk management was equivalent to that of safety. The strategy was developed through a review of successful contractor-led initiatives across Sydney Metro which

included those applied in other high-risk industries such as tunnel construction (16), in addition to a review of best practice and health and safety performance on an international scale (17).

The collation of local and international best practice was applied to the development of the construction industry's first Occupational Health, Hygiene & Wellbeing (OHHW) Standard which was applied to systematically identify and control health risks through standardised methods of health risk assessment, control verification and ongoing review (18). The Standard established clear systems of work and minimum performance requirements that afforded Sydney Metro governance and understanding of occupational health risks across all project programs. The Standard was embedded in Sydney Metro tender evaluations with relevant elements included in the *Sydney Metro Principal Contractor Health and Safety Standard* (19) which formed the conditions of all contracts, including demolition works. The key elements of the standard included minimum competency requirements, a transparent and standardised approach to health risk assessment, health risk control, health monitoring, and routine review processes (20).

One aim of the client-led occupational health strategy was to be able to positively influence the control of occupational exposure to RCS in high risk areas such as demolition, in addition to creating a body of knowledge to assist in the management of RCS exposure for future projects.

### 3. METHOD

*Under the Sydney Metro Principal Contractor Health and Safety Standard, each PC was required to engage their own Certified Occupational Hygienist (COH)<sup>®</sup> who provided governance of the PC's OHHW program. This included undertaking health risk assessments (HRAs), occupational exposure assessments, the development of control plans, and undertaking regular review for example.*

*This paper includes information collected independently by or for COHs working on the Sydney Metro program and includes information from health risk assessments, exposure monitoring, and information on the control measures used across major demolition sites on the Sydney Metro project. Information has been de-identified from the PC, COH, occupational hygiene consultancy and analytical laboratory for the purposes of this paper.*

#### 3.1 Sampling and Analysis Method

COHs reported that the sampling and analysis of respirable dust and RCS was performed in accordance with Australian Standard 2985 "Workplace atmospheres - Method for sampling and gravimetric determination of respirable dust" (21). Samples were analysed for respirable dust and respirable quartz by four (4) different NATA accredited laboratories, with  $\alpha$ -quartz determination performed through Fourier Transform Infrared (FTIR) spectroscopy or X-ray diffraction (XRD).

The WES of  $0.1\text{mg}/\text{m}^3$  was used to determine exposure acceptability by each COH. In all cases exposure acceptability was determined without regard for the protection afforded by the use of personal protective equipment (PPE), if utilised. The TWA-WES was adjusted to account for extended work shifts as per guidance published by the Australian Institute of Occupational Hygienists (AIOH) (22). The requirements for exposure acceptability were determined by each COH and included:

- Individual exposures to be below an "action limit" which was 50 per cent of the WES ; and/or
- Where the 95% upper confidence limit (UCL) of the minimum variance unbiased estimate (MVUE) of a Similar Exposed Group (SEG)'s exposure was below the TWA-WES.

#### 3.2 Statistical Methods

RCS exposure data obtained from each COH were grouped into over-arching SEGs and statistically assessed. The unbiased arithmetic mean (AM) and the MVUE were the statistical parameters selected and applied to reliably estimate the SEGs average exposure and confidently predict the upper exposure magnitude.

Data sets were established to represent personal exposure sample results for each SEG. Statistical analysis was then performed in accordance with the following process on each data set to determine each SEG's exposure profile, including mean values and the upper and lower confidence limits around the mean:

1. Determining if the data set comprised a minimum number of samples to perform statistical analysis;
2. Determining the sample distribution (normal or lognormal);
3. Treatment of non-detects using regression on order statistic (via the tool NDEspo)
4. Calculating the AM as the MVUE as appropriate dependant on distribution;

5. Calculating the geometric standard deviation (GSD) as the measure of data set variability;
6. Calculating confidence intervals, as represented by the upper and lower 95% confidence limits.

The above process was performed for the following purposes:

1. To review each SEGs exposure profile and ensure correct SEG definition;
2. To compare similarities between SEG exposure profiles and determine the suitability of merging SEG's when assessing exposures at future projects;
3. To evaluate the significance of exposure variability between SEG's performing similar or the same activities at different project sites;
4. To assess exposure compliance by comparing the mean exposure to the WES; and
5. To evaluate exposure variability observed within each data set to ensure exposure acceptability with 95% confidence.

The distribution of each SEG's exposure data were reviewed for goodness of fit and therefore dictated the selection of descriptive statistical parameters to be used when determining exposure acceptability. Exposure acceptability was determined by comparing the one-sided 95% UCL against the relevant time (shift) adjusted TWA-WES. Table 1 contains details on the method for selection of statistical parameters.

**Table 1. Statistical Parameter Selection**

Distribution of Data	Statistical Parameter used to Determining Exposure Acceptability
Lognormal distribution; or Both a lognormal and normal distribution	Estimated AM exposure as the MVUE; and Compare the upper confidence limit (UCL) <sub>1,95%</sub> Land's "Exact" with WES;
Normal distribution	Mean exposure; and Compare UCL <sub>1,95%</sub> (t statistics) with WES
Neither lognormal or normal distribution	Check if true SEG; Mean exposure; and Compare UCL <sub>1,95%</sub> (t statistics) with WES in the interim of collecting more data

#### 4. RESULTS

Between June 2017 and June 2019, six (6) PCs were engaged to perform demolition activities across Sydney Metro. Five (5) COH's collectively produced health risk assessments prior to commencing demolition activities and undertook or oversaw the implementation of 40 rounds of exposure assessment. This resulted in a total of 313 personal exposure samples for RCS being collected from workers performing demolition activities.

For demolition contractors, the Sydney Metro project has been the first time they have engaged such a specialist to assess RCS exposure.

##### 4.1 Establishment of Similar Exposed Groups (SEGs)

*The demolition process involves various phases, most of which are sequenced in a defined order of events or activities, while others occur simultaneously throughout the building. Based on the particular phase of work at the site, work activities, equipment and workers required on site can be variable however over-arching phases were apparent which included:*

1. *Enabling work: set-up and preparation of the site for demolition works. Such includes scaffold installation, engineering inspections, progressive isolation of services, set-up of site office and amenities, the preparation of the "drop zone" and the load out area for removal of demolition materials.*
2. *Soft demolition: removal of internal components from the building including internal walls, furniture, toilets, carpet, ceilings and insulation.*
3. *Hazardous materials removal: removal of asbestos containing materials, lead based paint, PCBs etc.*
4. *Structural demolition: heavy machinery used to systematically break up structures and building fabric for removal from the site with labourers acting as spotters to support these activities.*
5. *Material load out: Removal of demolition materials from the load out area.*

Each COH categorised workers into SEGs using similar processes. The SEGs developed were not identical in each case with subtle differences apparent dependant on the work scope and level of detail available at the time of performing the HRA. Table 2 lists the overarching SEGs identified to be performing demolition activities.

**Table 2. Similar Exposed Groups in Demolition**

SEG Name	SEG Broad Description
Scaffolding erection	Workers involved in erecting scaffolding prior to demolition works
Scaffolding dismantlement	Workers involved in dismantlement of scaffolding which is undertaken at the same time as demolition activities
HazMat removal	Workers involved in removal of hazardous building materials (e.g. asbestos / lead)
Stripout	Workers involved in removal of non-hazardous building materials (e.g. materials other than asbestos and/or lead)
Services	Trades connecting / disconnecting services (water / electricity etc.) as required for each level prior to demolition
Structural demolition	Workers on foot and operating heavy plant such as excavators and bobcats etc. Further divided into the following sub-SEGs: 1-Spotters (labour) 2-Heavy plant operators (HPO) within a machine fitted with an enclosed cabin 3-HPO within a machine fitted with an open cabin 4-Cutting and drilling to create access to levels below (labour) 5-HPO performing load out activities
Crane operators	Divided into two sub-SEGs as: 1 –Workers directing crane at loading and receiving points for crane operations; and 2 – Worker within tower operating crane
General labourers	Workers performing various duties and tasks throughout the day. Further divided into the following sub-SEGs: 1-General duties 2-Traffic control 3-Cleaning 4-Installing, maintaining, and decommissioning propping and overhead protection support
Supervisor and support workers	Site supervisor, engineers, support staff.

#### **4.2 Anticipated level of risk of exposure to RCS**

HRAs performed by each COH prior to the demolition contractor commencing work, identified select SEGs that may be at a significant risk to health from exposure to RCS. The following SEGs were subsequently prioritised for exposure assessment:

- Scaffolding dismantlement
- Stripout
- Structural demolition
- General labourers
- Supervisor and support workers

#### **4.3 Controlling exposure to RCS during demolition**

Exposure Control Plans (ECPs) were prioritised and produced by COHs for SEGs that were assessed to be at significant risk to health. ECPs documented how exposures to RCS would be controlled by the PC in the order of the hierarchy of control (HOC) so far as reasonably practicable. Table 3 provides a summary of those control measures listed in ECPs that were generally common across all demolition sites.

Some of those control measures were deemed to be crucial to prevent or minimise exposure, and in which case they were identified as critical control measures. Those control measures were reviewed by occupational hygienists as part of performing exposure assessments on each demolition site on a monthly basis through what was termed a “critical control audit”. In addition, those critical control measures were also included in surveillance activities performed by Sydney Metro.

**Table 3. RCS Exposure Control Measures**

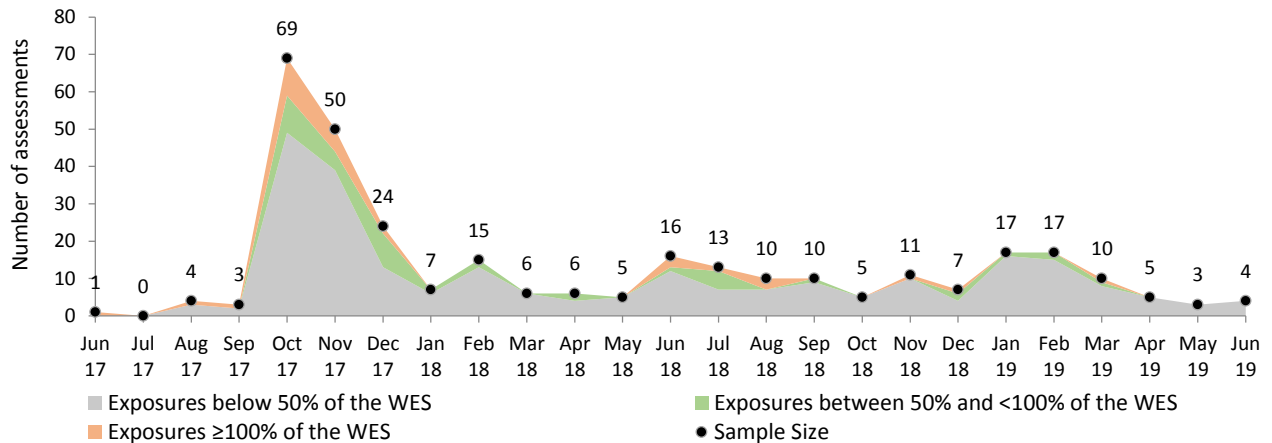
Control Hierarchy	Control Measure
Substitution	Demolition methodology is designed to not use hydraulic breaking equipment on the façade
Substitution	Large self-supporting saws will be used where practicable to minimise the use of hand-held cutting saws
Engineering	Misting type water sprays to be placed within the loadout area to control dust emitted from the drop zone, mobile plant/heavy vehicle movement and the loading of trucks
Engineering	All concrete/masonry cutting or coring equipment used onsite to be fitted with dust extraction and/or dust suppression systems; where dust extraction systems are used, a 99% efficiency rating is to be achieved for dust emitted with a particle size less than 10 micrometres
Engineering	Provide adequate ventilation. e.g. work areas on live floors to have increased ventilation through exposed areas where panels and ceiling have been removed
Engineering	Only wet cutting to be used if cutting is required
Engineering	Misting dust suppression to be used through machinery, rather than workers manually applying dust suppression (e.g. no spotters on hoses)
Engineering	Use covered chutes and skips where needed and screen off areas to prevent dust spreading
Engineering	Dry brush or broom sweeping is prohibited; wet methods to be used for cleaning; spray down dusts prior to sweeping; use HEPA vacuum where practicable
Administration	No mobile plant air conditioning filters are to be cleaned and or dusted down using compressed-air onsite
Administration	All vehicle trafficable areas are regularly wetted down with water and load out areas are to be cleaned using a vacuum truck or hosed into a wedge pit (or equivalent) for later removal as waste
Administration	Training and awareness of RCS and the control measures required, including the correct use of respiratory protection
Administration	All workers who are required to wear respiratory protection are to be clean shaven, facial fit tested, and trained in the use of respiratory protection
Administration	Powered tools will be inspected daily prior to use to ensure dust controls are operational. A formal maintenance inspection will be performed for all items of equipment in accordance with the manufacturer's requirements
Administration	Exclusion areas will be set up around any live structural demolition activities, with areas to be enclosed by sheeting and screening to control the spread of dust where practicable
Administration	Heavy plant cabin doors and windows should be closed at all times when demolition is in progress or in operation
Administration	No smoking policy while onsite
Administration	Crystalline silica baseline health monitoring to be performed for SEGs assessed to be at significant risk to health due to exposure to RCS
Administration	All levels of supervision and management, by personal example and principle, shall enforce the use of respiratory protection.
PPE	Workers who are conducting activities that generates dust or where otherwise signposted, must wear Class P1 (as minimum) respiratory protection

#### 4.4 Exposure Assessment Results

Exposure assessment occurred over 11 major demolition sites. Reports from COHs included details of exposure scenarios to various SEGs, commentary on the control measures implemented, and an audit of the implementation of numerous control measures that were deemed to be critical to the prevention of exposure to RCS.

Individual exposure monitoring results were classified into one of three categories which were: equal or above the TWA-WES; equal or above 50% of the TWA-WES; or below 50% of the TWA-WES. Figure 1 provides a summary of exposure monitoring results received.

In circumstances where individual personal exposure measurements were recorded to be above the shift-adjusted TWA-WES, and exposure was not controlled, PCs were required to report this to Sydney Metro as a significant health and safety incident. Once an incident was raised, an investigation was required to be undertaken by the PC to prevent future occurrences. Sydney Metro was the first NSW government agency to have included the reporting of RCS exposure in the health and safety incident framework within the infrastructure sector. These requirements subsequently resulted in an improved focus on controlling RCS exposure.



**Figure 1. Results of RCS occupational exposure assessment – demolition workers**

It is important to note that a conservative approach was taken when determining if exposure was controlled. For example, an exposure to RCS was only deemed to be controlled if:

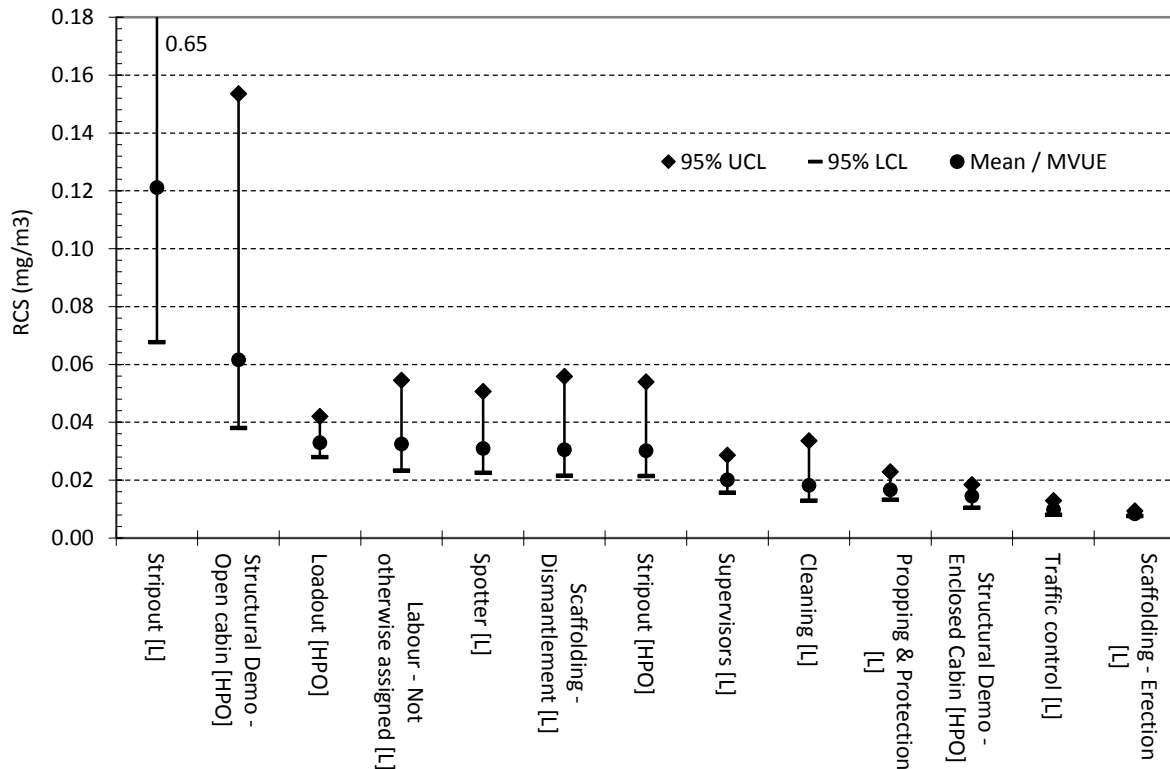
- An appropriate level of respiratory protection was utilised during the exposure period;
- The worker had been fit tested for the make and model of respirator used; and
- The worker was clean shaven where the respiratory protection relied on facial fit to be effective.

To understand the exposure profile of each SEG, statistical analysis was performed on exposure data with the results summarised in Figure 2 and provided in Table 4. It is noted that the shift-adjusted WES nominated for each SEG were not consistent from each report, due to the varying shift-times worked across different demolition sites, with the shift-adjusted WES ranging from 0.05 mg/m<sup>3</sup> to 0.07 mg/m<sup>3</sup>. To provide context for the presented results, the mean shift-adjusted WES was calculated for each SEG and has been included in Table 4.

**Table 4. RCS Exposure Results<sup>1</sup>**

Main SEG	Sub-SEG	Type	No. of Samples	No. ≥ WES	Log-normal	MVUE / AM	95% LCL	95% UCL	GSD	Shift-adjusted WES
Scaffolders	Erection	L	5	-	Yes	0.01	0.01	0.01	1.1	0.05
	Dismantlement	L	11	2	Yes	0.03	0.02	0.06	2.1	0.05
Stripout	Labour	L	7	4	Yes	0.12	0.07	0.65	2.8	0.07
	HPO	HPO	12	1	Yes	0.03	0.02	0.05	2.1	0.07
Structural Demolition	HPO – Closed Cabin	HPO	43	2	No	0.01	0.01	0.02	2.1	0.07
	HPO – Open Cabin	HPO	28	5	Yes	0.06	0.04	0.15	4.3	0.06
	HPO – Load Out	HPO	59	7	Yes	0.03	0.03	0.04	2.2	0.06
	Spotter	L	34	1	Yes	0.03	0.02	0.05	3.0	0.06
General labourers	Cleaning	L	8	-	Yes	0.02	0.01	0.03	1.8	0.05
	Propping & protection	L	39	1	Yes	0.02	0.01	0.02	2.4	0.06
	Traffic control	L	16	-	Yes	0.01	0.01	0.01	1.7	0.06
	General (not otherwise assigned)	L	45	6	Yes	0.03	0.02	0.05	3.5	0.07
Supervisors	Supervisor and support workers	L	11	-	Yes	0.02	0.02	0.03	1.7	0.06

<sup>1</sup> GSD: Geometric Standard Deviation, HPO: Heavy Plant Operator, L: Labourer, LCL Lower Confidence Limit, MVUE: Minimum Variance Unbiased Estimate, No: Number, UCL: Upper Confidence Limit



**Figure 2. Occupational exposure assessment statistical analysis**

In some cases there was a high degree of variability displayed in the data set, which generally related to the varied degree of working environments of each SEG. For example, heavy plant operators in an open cabin were working in environments that were both generally open to the surrounding air (if on the top deck of a building) and also working within relatively enclosed areas (if within the building).

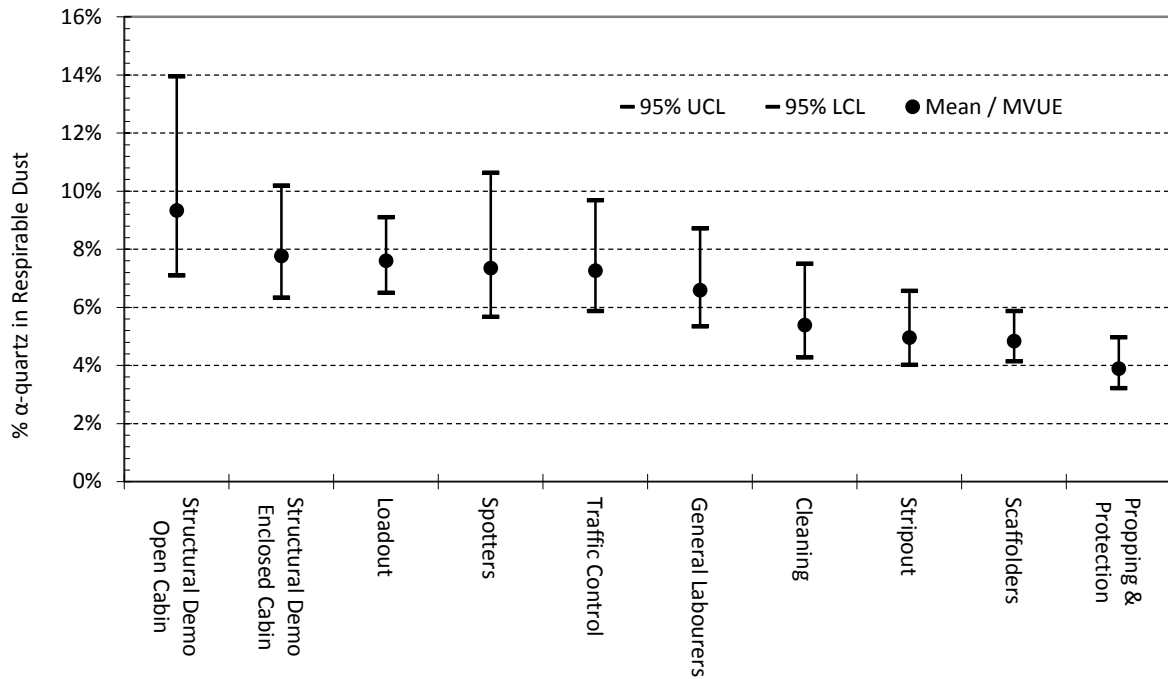
It was not possible to determine whether heavy plant operators performing load out activities were situated in heavy plant fitted with an enclosed cabin or an open cabin in all cases. Therefore all exposure data for load out activities were subsequently grouped together with statistics calculated from the personal exposure data over the entire SEG.

SEGs with the highest measured exposures, including those with the 95% UCL above their respective shift-adjusted WES were demolition labourers performing activities involving strip out and the dismantlement of scaffolding. The only group of heavy plant operators with exposures above the 95% UCL were those with open cabins performing structural demolition.

Workers operating heavy plant as part of stripout and load out activities, in addition to supervisors and demolition labourers performing spotting, cleaning or other activities are targets for further exposure control as the 95% UCL was calculated for each of these SEGs to be at or above the action limit, set at half the value of the current TWA-WES.

The 95% UCL was above SWA's proposed draft TWA-WES of 0.02 mg/m<sup>3</sup> when shift-adjusted, for all remaining SEGs assessed with the exception of scaffolding erection. This includes workers performing structural demolition within enclosed cabins, undertaking propping and protection activities, and traffic control.

The average proportion of  $\alpha$ -quartz reported in the respirable dust samples was calculated to be 7%. Figure 3 provides a summary of statistical analysis of the percentage of  $\alpha$ -quartz measured across each SEG to demonstrate the relative consistency.



**Figure 3. Percentage of alpha-quartz reported in respirable dust samples**

#### 4.5 Implementation of Control Measures

The process of identifying and documenting control measures to prevent or mitigate RCS exposure to workers was a relatively straightforward task for each PC. Challenges were experienced at the commencement of demolition activities in the implementation of some control measures, largely due to the level of awareness of the risk of RCS exposure. Improvements were observed to be made as each project progressed, largely due to the result of reviewing exposure assessment results, incident investigation, intervention by the COH and/or intervention by Sydney Metro.

Examples of positive work practices observed included the use of HEPA vacuums to remove settled dust rather than the use of brooms for dry sweeping, the use of misting systems at the base of drop zones to keep demolition debris wet, and the use of water to dampen materials immediately prior to demolition.

Areas that were observed to be challenging for PCs to consistently implement included the use of mobile or fixed misting dust suppression on live demolition decks, dust extraction on hand-held tools, respirator fit testing for all workers who were required to utilise close face fitting respiratory protection, and continued application of the PC's clean shaven policy.

Where RCS exposure was assessed to be a significant risk, health monitoring for crystalline silica was required to be undertaken. It is noted that the Sydney Metro project was the first time that many demolition workers had undertaken health monitoring for crystalline silica, and many were largely unaware of the level of risk posed by the work activities to be conducted.

### 5. CONCLUSION AND RECOMMENDATIONS

Sydney Metro recognises the important issue of preventing work related illnesses and diseases for the thousands of workers who will contribute to the successful delivery of our world-class infrastructure. The client-led occupational health strategy aimed to positively influence the control of occupational exposure to RCS in demolition workers, in addition to creating a body of knowledge to assist in the management of RCS exposure for future projects.

Traditionally, the focus in the demolition industry has been towards safety due to the immediate impact of injuries or fatalities, rather than a focus on issues such as ill health, which may take years to manifest. Sydney



Metro worked to proactively balance this focus through the creation of a new OHHW Standard, which contained specific contractual requirements pertaining to health.

The OHHW Standard has been in place since early 2017. Since that time, each major PC on the Sydney Metro project has engaged the services of a COH. The COH works to assess the risk to health of their workforce, works with the PC to develop suitable methods to control the risk; and then reviews the effectiveness of those methods using a risk-based approach. For demolition contractors, the Sydney Metro project has been the first time they have engaged such a specialist to address RCS exposure.

In comparison to other industry sectors where high-quartz containing materials are encountered such as kitchen benchtop manufacture and tunnel construction, the general level of awareness of the magnitude of the risk of RCS exposure in the demolition sector is low. This may be due, in part, that the proportion of quartz in products encountered during demolition by comparison to those sectors is also relatively low. This was further confirmed through an analysis of the proportion of quartz in exposure samples being on average 7%. Notwithstanding, the level of exposures to RCS recorded demonstrates that RCS presents a significant risk to health for demolition workers.

SEGs with the highest measured exposures, including those with the 95% UCL above their respective shift-adjusted WES were demolition labourers performing activities involving strip out and the dismantlement of scaffolding in addition to heavy plant operators with open cabins performing structural demolition.

In many cases, the Sydney Metro project was the first time that demolition contractors had put specific control measures in place to protect workers from exposure to RCS and had completed health monitoring for crystalline silica for their workforce. Over time, there were many examples of positive work practices being applied to protect the health of demolition workers. Notwithstanding, there remains opportunities to improve the control of RCS exposure including the need for more widespread use of misting dust suppression and dust extraction and greater management of fit testing and clean shaven requirements for the use of respiratory protection.

It is noted that should the WES be reduced to the value proposed in Safe Work Australia's draft, that other SEGs involved in demolition activities such as propping and protection, cleaning, and traffic control, would be impacted, as the 95% UCL was calculated to be above the respective shift-adjusted TWA-WES. Additional control measures to reduce exposure will be needed for such occupations.

While the level of awareness of the extent and magnitude of RCS exposures in this industry is improving; it is evident that further intervention to address the level of RCS exposure to those servicing the demolition sector would benefit this industry.

It is noted that limited information is currently readily available to assist demolition contractors, health and safety professionals, or occupational hygienists in the anticipation recognition, evaluation and control of occupational exposures to RCS in the demolition industry. This may be addressed, at least in part, through the inclusion of this risk and associated practical control measures in a revised edition of the existing Code of Practice for Demolition Work (1), which currently does not include the risk of RCS exposure. It is recommended that the risk of RCS exposure be included in future revisions of the Code by health and safety regulatory authorities along with relevant practical control measures and requirements for health monitoring.

Further awareness raising activities are needed to share information on the extent of RCS exposure to PCs and workers in the demolition sector. It is recommended that industry and awareness forums on RCS include demolition activities and be extended to those servicing the demolition sector.

## 6. LIMITATIONS

*Sydney Metro did not directly collect the information presented within this report. All data referenced in this paper were collected by numerous and different occupational hygiene consultancies, each working under the governance of a COH engaged by a PC. While each occupational hygiene consultancy utilised sampling and analysis methods in accordance with AS2985, it is appreciated that there is a level of inherent variability expected within that method.*

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PARALLEL PARTICLE IMPACTOR: A NEW SAMPLER FOR ACCURATE FRACTIONING OF RESPIRABLE DUST AT A CHOICE OF FLOWRATES

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SKC Inc.

**Abstract:** Respirable dusts including silica are high priority issues for occupational hygienists in both the U.S. and Australia. Both countries have seen a worrisome increase in lung disease in industries such as stonecutting and mining. In response, U.S. OSHA lowered the permissible exposure limit for respirable crystalline silica (RCS) to 50 ug/m<sup>3</sup> in 2016. Similarly, there have been proposals by the Australian National Standards to substantially lower the allowable levels for respirable coal dust and RCS to align with health-based limits. Cyclones have been the long-standing sampler for respirable dusts and the flowrates for traditional models have been modified through the years to better approximate the performance criteria specified in pertinent standards. A new impaction-based sampler called the Parallel Particle Impactor (PPI) was developed to precisely match the current ISO 7708 criteria (ISO/CEN convention) at flows of 2, 4, or 8 L/min. Test results indicate the PPI closely follows the ISO/CEN convention and samplers continue to perform as designed even after prolonged exposure to coal mine dust. The higher flow options also enhance the limit of detection. Reusable models are available in aluminum and single-use models are available in anti-static plastic. The PPI personal impactors are described in the U.S. silica rule as meeting the ISO/CEN convention and are very widely used as an alternative to cyclones.

## 1. INTRODUCTION

Pneumoconiosis is one of the oldest recognized occupational diseases, but many workers worldwide are still suffering and dying from some form of this disease today. A 2018 press release by NIOSH noted that one in ten underground coal miners in the U.S. who worked in mining for at least 25 years have black lung disease. See <https://www.cdc.gov/niosh/updates/upd-07-20-18.html>. Also, a whole new generation of workers is being exposed to silica in the manufacture of countertops made of artificial stone which may contain up to 90% silica. (1)

The good news is that today as throughout history, the occupational hygiene profession and standard-setting bodies remain committed to advancing our science to better protect workers. A prime example is the development of sampling criteria for particulate matter in the workplace based on health-related particulate size fractions. Ultimately, such criteria allow hygienists to measure the true health-related dose and leads to the development of health-based standards. The criteria also provide a target specification for size-selective sampler development and comparison.

Historically, the concept of particle size selection based on aerodynamic diameter of particles began in the 1950's. In 1952, the British Medical Council (BMRC) developed a particle size selection curve for respirable dust with a 50% cut-point of 5 um. (2) In the 1960's, the Atomic Energy Commission (AEC) in the U.S. and ACGIH each developed alternative curves each with a 50% cut-point of 3.5 um. Beginning in the 1980s, discussions were led by ISO and ACGIH to define new size fractions which ultimately led to the development of the ISO/CEN convention. The particle size selection curve for respirable dust specified in this convention has a 50% cut-point of 4 um.

Through the years, various models of respirable dust cyclones were developed and used at specified flowrates to meet size-selective sampling criteria in effect at that time. In the late 1960's, the first version of the Higgins-Dewell cyclone sampler was developed in the UK to meet the BMRC size selection curve for respirable dust at 1.9 L/min. Later, a modified version called the SIMPEDS was developed for coal mines. The SKC aluminum cyclone and the SKC plastic cyclone were also originally developed to meet the BMRC curve at a flowrate of 1.9 L/min. During this same time period, the nylon Dorr-Oliver cyclone was developed in the U.S. to meet the AEC and ACGIH criteria at 1.7 L/min.

Each of these respirable dust cyclones was developed prior to the ISO/CEN respirable convention that has now been adopted globally by most occupational hygiene organization and standard-setting bodies. So to meet the new convention, the specified flowrates of these cyclones were modified with the exception of the Dorr-Oliver which remains at its original design flowrate of 1.7 L/min. The flowrates now specified allow these older cyclone samplers to meet the ISO/CEN convention with a reasonable level of bias.

## 2. A NEW SAMPLER TO PRECISELY MATCH THE NEW CRITERIA

### 2.1 Design Concept

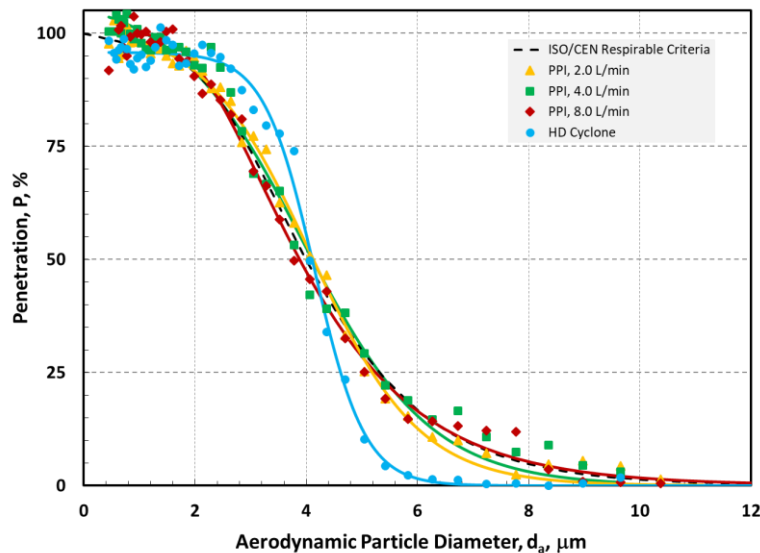
Particulate samplers based on the principle of inertial impaction are well known and widely used for occupational and environmental sampling applications. Standard impactors exhibit sharp cut-off characteristics that make them ideal for sampling PM<sub>10</sub> or PM<sub>2.5</sub>. This sharp cut however means that traditional impactors can not match the performance specified in the respirable size-selection curve. In 1978, however, Marple found a solution to this dilemma. He used a number of conventional impactors each with different cut-points to fractionate particles matching a defined size selection curve. (3) The inertial impactors were arranged in parallel with each impactor collecting a specified size of dust in the curve such that the overall performance precisely matched the criteria. The different cut-points were achieved by using number of nozzles of various sizes. Marple's design however wasn't very practical – it included high number (more than 50) of very small nozzles making the manufacturing and maintenance of the sampler difficult. SKC came up with novel sampler design which simplifies use of several impactors in parallel (US Patent 7,073,402).

### 2.2 Design Features

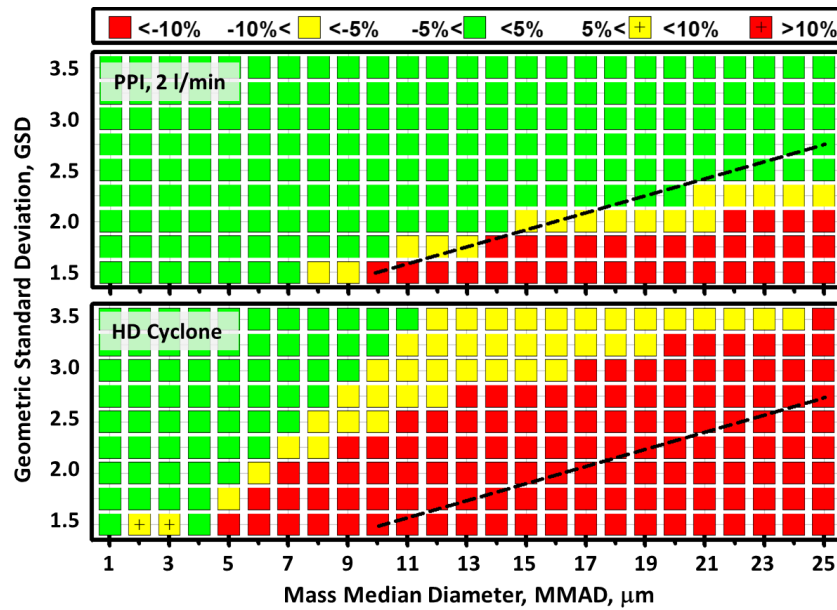
The new respirable dust sampler called the Parallel Particle Impactor includes 4 internal pre-oiled impactor plates. A reusable sampler is available in aluminum and single-use disposable models are available in anti-static plastic. To provide flexibility in sample duration reusable and disposable samplers are available for use at 2, 4, and 8 L/min. The plastic models preloaded with filters also offer the advantages of no pre-sample assembly or post-sample cleaning by the user and a handy calibration adapter. Ease of use is particularly important when sampling is being done by safety supervisors or others who do not have extensive training in occupational hygiene. A standard 37-mm PVC filter is used for respirable dust sample collection with analysis following NIOSH or similar methodologies.

## 3. RESULTS AND DISCUSSION

Figure 1 shows the penetration characteristics of the 2, 4, and 8 L/min respirable PPI relative to the ISO/CEN respirable convention. It also includes penetration curve for HD Cyclone for comparison.

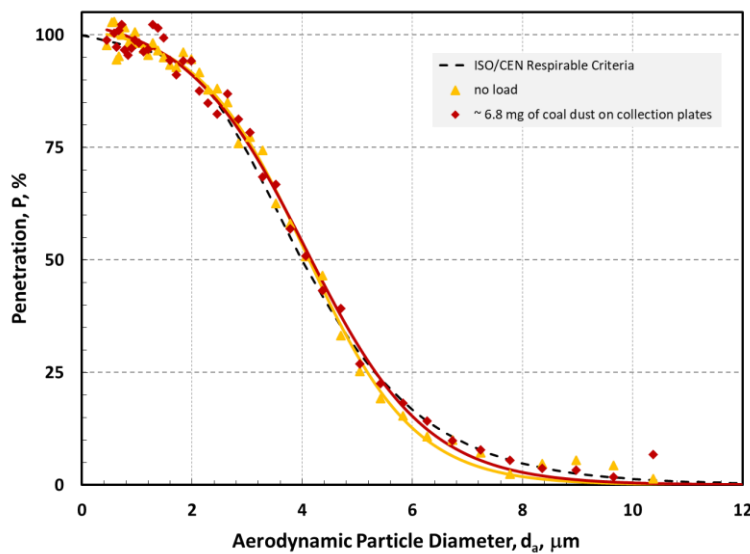


**Figure 1.** Comparison of three Respirable PPI and HD Cyclone performance to the respirable convention.



**Figure 2.** Bias maps plotted for the respirable PPI (4.0 L/min) and HD Cyclone.

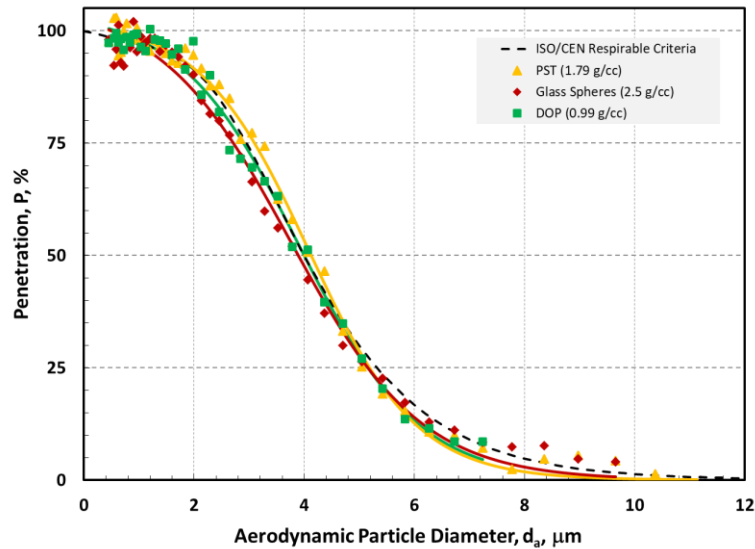
Figure 3 shows the penetration characteristics of the 2 L/min PPI relative to the respirable convention in two different sampling scenarios. (4) The triangles represent the penetration measured using a PPI sampler with new, clean impaction substrates installed. The diamonds represent the penetration measured for the same sampler after it was exposed to coal mine dust for six hours.



**Figure 3.** Comparison of 2 L/min Respirable PPI performance to the respirable convention before/after exposure to coal mine dust.

To assess loading on the performance of the PPI, the 2 and 4 L/min models were operated for six hours in a Marple chamber at the NIOSH Pittsburgh Research Laboratory in Pittsburgh, PA. The impaction substrates were loaded with approximately 3.4 and 6.8 mg in the 2 and 4 L/min respirable PPIs, respectively. As shown in Figure 2, this amount of loading of the impaction substrates did not affect the performance of either PPI. The oil-impregnated impaction substrates were also found to be effective in eliminating any particle bounce-off or blow-off of collected particles in line with findings previously reported by Marple and McCormack. (5)

To ensure the test results were not affected by the type of test particle used in the study, further testing was done using both solid and liquid particles. In addition to the potassium sodium tartrate (PST) particles recommended by ASTM Standard D6061-01 (6), the 2 L/min PPI sampler was also tested using glass microspheres (G) and dioctyl phthalate (DOP) test particles. Figure 3 shows that there was no significant difference in performance with either type of test particle.



**Figure 4.** Comparison of penetration characteristics of the 2 L/min Respirable PPI using different test particles.

#### 4. CONCLUSIONS

The test results of the new PPI sampler based on the use of four inertial impactors arranged in parallel showed penetration characteristics that closely matched the ISO/CEN respirable convention. Test data also indicate that the sampler performance does not depend on the type of particles collected. A dust load up to 6.4 mg of coal dust on the impaction substrates did not affect the performance.

The PPI design also offers unique advantages to users. PPI samplers do not have the tipping hazard of cyclones where dust in the grit cap lands on the filter if the device accidentally inverted. A calibration adapter eliminates the need for a calibration jar. A choice of flowrates allows for adequate detection over a variety of sample durations. Pre-loaded plastic models allow less trained individuals to collect reliable samples which may be particularly useful in industries such as construction and stonecutting.

At the request of Australian hygienists, the PPI is undergoing further testing at this time by a third-party and the data will be provided at the AIOH conference if available.

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STATE-OF-ART ANALYSIS OF RESPIRABLE CRYSTALLINE SILICA BY DIRECT-METHOD USING X-RAY DIFFRACTION (XRD) AND RECENT FINDINGS FROM WORKPLACE AIR SAMPLES.

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**ABSTRACT**

Exposure to Respirable Crystalline Silica (RCS) can result in the development of a range of adverse health effects, including silicosis and lung cancer. Internationally RCS occupational exposure limits are being lowered, putting pressure on the capability of the analytical techniques used. To monitor the Crystalline Silica ( $\alpha$ -Quartz and Cristobalite) in air, X-Ray Diffraction (XRD) or Fourier Transform Infra Red (FT-IR) is used. At the last conference, a comparison of two direct on filter methods showed that using XRD has better results compared to FT-IR on several points: less interferences from common matrixes, ability to handle up to 2 mg and correct for overloading, and ability to achieve lower detection limits.

In this paper, we will discuss further developments on lowering the limit of detection using a state-of-art XRD instrument, and show recent findings from workplace air samples from kitchen benchtop manufacturing.



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## WHAT DO OCCUPATIONAL HYGIENISTS REALLY KNOW ABOUT DERMAL EXPOSURE?

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### BIO

Dr Sharyn Gaskin (MAIOH) is a Senior Research Fellow in the Environmental and Occupational Health Sciences Unit at University of Adelaide. Her field of expertise is in Occupational & Environmental Health having a primary focus on industry partnerships and relationships, including defence and security-related applied research in occupational and community health.

Her research program explores the pathways and impacts of occupational hazards on human health and society, and leads to the development of effective interventions to control and prevent exposure to hazards.

### ABSTRACT

This paper describes the AIOH and BOHS member responses to a questionnaire on current work practices and understanding of the management of dermal exposure issues in the workplace. The aim was to explore the knowledge and practice of OHS professionals relating to dermal exposure to hazardous agents in the workplace. The survey comprised of questions in four key areas: employment demographics, experience managing dermal exposure, knowledge of dermal exposure management and resources, and opinions on professional knowledge gaps and preferred training methods. The survey was disseminated in 2016 in the UK and 2018 in Australia, with a total of 116 and 114 responses from each jurisdiction, respectively.

The results showed the majority of respondents had personally evaluated the risks of dermal exposure to chemicals (BOHS 92%, n=107; AIOH 86%, n=76), albeit infrequently (less than a few times per year).

Occupational Hygienists reportedly adopted a range of strategies to control dermal exposure problems, including higher order hierarchy of control measures such as chemical elimination/substitution (BOHS 68%, n=75; AIOH 68%, n=59), changing work practices (BOHS 79%, n=87; AIOH 75%, n=65), and education (BOHS 77%, n=85; AIOH 83%, n=72). The use of gloves or other PPE remained the most commonly cited exposure control measure (BOHS 99%, n=109; AIOH 97%, n=84). While there appeared to be a good understanding of common dermal exposure workplace scenarios (e.g. isocyanate exposure in motor vehicle repair, solvent exposure during spray painting), the overwhelming majority of respondents wished to find out more about assessing the risks from dermal exposure to chemicals (BOHS 89%, n=103; AIOH 88%, n=72).

The outcomes will help suggest ways to increase the competence of professionals in dealing with dermal exposure matters in the workplace, through mechanisms such as web based guidance, interactive educational materials and webinars, as well as workshops and seminars

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A COLLECTIVE APPROACH TO MANAGING POTABLE WATER HEALTH RISK – A CASE STUDY IN HOW OCCUPATIONAL HYGIENISTS CAN ‘RE-SYNERGISE’

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Superintendent Occupational Hygiene

**BIO**

David is a Certified Occupational Hygienist (COH) who has worked in the mining industry for eight years across various operations Australia-wide. David holds degrees in Biological Science, Occupational Therapy and is currently a Doctor of Philosophy (PhD) candidate at Curtin University of Technology in Western Australia. Currently holding the role of Superintendent Occupational Hygiene with Rio Tinto, David and his team are responsible for the delivery of Occupational Hygiene services and support across all of Rio Tinto’s Western Australian operations .

**ABSTRACT**

Health risks associated with the provision of safe drinking water can be significant, and the risk perceptions associated with drinking water from a consumer standpoint can be emotive. Across many industries, Occupational Hygienists are becoming a focal point for biological risk management with respect to drinking water on account of their holistic process of Anticipation, Recognition, Evaluation, Communication and Control of health hazards. The paper outlines a case study detailing the pathway from the identification of a significant pathogen (*Naegleria fowleri*) in a mine site potable water supply, through to the collaborative approach that was taken to communicate the risk to the workforce, inform appropriate controls, and complete control verification. In addition, the paper provides a template for how operational, communications, safety and occupational hygiene teams can collaborate to produce positive health outcomes for the workforce through leveraging the skillsets of a true multidisciplinary team.

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CROWDSOURCING OH DATA TO CREATE VALUE INSIDE & OUTSIDE THE FACILITY FENCELINE

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*Vivek Patel*

Lead Occupational Hygienist | Chevron Energy Technology Company

**BIO**

Vivek spent 6 years working in refineries, gas plants, and onshore upstream facilities with BP, before joining the Energy Technology Company in Chevron in 2018. His experience has been mostly in the practice of field industrial hygiene, with specific focus in mercury, and radiological hazards (NORM). He also claims membership to the millennial generation, deep diving into data science to visualize and analyze big data sets in the field of health and safety. Most recently he's been managing the Safety & Health Risk Management R&D Program, scanning for new technologies and research opportunities to prevent serious injuries and fatalities.

**ABSTRACT**

Crowd-sourcing has engulfed our society. Mass communication and technology have connected a grandmother with a surplus of home-made pad thai, to an Uber driver willing to take a detour, to a hungry customer without the time to cook that night. Crowd-sourcing exists across all social and business interactions and is changing how we work. The practice of occupational hygiene (OH) should not be left behind and we should leverage the power of many to improve health and safety outcomes for our workers.

Chevron has operations across the globe, each with a unique set of OH hazards, and varying levels of associated risks. Despite being on different continents, a refinery in Kazakhstan should be able to leverage mercury exposure controls already established and in practice from a gas plant in WA. Organized OH data should be able to facilitate this process instantly. Being a data-poor field, each OH sample is incredibly valuable, and must be maximized to its' fullest potential.

We have integrated Chevron global OH databases from 1982, and visualized results in an analytical platform, to derive valuable health insights through data visualization, discovery, and data wrangling for several applications. Practical examples to date include:

- Developing a PPE matrix for welding exposures at a facility with zero OH data
- Approval of a corporate mercury standard based on historical trending of occupational exposure limits and sample results
- Justification for an improved new chemical management of change process
- OH sample data standardization to inform future epidemiological studies

This presentation will explain the approaches above, which we have accomplished through statistics, exploratory analyses, and connecting disparate data sets. Our efforts leverage hard-earned field work to implement more sweeping change, motivate stakeholders to make data driven decisions, and improve our risk communication to business leaders to take targeted action to improve workers health.

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BARANGAROO - THE DEVELOPMENT OF DYNAMIC OCCUPATIONAL HYGIENE CONTROL PLANS IN A UNIQUE CBD ENVIRONMENT

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*Haysam Elhassan*

Principal Occupational Hygienist | WSP Australia

**BIO**

Haysam is a Certified Occupational Hygienist with over 15 years' experience in occupational hygiene, OHS practice, environmental and ecological management. Having graduated from the University of NSW with a Master of Environmental Science, Haysam has also completed a Master of Occupational Hygiene Practice at the University of Wollongong. In his current role as the Principal Occupational Hygienist at WSP Australia (Sydney), Haysam has been managed several high profile projects including the provision of Occupational Hygiene Services on Stage 1B of Barangaroo Remediation Project, and continues to assist key clients such as the NSW Department of Education and Sydney Trains with their occupational hygiene requirements.

**ABSTRACT**

The Barangaroo remediation project is one of the most unique and large-scale environmental projects in Australia.

As a former gas works site with significant contamination and exposure risk, it is currently Sydney's largest urban regeneration project. The remediation and removal of asbestos, coal tar, cyanide, zinc, benzene and other contaminants from an area on the edge of the CBD has been a significant and complex undertaking, alongside the noise, heat stress and air quality issues that accompany removal activities undertaken in a large odour control enclosure.

This presentation highlights the development of controls measures at various phases from the initial use of PPE to the development and installation of unique local exhaust ventilation systems. It also highlights the expanding expectations on hygienists to work closer with all stakeholders including engineering and communications specialists in large scale projects to ensure comprehensive exposure protection.

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PREVENTION OF CHRONIC HEALTH RISK THRU HEALTH PERFORMANCE TRACKING AND ANALYSIS

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*Ahmad Khairi B Abdullah*  
Petronas

**BIO**

12 years working experience in HSE background specifically on Industrial Hygiene starting from facility moving to business corporate level and current at PETRONAS group. Experience conducting various risk assessment, exposure monitoring and implementation control from asbestos abatement, engineering control evaluation & installation (LEV and GEV system), noise control assessment, integrated IT system implementation, administrative control and PPE evaluation & implementation

**ABSTRACT**

1. Problem Statement/Situation,

There is a need for to improve the health performance tracking and analysis due to the increasing number of occupational illness cases from year to year, inconsistent implementation of requirement resulting in lapses in chronic health risk management causing inaccuracy of data and no dedicated tracking & analysis to identify the root causes of poor performance.

2. Methodology/Resolution,

It is 3 year journey

- a) Situational assessment was conducted with focus on the hearing conservation program to identify lapses in the reporting and analysis of hearing conservation program.
- b) Verification of the data and analysis on hearing loss & threshold shift based on group wide occupational health integrated information system.
- c) Root causes analysis based on illness investigation report
- d) Improvement of the tracking and analysis with the introduction of health performance triangle.
- e) Update to management on agreed health performance indicator for each facility.

3. Results,

Better understanding of chronic health risk data and root causes that improve the intervention and possible application of predictive analysis hearing loss.

4. Discussion/ Conclusion/Lessons Learned

There is a need for better leading performance indicator for other chronic health risk that control measures adequacy or effectiveness (not limiting to risk assessment, exposure monitoring and medical surveillance) or using health impact index.

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ARE YOU PART OF A BIGGER PICTURE? OR DO YOU HAVE TUNNEL VISION?

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*Peter Aspinall*

Principal Occupational Hygienist | WSP

**BIO**

Peter Aspinall is Principal Occupational Hygienist at WSP, a Certified Occupational Hygienist (COH), a full member of the Australian Institute of Occupational Hygienists (MAIOH) & New Zealand Occupational Hygiene Society (NZOHS).

Peter has over 20 years' experience working and consulting in multiple industry disciplines including Oil & Gas, Mining, Construction and Healthcare. Peter's holistic approach to worker health has been shaped by his health background and additional studies including Masters of Science - Occupational Hygiene Practice, Grad. Dip Occupational Health & Safety, and Nursing Science Degree.

When not talking health & safety to anyone that listens, he is picking up kids or volunteering at the football club and can be found on Twitter & LinkedIn (via #occupationalhygiene).

**ABSTRACT**

Having the skills to understand the health and safety duties of the hygienist, complying with current and pending legislation changes, or anticipating when to apply reasonably practicable solutions to control hazards, is something that develops with time and experience. How do you obtain this skill and get the help and support when required? Consulting hygienists can be ethically compromised when communicating identified hazards of a workplace. Are you just trying to "get more work", down playing a potential issue, or are you strengthening the occupational hygiene brand and adding value? Are you still meeting your duty of care?? What you do as an industry professional can impact on you, your company and the greater occupational hygiene brand. This presentation reviews some of the actions and outcomes of workplace case studies to identify potential traps for new hygienists, and flags issues which may cause experienced ones to lose sight of the bigger picture.

ENGINEERING CONTROL OF DUST EXPOSURE – A CASE STUDY

Simon Worland<sup>1</sup> and Dave Collins<sup>2</sup>

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**Abstract:** Emerging cases of silicosis can be attributed to elevated respirable crystalline silica (RCS) exposures and ineffective PPE. In principle, these exposures can be prevented by real-time exposure monitoring and process feedback systems. This case study demonstrates this principal when applied to engineering control of a dust generation process.

**INTRODUCTION**

Many factors, acting in isolation or in combination, influence particulate toxicity. Some of these factors are shown in Figure 1.

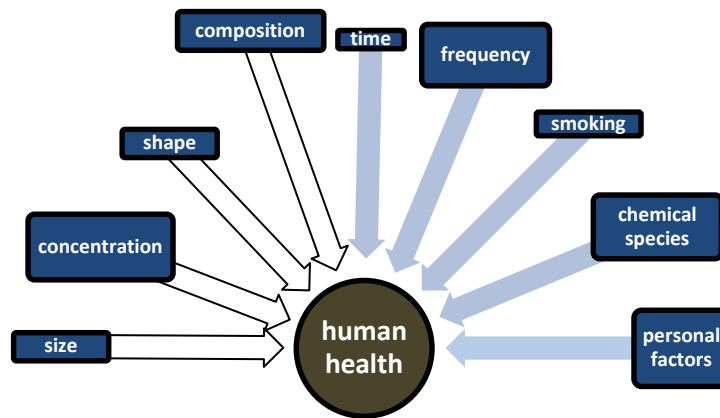


Figure 1 – Some of the factors that influence toxicity

Particle composition shapes and sizes determine where the particles lodge in the lungs and how long they remain. Just a few of airborne particle shapes observed are illustrated by Figure 2.

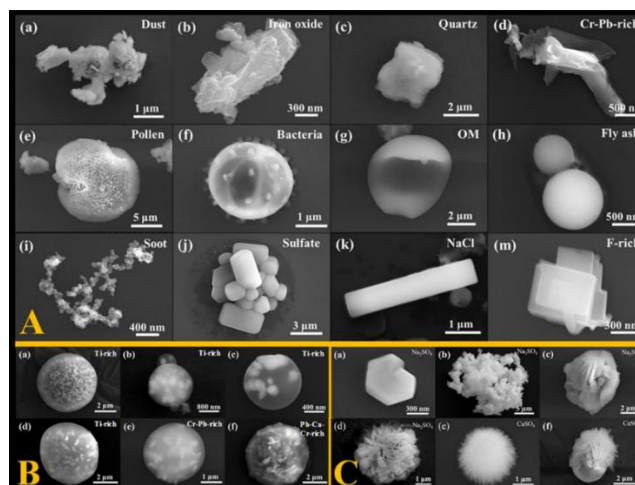


Figure 2 - Sample of airborne particle shapes (1).

Despite these complexities and limits of our understanding, agreed exposure standards, supplemented by Governmental regulated monitoring and medical screening in some industries, was assumed sufficient to protect worker health.

Hence, the recent steep increase in reported silicosis and related disease has come as a shock to the medical community, industry and Governments, and showed that the government health surveillance and enforcement system, and ultimately industry practices, was ineffective. The disease has occurred mainly within mining and stone-top bench cutting (Figure 4) industries where exposure to respirable crystalline silica (RCS) is common. The issue has received considerable media exposure (Figure 3) and worker concerns, with many asking “Is RCS the next asbestos?”.



**Figure 3 – Sample media reports**



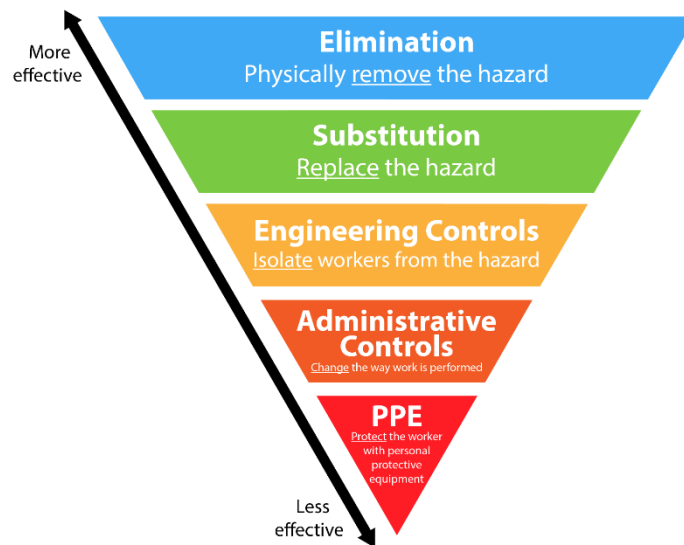
**Figure 4 - RCS generation during stone benchtop cutting**

Studies undertaken by Government and industry show that the extent of RCS exposure is considerable, with (2 and 3) 11% of measured quarry/mine exposures exceed relevant occupational exposure limits, with actual exposures thought to be even worse due to “hygienist effect” (4).

These exceedances are of particular concern as the evidence suggest that there is a poor PPE compliance culture, with PPE seldom worn, and even when it is worn, as 75% of the workers had facial hair, there was a 95% fit test failure (2).



In response, increasing ramping down from 0.1 to Industries are taking exposures in control hierarchy reducing reliance on engineering



Governments are surveillance and exposure standards 0.05mg/m<sup>3</sup> (5). steps to reduce accordance with risk (Figure 5) by PPE through controls.

**Figure 5 – Risk control hierarchy**

However, many engineering controls have been available for some time, including water sprays and chemical application on road surfaces, misting sprays on conveyor transfer, RoM hoppers and crushers, pressurisation and filtration systems in draglines and cabinets. There is evidence that these controls, while available, were not in use at half of the sites visited in a recent audit (3).

This paper examines the potential for improving the uptake and effectiveness of engineering controls by human-centered design, incorporating real-time continuous monitoring, warning alarms, and fail-safe automatic feedback.

Compressed air cleaning of electrical cabinets was chosen as a case study as it is responsible up to 50% of RCS exceedances in Queensland open cut coal mines (6):

*“In 2017, approximately 50 per cent of respirable dust and respirable crystalline silica (RCS) exceedances that occurred in surface coal mines, related directly to the use of compressed air for cleaning down enclosures and equipment during maintenance activities.”*

## CASE STUDY

### Background

Current compressed air cleaning methods are very noisy and create clouds of dust which expose others working in the vicinity, and even when no-one is close-by, the clouds of dust settles across the workshop and is available for re-entrainment. As workshops must be cleared of people, i.e., other activities cannot be undertaken in parallel due to the risk of secondary exposure, the task incurs 30 to 60 minutes of additional truck downtime/clean at cost of tens of thousands of dollars per clean. In addition, as workers in the workshop must down tools, and the cost of loss work could be thousands of dollars per clean.

Preventing all dust contamination of equipment is very difficult to achieve in mining environments, and alternative cleaning methods such as water sprays damage electrical equipment, as water and electricity do not mix.



**Figure 6 - Example of traditional compressed air cleaning of Komatsu 960E truck electrical cabinets**

### Solution

An engineered containment system and portable local exhaust ventilation system (pLEV) was developed for fail-safe compressed air cleaning of electrical cabinets. The system consists of dust containment covers, and a real-time monitoring, feedback and fail-safe portable local exhaust ventilation (pLEV) system, as shown in Figure 7. Note there is no visible dust. The pLEV system is designed and fabricated to be portable and easy to use as shown in Figure 8.



**Figure 7 – Komatsu 960E electrical cabinet pLEV application. Note there is no visible dust.**



**Figure 8 - Carry bag pLEV for Komatsu 730E electrical cabinet application**

pLEV has been proven to be effective at multiple mine sites for cleaning electrical cabinets, motors, MG sets, without any measureable increase in personal airborne dust exposure. An example of the pLEV equipment during use on M-G sets and truck alternators is shown in Figure 9 and 10 respectively. Note that there is no visible dust.



**Figure 9 – MG set pLEV application. Note there is no visible dust.**



**Figure 10 - Truck alternator application. Note there is no visible dust.**

### Summary of pLEV benefits and features

- Transparent containment covers provide a clear view of the dust removal process, and assures effective cleaning, and dust containment.
- The pLEV creates a negative pressure to prevent dust escape from the equipment being cleaned.
- Provides more complete and more consistent removal of dust build-up, unlike vacuuming which fails to remove hidden dust.
- Dust concentration in the extraction air is measured continuously so that the operator knows when the equipment is clean.
- Compressed air use is controlled and used only when required, reducing energy costs and GHG emissions.
- Transforms compressed air cleaning into a controlled and capable process.
- Other personnel can continue to work safely alongside the cleaning process avoiding work interruption.
- Heavy mining equipment (HME) down-time of 30 minutes to 60 minutes required for cleaning is avoided.
- Lance sensor detects and only opens supply air valve only when lance tip is inside equipment, preventing risk of compressed air injury.
- Professionally engineered, robust and quiet <82dBA.
- Critical data measured, alarmed and logged continuously to provide an audit trail.
- Alarm display (Figure 11) on pLEV provides fast intuitive diagnosis in the event of a fault.
- All measured data (sample is shown in Figure 12) is recorded electronically for trouble shooting, analysis and reporting to identify trends and patterns to provide operational suggestions, guidance and statistics to identify opportunities for improvement, aberrant conditions and predictive maintenance of equipment.
- The collected dust can be stored and analysed as a record of the dust contamination within each HME.
- Available as a light-weight version for workshop, or with heavy-duty large wheels for rough surfaces.
- The time to obtain and fit, uncertainty of protection and the discomfort of PPE is avoided.
- Intuitive, quick and easy setup and use supported by safe work instructions.
- Automated monthly compliance report available for management.
- Can be adapted to most compressed air cleaning tasks.



Alarm parameters
Cyclone differential pressure
Extraction airflow rate
Bag/cartridge differential pressure
HEPA differential pressure
Fan differential pressure
Motor cooling differential pressure
Inlet dust concentration
Outlet dust concentration
Dust container level
Ambient dust concentration
Internal case temperature
Motor temperature

**Figure 11 – Alarm display (LHS) and alarm description (RHS)**

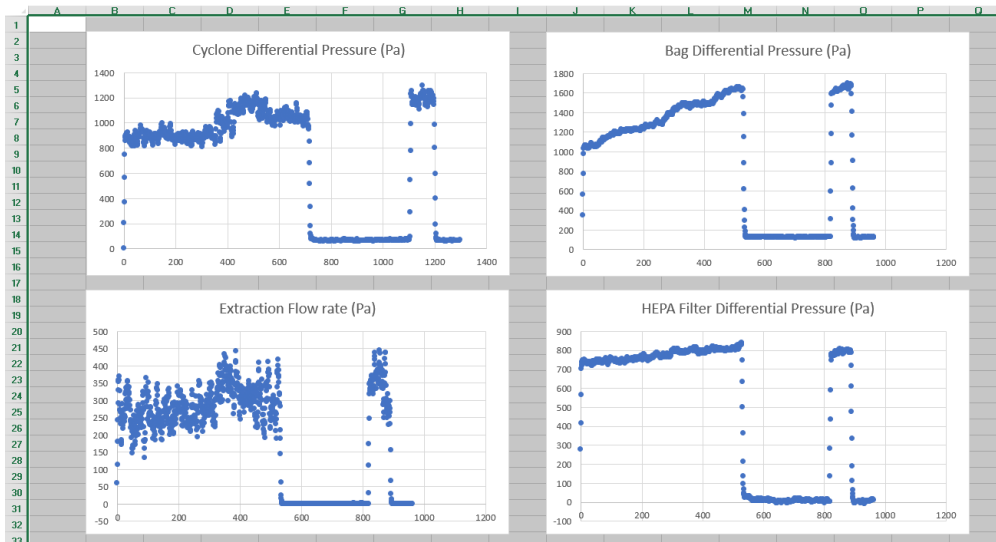


Figure 12 – Sample of data collected by pLEV

### Future developments

- Compressed air flow rate measurement and continuous control
- Remotely programmable IOT
- Personalise pLEV settings for sites and individuals
- Compact lightweight back pack
- Battery powered pLEV and compressed air blower
- VSD to minimise energy consumption
- Ultra-lightweight compact covers
- Digital display on pLEV
- Data storage in the cloud
- Personalise pLEV settings to changing regulations and each mines needs applied to many applications



Figure 13 – Portable pLEV

## CONCLUDING COMMENTS

This paper examined the potential for improving the uptake and effectiveness of engineering controls for RCS exposures by application of human-centered design principles, incorporating real-time continuous monitoring, warning alarms, and fail-safe automatic feedback.

Compressed air cleaning was chosen as a case study as it is known to be high risk in terms of the RCS exposures, and until the work described in this paper, implementation of engineering controls was thought to be impractical.

A new engineering control “pLEV” developed in accordance with these human-centered design principles was shown to be effective for compressed air cleaning of electrical equipment, and also substantially reduced HME downtime, without visible airborne dust, and with personal exposures well below relevant occupational exposure limits.

It is recommended that the human-centered design principles employed in the development of pLEV be applied to all engineering controls, i.e.:

- real-time continuous monitoring;
- warning alarms; and
- fail-safe automatic feedback.

## 4. ACKNOWLEDGEMENTS

Golding Contractors, Rio Tinto, Glencore

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CHANGES IN HEARING THRESHOLD LEVELS FOR WORKERS ENTERING AUSTRALIAN COAL MINES BETWEEN  
1991 - 2015

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**BIO**

Adelle is a Certified Occupational Hygienist (COH, MAIOH) with 13 years' experience in Occupational Hygiene Investigations, Workplace Health & Safety (WHS) Management, Project Management and Teaching & Learning. Her work experience ranges from gold and coal mining operations, to industrial and manufacturing facilities, with work in both private practice and as a consultant. She joined the University of Newcastle as a lecturer in Occupational Hygiene and Toxicology in 2014 and is currently enrolled in a PhD in Environmental and Occupational Health through the University of Newcastle's School of Health Sciences, Faculty of Health and Medicine. Her area of research is aimed at audiometry and prevention of noise induced hearing loss in workplaces.

**ABSTRACT**

The objective of this study was to identify changes in audiometric test results for workers commencing work in Australian coal mines, operated within in the state of New South Wales (NSW). Firstly, we aimed to determine if workers commence work on the mine sites with an existing degree of noise induced hearing loss (NIHL); secondly, compare the extent of any NIHL between age groups, and lastly; to compare the mean hearing threshold level (HTL) of current workers to those of previous decades. This is an observational, retrospective, repeated cross-sectional study, where paired t-tests were conducted to determine the difference in mean HTL between ears, and linear regression to establish changes in mean HTL over time. De-identified audiometric records of employees entering NSW coal mining between 1991 – 2015 were utilised. Evidence of audiometric notches were found for all workers, 18 – 65 years, between 2001 – 2015 at 6kHz. The study found that mean HTL improved over time; the greatest improvement in hearing between 1991 - 1995 and 2001 - 2005. This is the first study to investigate audiometric data for workers entering NSW coal mining, and results can inform development of effective hearing conservation programs in coal mines.



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RECALIBRATION OF LOCAL EXHAUST VENTILATION SYSTEMS FOR SOIL SAMPLES ANALYSIS

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Occupational Hygiene Technician – Greater Tom Price Marandoo Operations | Rio Tinto

**BIO**

Carl has worked in the field of occupational health, hygiene and safety for the past seven years in the Mining, Consulting, Public Services, Construction and Manufacturing industries. Carl holds a Master of Occupational Hygiene and Toxicology and Master of Occupational Health and Safety from Edith Cowan University, as well as multiple Advanced Diploma, Diploma and Certificate IV level qualifications from various institutes. Carl is currently employed with Rio Tinto where he holds the position of Occupational Hygiene Technician – Greater Tom Price Marandoo Operations.

**ABSTRACT**

This project aimed to recalibrate the efficacy of local extraction ventilation (LEV) systems used to reduce dust emissions in the laboratory testing services industry. The aim of the study was to determine the efficiency of those extraction ventilation systems and whether they are suitable for controlling exposures to dust during soil preparation in a laboratory.

A multidisciplinary approach was adopted which harnessed input from soil analysis experts, environmental scientists, as well as laboratory personnel, and was considered in conjunction with information extracted from a robust literature review of the hazard. This approach aided in illustrating a problem statement, anticipating hazards associated with soil preparation within the laboratory setting, recognising health impacts associated with soil preparation, evaluating dust concentrations and extraction system suitability, as well as to provide suitable controls.

LEV measurements collected from the suction inlets indicated that both inlets were unsuitable to adequately capture rogue dust, respirable particles and asbestos dust during soil preparation with either a single inlet or multiple inlets operating. The measurements collected from the ventilation duct indicated that the LEV system was inadequate to capture rogue dust, respirable particles and asbestos dust releases during soil preparation. The recommendations made as a result of this project were made harnessing a multidisciplinary approach and in consultation with key users of the control to ensure the installation of an appropriately designed and installed receiving hood. Due to extensive stakeholder engagement, recommendations made were pragmatic and ensured adequate capture velocities without impeding movement in and around the LEV system.

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## OCCUPATIONAL NOISE EXPOSURE DURING PREGNANCY AND ITS EFFECT ON THE FOETUS

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OHMS Hygiene

### ABSTRACT

The aim of this study is to analyse the current literature on occupational noise exposure during pregnancy, the health outcomes for the foetus, and to identify if there is a consensus of opinion.

The foetal cochlea is structurally ready to function as early as the eighteenth week of pregnancy and studies have found that noise travels well in the uterine environment. Sound transferral and foetal responsiveness within this environment depend on a variety of factors including gestational age, sound frequency, sound level of the noise floor, and attenuation of the environment to external sounds.

Past studies have noted that the maternal abdomen partially filters high and mid- frequency sounds but not low frequency sounds, with some suggestion that the uterine environment can enhance the intensity of low frequency sounds by up to 4 dB and attenuate other frequencies by up to 50 dB. As a result, much of the research shows that children whose mothers were exposed to noise during their pregnancy have a higher risk of hearing loss, low birth weight and prematurity, however, there are some studies that contradict these negative outcomes.

Currently, the effects of noise on the foetus remain unconfirmed, however, we believe there is sufficient evidence to recommend that pregnant women are removed from noisy workplaces at the stage where the foetal auditory system is developed.

### INTRODUCTION

Noise is defined as unwanted or undesirable sound that subjectively disrupts or is physiologically or psychologically stressful for an individual (Kam, Kam and Thompson 1994). Negative health effects to high noise levels include noise-induced hearing loss (NIHL), and noise-induced stimulation of the sympathetic nervous system and endocrine system resulting in increased production of stress hormones and increased blood pressure and heart rate (American Academy of Pediatrics 1997, Kam, Kam and Thompson 1994, Hohmann, et al. 2013, Selander, Rylander, et al. 2019).

Within an industrial environment, noise may be a higher risk: noise may be more excessive and there may be interaction with other atmospheric contaminants (ototoxicants) to increase hearing loss. In adults, hearing loss is usually the consequence of repeated exposures to noise resulting in a general reduction in hearing between 3000 and 6000 Hertz (Gerhardt and Abrams 2000).

Most of the literature centres on individuals who were personally exposed to occupational noise rather than the foetus (American Academy of Pediatrics 1997).

Due to the changing working environment, more women participate in a full-time work with many women choosing to work well into the third trimester (Selander, Albin, et al. 2016). The changing workforce makes it imperative to identify occupational risk factors, such as noise, that could passively impact the foetus prior to birth and to evaluate how well current exposure standards protect these vulnerable groups.

The aim of this review is to analyse the current literature on noise exposure during pregnancy, the health outcomes for the foetus, and to suggest possible solutions to eliminate or reduce any foreseeable risk.

### FOETAL HEARING

The foetal cochlea is structurally ready to function as early as the eighteenth week of pregnancy and studies have found that noise travels well in the uterine environment. In utero, the foetus is surrounded in amniotic fluid, filling the outer and middle ear cavity. The liquid medium of the uterus will modify how sound travels and is heard by the foetus with a larger focus being played through bone conduction of sound (Gerhardt and Abrams 2000). This will affect how noise induced hearing loss will present in infants exposed to high noise levels in the uterus compared to individuals exposed to noise after birth.

The sound environment in the uterus comprises both internally generated noises along with sounds originating from the external environment (Gerhardt and Abrams 2000). Sound transferral and foetal responsiveness within this environment depend on a variety of factors including; gestational age, sound frequency, and attenuation of the environment to external sounds (Gerhardt and Abrams 2000, Parga, et al. 2018).

Initially, the foetus is more sensitive to low frequency sounds but as the foetus progresses towards 37 weeks, the responsiveness towards sound stimuli becomes more sensitive to a wider range of frequencies and lower intensity levels (Gerhardt and Abrams 2000).

### SOUND ENVIRONMENT OF THE UTERUS

Gerhardt & Abrams (2000) summarised the current knowledge of sound transmission and attenuation into the uterus: while the foetal cochlear is functionally ready by the 18<sup>th</sup> week of gestation, sound transmission in the uterus is more likely via bone conduction. Previous studies have shown higher attenuation of high frequency sounds compared with low frequency sounds in the uterus.

Parga et al (2018) collected intra-abdominal sound recordings from pregnant women at different stages of gestation and analysed the differences in sound attenuation between mothers and non-pregnant abdomens. The study found gestation is an important factor towards sound attenuation with an increasing amount of energy filtered from mid and high frequency sounds as the foetus progresses. The study also analysed how different positions affected sound transmission in the uterus noting that high frequency sounds were better filtered when the mother was lying down compared to sitting or standing.

A recent study by Gelat et al (2019) evaluated sound transmission to the foetus inside the uterus of a pregnant sheep in 6 Hz frequency steps between 100 Hz and 20 kHz (i.e. across most of the human audio range). Results found that sound in the amniotic sac was attenuated for some frequencies above 10 kHz by as low as 3 dB.

Another study has shown that low-frequency sounds (0.125 kHz) generated outside the mother were enhanced by an average of 3.7 dB, but otherwise there was a gradual increase in attenuation for increasing frequencies, with a maximum attenuation of 10.0 dB at 4.0 kHz (Richards, et al. 1992). Gerhardt and Abrams (2000) support this indicating that “energy above 0.5 kHz is attenuated by 40 to 50 dB”.

### ANIMAL STUDIES

Experimental studies using animals have provided an insight towards the negative effects of noise on a foetus without relying on retrograde information, or harmful experimental designs on human foetuses.

One rat study evaluated how noise exposure impacted hearing loss at different developmental stages for maturation of the auditory system in rats (Freeman, et al. 1999). Results found increased histological damage and hearing loss in the rats exposed to higher noise intensity (102dB SPL) with reduced damage and loss found in rats exposed to 90dB SPL.

An exposure of 90 dB SPL broad-band noise caused no long-term change in auditory function in either age group. A higher exposure (102 dB SPL) caused greater long-term changes in hearing in the adult compared to the young noise-exposed rats, although histology showed greater damage to hair cells in the younger animals. Therefore, functionally, the developing ear does not seem more vulnerable than the developed ear to acoustic trauma

Another rat study observed the effect of construction noise at 70 and 90 dB(A) on the gestation and neonatal growth of foetuses in Swiss Webster mice, where mice during the first, second and third weeks of gestation were all found to have a significant correlation with an increased risk of stillbirths (Rasmussen, et al. 2009). A 2017 study also evaluated the effects of 90dB white noise during crucial developmental stages of a rat foetus, results showed that the rats exposed to white noise during the foetal development period presented with lower body weights compared to the control group and those exposed to noise post-birth (Salehi, et al. 2017).

A study looking at auditory brainstem responses of late gestational age foetal sheep confirmed low-frequency (1 kHz) sound transmission at 120dB was demonstrated in the foetal inner ear through bone conduction (Huang, et al. 1997).

### HUMAN STUDIES

While occupational noise and foetal development have been research topics for the last few decades, there are few studies focussing on how noise exposure during pregnancy can affect the foetus. Additionally, there is no adapted exposure standard towards occupational noise levels for vulnerable occupational groups such as pregnant women or at what stage of pregnancy excessive noise is harmful.

However, these few studies have found a range of results which have negative effects on the foetus. Even as early as 1997 results suggest excessive noise during pregnancy may result in high-frequency hearing loss,

prematurity, and intrauterine growth delay in newborns (American Academy of Pediatrics 1997). Recently, with the improvement of technology, the quantity and quality of human studies have improved.

An older exploratory study conducted on examined children whose mothers worked during pregnancy in occupational noise conditions between 65 to 95 dB(A). Results showed a link between high-frequency hearing loss in children between the ages of 4-10 years of age and noise exposure during pregnancy in the range of 85 to 95dB(A) (Lalande, Hetu and Lambert 1986). Conversely to this Gerhardt & Abrams (2000) reported that intense, sustained noises or impulses produce changes in the hearing of the foetus and damage the inner and outer hair cells within the cochlea, occurring in the region of the inner ear that is stimulated by low-frequency sound energy.

In 2005 a prospective observational study assessed how standing, lifting and noise affected the number of pre-term births, growth restrictions and perinatal deaths in pregnant military women. While the study size was large overall, the number of women in the study exposed to high noise levels was small. Results from the study found that of the women exposed to noise, there was a higher incidence of pre-term labour (Magann, et al. 2005). In 2006 a case-control study identified whether occupational conditions during pregnancy increased the incidence of small for gestational age infants. Results from the study found there was an association between noise and small for gestational age along with night work, standing, and lifting loads (Croteau, Marcous and Brisson 2006).

Another 2007 review of previous studies indicates that children whose mothers were exposed to noise during their pregnancy have a higher risk of hearing loss, low birth weight and prematurity (Goines and Hagler 2007).

Dzhambov et al. (2014) performed a meta-analysis of studies assessing noise exposure during pregnancy and negative birth outcomes. It was concluded from the studies analysed, that women exposed to high noise levels (above 80dB) during pregnancy were at significantly higher risk of small for gestational age, gestational hypertension, and congenital malformations (Dzhambov, Dimitrova and Dimitrakova 2014). The study discussed the fact that during pregnancy with long-term stress or high noise levels, the neuroendocrine systems can become overloaded with the placenta passing the cortisol to the foetus with the potential for a reduction in foetus growth.

Also in 2014 a systematic review of 14 epidemiological studies on the effect of occupational noise exposures on reproductive outcomes was completed agreeing with negative health outcomes: results from the study presented evidence towards there being an association between noise exposure and low birth weight, pre-term birth and small for gestational age (Ristovska, Laszlo and Hansell 2014).

A 2016 cohort study analysed single births in Sweden to investigate if there was an association between occupational noise exposure during pregnancy and hearing dysfunction post birth in the children. The study found that there was an association between occupational noise and children with hearing dysfunctions for women reportedly exposed to constant occupational noise levels above 85dB(A) during pregnancy (Selander, Albin, et al. 2016).

A more recent study (Selander, Rylander, et al. 2019) aimed to identify if there was an association between birth weight, size, or prematurity and occupational noise while factoring in confounding factors such as type of employment and amount of sick days taken throughout pregnancy. The cohort study was divided into three groups by noise exposure; low noise levels (<75dB(A)), mid-high noise levels (75-85dB(A)) and high noise levels (>85dB(A)). It was found that women exposed to high occupational noise levels (>85dB(A)) in full time work throughout their pregnancy were at increased risk having a child small for gestational age or low birth weight. Similar results were found for the group of mothers exposed to noise levels between 75 to 85 dB(A). These results were only identified in women whom worked full time with less than 20 days of sick leave during their pregnancy.

It should be noted that of the multiple literature reviews that have been performed looking into current evidence between occupational noise and adverse health effects on the foetus Hohmann et al. (2013) found no association between noise and pregnancy outcomes such as low birth weight, pre-term birth, congenital abnormalities, or perinatal/neonatal death.

## DISCUSSION

Negative birth effects in relation to noise have been studied in various themes. Some studies focus on hearing impairments, some towards gestational outcomes for the child. Most of the current literature focusses on birth weight and prematurity. Conflicting results of multiple study designs, small sample sizes, and variety of

health effects researched has given a broad overview with no conclusive outcome towards the effects of noise on the foetus.

From this review of literature, there are gaps in what is known and inconsistencies within the studies. Studies that indicated negative health outcomes are showing that some or all of the following may be expected:

- low birth weight;
- small for gestational age;
- pre-term birth; and
- hearing loss.

How sound is perceived in the womb has also been revised with the improvement of technology, finding that sound attenuation in the womb is highly associated with gestational development and body positioning compared to the environmental noise.

More research is needed to build up the knowledge base to define conclusively the health impacts of noise on the unborn foetus.

### **CONCLUSION**

There are defined exposure standards for safe noise levels for both the time weighted average 8-hour day (85 dBA) and for peak noise levels (140 dB(lin) or dB(C) depending upon the jurisdiction you are in).

Currently, the effects of noise on the foetus remain unconfirmed with gaps in the literature and research towards the effect of noise on the unborn foetus remaining, yet, compelling information from the research already published indicates that occupational sound levels above the 8-hour exposure standard are likely to be hazardous to the foetus.

More research is needed to confirm our understanding:

- of the health impacts of high sound levels during pregnancy;
- towards the attenuation of sound levels within the amniotic sac and uterine environment; and
- the role of body position towards permeation of sound into the uterus.

However, we believe there is sufficient evidence that where occupational sound levels exceed the exposure standard the exposure must be mitigated without the use of hearing protection devices for pregnant women: it is recommend that pregnant women are removed from noisy workplaces at the stage where the foetal auditory system is developed.

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OCCUPATIONAL HYGIENE EXPOSURE ASSESSMENT OF TANK OPERATORS DURING MANUAL TANK GAUGING IN  
THE DOWNSTREAM OIL AND GAS INDUSTRY

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**BIO**

Ayman Arfaj is a qualified occupational health professional and interested in occupational health risk assessment and occupational exposure sampling strategies. He has carried out extensive research on several topics with the Institute of Occupational Medicine and University of Bradford UK. Ayman has a PhD in occupational health and he is a Registered Occupational Hygienist with the British Occupational Hygiene Society (BOHS, UK).

**ABSTRACT**

**Problem-**This study is focused on assessing the potential inhalation exposure of workers to hydrocarbon gases and vapors at the onshore terminal, distribution and refinery tank farms during manual tank gauging. Nine fatalities which were attributed to occupational exposures to hydrocarbon vapors and gases were reported by NIOSH thus a similar exposure assessment was conducted in this study.

**Methods -** A total of 101 personal breathing zone air samples were collected. Since the job task was of short duration, Tedlar bags connected to calibrated air sampling pumps were used to collect the required volume of air sample. The sampling procedure followed the NIOSH and OSHA sampling and analytical methods. **Results -** The results obtained were in range of (<0.2 -0.6 ppm) for benzene, (<0.2-1 ppm) for Ethylbenzene, (<0.5-2 ppm) for Toluene, (<0.5-2 ppm) for n-Hexane, (<1.2-4.1 ppm) for Xylene, (<0.28-0.38 ppm) for Propane and (<0.21-2.2 ppm) for Butane. The results showed that the exposure of outside workers during manual tank gauging to hydrocarbon vapors and gases were well below the pertinent Occupational Exposure Limits set by the OSHA.

**Conclusion-** This led to conclude that the potential occupational exposure risk exposure of operators to hydrocarbon gases and vapors at the downstream is considered a low risk. Proactive recommendations as measures include: workers shall wear required PPE and use multi-gas meter at all times, communicate the possible identified health hazards to workers, and follow standard operating procedures while performing manual tank gauging tasks and provide on the job training.

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## MANAGEMENT OF DIESEL EXHAUST IN UNDERGROUND MINES

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### BIO

Mark Desira (COH MAIOH) is an Inspector of Mines - Occupational Hygiene, working in the northern region with the Queensland Mines. In this role, Mark inspects, audits and mentors metalliferous mines and quarries in the management of health and safety with specific focus on occupational hygiene matters.

Mark has been working in occupational health and safety since 1995. Mark graduated as an analytical chemist and holds post graduate qualifications in occupational hygiene and mine ventilation.

Fritz Djukic (COH MAIOH) has over 25 years' experience in the field of occupational hygiene, primarily in the resource sector and has held senior roles with consultancies, industry, and regulator.

In 2012, Fritz was appointed as an Inspector of Mines (Occupational Hygiene) with the role focused on assisting industry to manage exposures to physical, biological and chemical stressors including respirable dust, diesel exhaust, noise and hazardous chemicals.

### ABSTRACT

The underground mine environment may contain a number of airborne contaminants that affect worker health. This includes diesel plant exhaust (gases and particulate matter) that is emitted into the underground work environment. The classification of diesel exhaust as a Class 1 'confirmed human carcinogen' by the International Agency for Research on Cancer (IARC) necessitates the management of the workers' exposure to diesel exhaust. The Mines Inspectorate has undertaken a study of Queensland underground mines to evaluate the level of risk to mine workers and the effectiveness of differing management strategies for diesel exhaust. In the initial phase of this study, the monitoring results for mine worker exposure to diesel exhaust were collated for underground Similar Exposure Groups (SEGs). The characterisation of the exposure monitoring found that some SEGs (service crews and drilling operations) have higher exposure risk. In the second part of the study, the effectiveness of the control measures applicable to different SEGs were analysed to identify the optimal control strategies. This paper presents the finding that no single control measure is sufficient, and that a multifactorial approach incorporating complementary control measures is required to ensure the effective management of diesel exhaust in underground mines.



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A STUDY TO DETERMINE THE HEALTH RISKS OF USING WATER MIST SYSTEMS AS A COOLING INTERVENTION IN PUBLIC PLACES IN THE PILBARA REGION OF WESTERN AUSTRALIA

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## ABSTRACT

In this study, a sample of 10 water mist systems (WMS) used for cooling public spaces was investigated over a 9-month period from January – September 2019. The aim was to assess the health risks associated with using these WMS. Bioaerosol, biofilm and water samples were collected during 3 sampling events in February, May and August/September. The water profile of WMS was determined by measuring residual chlorine, temperature, pH, total dissolved solids (TDS) and total organic carbon (TOC). All samples were analysed by a National Association of Testing Authorities (NATA) accredited laboratory to detect and enumerate the presence of 5 major opportunistic premise plumbing pathogens (OPPPs) namely, *Legionella pneumophila*, *Pseudomonas aeruginosa*, *Mycobacterium avium*, *Acanthamoeba* and *Naegleria fowleri*. Bioaerosol results demonstrated the presence of *P. aeruginosa* (66.7%, n=30) at a PCR medium cycle threshold (Ct) value of 30-37. Of all microorganisms testing positive in 55 water samples, Thermophilic *Amoeba spp.* was 27.3%, *Legionella spp.* (21.8%), and *P. aeruginosa* (21.8%). Of the 12 *Legionella spp.* positive water samples, 10 were *L. pneumophila* (2-14) and 2 were *L. pneumophila* (1). Nineteen biofilm samples (n=30) tested positive for OPPPs, with 43.11% (8) of the OPPP positive samples being *Legionella spp.*, with 5 of these being *L. pneumophila* (2-14) and 2 *L. pneumophila* (1). *P. aeruginosa* was also positive in 43.11% (8) of OPPP positive samples. Temperature and TDS were correlated with *Legionella* and *Pseudomonas* occurrence in water, H statistic 18.41(2, N = 90) and 53.13 (2, N = 90) respectively. All water profile parameters showed significant differences between them and the occurrence of *Legionella*, *Pseudomonas* and *Thermophilic amoeba* in biofilms (H statistic 12.59 (1, N = 90), H statistic 9.64 (1, N = 90) and H statistic 44.26 (2, N = 90) respectively. No significant correlation was demonstrated between TOC and occurrence of OPPPs.

## 1. INTRODUCTION

Water mist systems (WMS) are defined as plumbing mechanisms installed in outdoor public places such as patios and gardens to regulate ambient temperatures. A high pressure water pump and lengths of high-pressure tubing are connected to nozzles which atomise water, releasing aerosols that flash evaporate in the ambient atmosphere, reducing surrounding temperatures (Ozmist, n.d.). The aerosols evaporate without wetting any surfaces.

A number of studies have demonstrated the effectiveness of these systems in temperature control (Farnham et al., 2015, Duan et al., 2012). WMS can be described as premise plumbing. Several studies have demonstrated that the premise plumbing environment suits and select for the colonisation and re-growth of opportunistic pathogens such as *Legionella spp.*, *Mycobacterium spp.*, *Pseudomonas spp.* and *Acanthamoeba spp.* (Storey and Kaucner, 2009, Liu et al., 2019, Mathys et al., 2008). The use of WMS is increasing, in hotter regions of Australia such as the Pilbara in Western Australia where summer temperatures average 36 – 37°C from November to April and 28 -29°C during May to October (Bureau of Meteorology, 2016).

Most of the research on WMS has been limited to experimental work on their efficiency (Chen et al., 2011, Chen et al., 2010, Lyons et al., 2010, Wong and Chong, 2010, Xuan et al., 2012). The public health risks they may present have not been studied. Extensive studies of other premise plumbing systems such as drinking water distribution systems (Whiley et al., 2014, Falkinham et al., 2015b), cooling towers (Luksamijarulkul et al., 2014, Lau et al., 2013, Kim et al., 2015), showers, water taps and faucets (Cassier et al., 2013, Williams et al., 2013, Shareef and Mimi, 2008, Bilinski et al., 2012) have already confirmed the presence of *Legionella spp.*, *Mycobacterium spp.*, *Pseudomonas spp.*, *Acanthamoeba spp.*, and *Naegleria fowleri*. There is a substantial gap in knowledge regarding the public health risks associated with WMS used for cooling public places. The objective of this project was to evaluate the potential of WMS used as a cooling intervention to be colonised by five OPPPs which have been linked to water borne diseases namely; *Legionella spp.*, *Mycobacterium spp.*, *Pseudomonas spp.*, *Acanthamoeba spp.*, and *Naegleria fowleri*.

## 2. MATERIALS AND METHODS

A total of ten selected WMS used as a cooling intervention in the Pilbara region of Western Australia were included in this study. Water, biofilm and bioaerosol samples were collected from the systems in February,

May and August of 2019. The three sampling events were timed to coincide with the seasonal variation in the study area and were designed to collect the data shown below.

Table 5 WMS sample types and parameters tested

Test parameters	Sample types		
	Water	Bioaerosol	Biofilm
Temperature	Yes	No	No
pH	Yes	No	No
Residual chlorine level	Yes	No	No
Particulate size	No	Yes	No
Total dissolved solids (TDS)	Yes	No	No
Total organic carbon (TOC)	Yes	No	No
<i>Legionella</i> spp.	Yes	Yes	Yes
<i>Pseudomonas</i> spp.	Yes	Yes	Yes
<i>Mycobacterium avium</i>	Yes	Yes	Yes
<i>Acanthamoeba</i> spp.	Yes	Yes	Yes
<i>Naegleria fowleri</i>	Yes	Yes	Yes

### 2.1. Bioaerosol sampling

The collection of bioaerosol samples for analysis by polymerase chain reaction (PCR) was done in accordance with the recommendations stipulated in the Field Guide for the Determination of Biological Contaminants in Environmental Samples, 2nd edition (Dillon et al., 2005). A NIOSH BC251 –2 stage sampler, fitted with a 15ml and 1.5 ml centrifuge tube as well as a conductive polypropylene filter cassette loaded with a 37mm, 3 µm pore size PTFE filter was connected to an SKC AirCheck XR 5000 sampling pump. The pump was run at a flow rate of 3.5 litres / minute for 30 minutes to collect bioaerosol samples from the WMS. The sampling pump was calibrated before and after each sampling event to make it possible to account for and factor in any variation in airflow during the sampling process (Lindsley et al., 2017). These samples were analysed by a National Association of Testing Authorities (NATA) accredited laboratory using polymerase chain reaction (PCR) and (qPCR) methods to isolate and enumerate *Legionella pneumophila*, *Mycobacterium avium complex*, *Pseudomonas aeruginosa*, *Acanthamoeba* and *Naegleria fowleri* respectively. The qPCR results were expressed as Ct values corresponding to the bacterial species genotype isolated (Pfaffl, 2012).

### 2.2. Biofilm sampling

Biofilm sampling was conducted in accordance with the requirements of the Centers for Disease Control and Prevention (CDC)'s sampling procedure for biofilms in *Legionella* outbreak investigations (CDC, 2015). Disposable sterile polypropylene-tipped swabs with plastic stems were used to collect biofilm samples from the internal surfaces of WMS piping and nozzles. The swabs were stored in 15ml sterile screw topped tubes before and after sample collection. The swab samples were stored and transported under temperature control to a NATA accredited laboratory where they underwent both culture and PCR analysis to isolate and enumerate *L. pneumophila*, *M. avium complex*, *P. aeruginosa*, *Acanthamoeba* and *N. fowleri*.

### 2.3. Water sampling

Water samples were collected, stored and transported to a NATA accredited laboratory in accordance with the requirements of AS 2013-2012, Water Quality – Sampling for microbiological analysis (Standards Australia, 2012). Culture methods were used to isolate *Legionella* spp., *P. aeruginosa*, *Acanthamoeba* and *N. fowleri*. Only PCR methods were used to detect the presence of *M. avium* due to the absence of a standard culture method for isolating it in waters and the associated challenges in growing it in a laboratory set up. The confirmation of microbiological species detected was done by both culture and qPCR methods. Water profiles were determined at sampling time by measuring the concentration of Total Dissolved Solids (TDS), residual chlorine disinfectant, temperature and pH. Samples of the water were laboratory tested for the concentration of total organic carbon (TOC). A calibrated TDS and temperature meter as well as a calibrated Palintest photometer was used to measure the water profile parameters.

### 3. STATISTICAL ANALYSIS

The OPPPs occurrence data reported as detected/not detected was dummy coded as (1) for detected and (0) for not detected, whilst data categorically reported by the analysing laboratory as less than the limit of detection e.g. <10CFU/ml for *Legionella* spp., <1CFU/ml for *P.aeruginosa* as well as <1mg/l for TOC was categorised as zero for no detection of the targeted parameter to enable testing of the data for normality. The Shapiro-Wilk test was used to test the water profile data for normality prior to statistical testing (Wang et al., 2017), with a 95% Confidence limit being set as a critical value for accepting a data set as normally distributed. Table 2 shows the data normality test scores for water quality profile data. The OPPPs occurrence data was subjected to the same normality tests.

Table 6 Data normality test scores for water profile data collected from WMS in Feb, May and Aug/Sep 2019

Data normality test scores for water profile data using the Shapiro-Wilk test for data normality					
Water profile data	95% critical value accepted range for normal distribution				
	Skewness	Kurtosis	P - value	Shapiro-Wilk test Score (W)	Data normality
Residual chlorine	2.0903	5.2110	0.0000	0.7477	Not normally distributed
Temperature	0.1939	-1.5385	0.0032	0.8822	Not normally distributed
pH	0.1214	-0.5241	0.6330	0.9733	Normally distributed
TDS	0.0221	-1.8294	0.0002	0.8252	Not normally distributed
TOC	1.6539	1.4581	1.0234	0.6119	Not normally distributed

Since most of the data was not normally distributed, the non-parametric Kruskal-Wallis test (McDonald, 2014) was applied to look for any correlations between the water profile data (Continuous variable) and the occurrence of OPPPs in bioaerosols, water and biofilm swabs (categorical), with a p-value of < .05 being the measure for determining statistical significance.

### 4. RESULTS AND DISCUSSION

#### 4.1. Water profile results

A summary of the water profile parameters observed during the 3 sampling events conducted in February, May and August 2019 is shown in Figure 1. The levels of residual chlorine concentration during the 3-sampling period ranged from 0 – 0.76mg/l, and the minimum and maximum water temperatures recorded were 21.7 and 38.5 °C respectively.

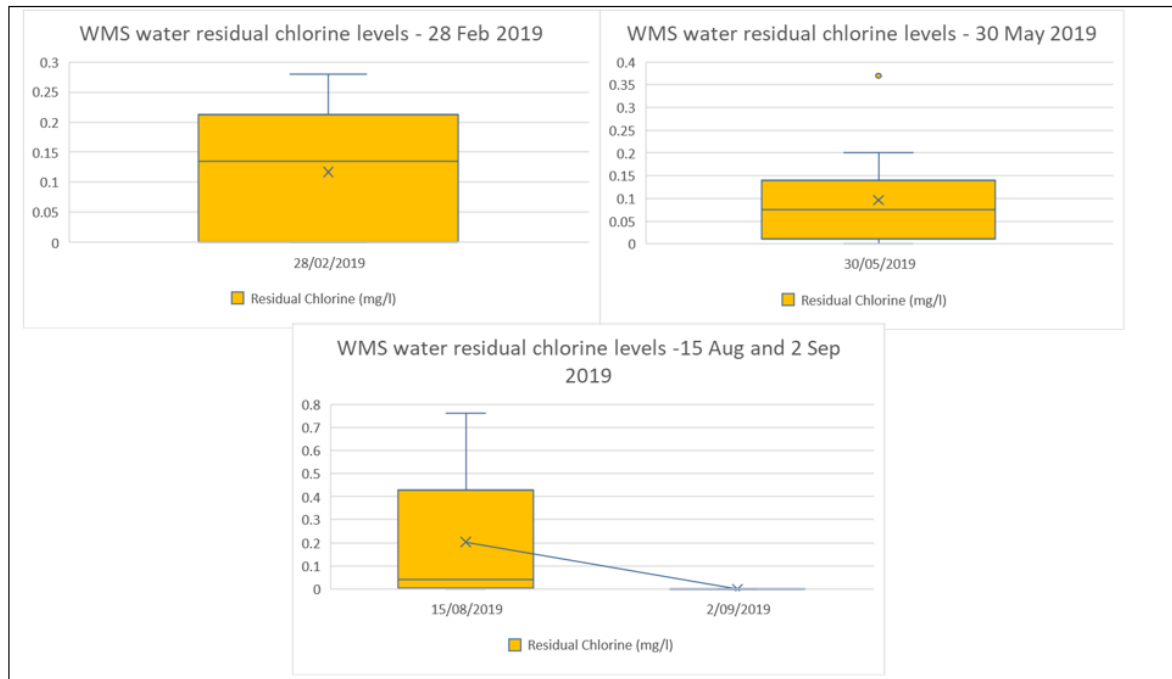


Figure 3 Free chlorine concentration in WMS samples in February, May and August/September 2019 (n=30)

Table 7 Maximum, Minimum and mean values of water profile parameters measured in Feb, May and Aug/Sep 2019 (n = 30)

Parameter	Maximum value	Minimum value	Mean
Residual chlorine (mg/L)	0.76	0.00	0.13
Temperature (degrees Celsius)	38.50	21.70	29.10
pH (pH units)	7.90	7.00	7.43
TDS (mg/L)	399.00	240.00	326.66
TOC (mg/L)	3.00	0.00	NA
<i>NA = not calculated. Categorical data</i>			

#### 4.2. OPPP occurrence

##### 4.2.1. Bioaerosol samples

*P. aeruginosa* was the only OPPP isolated from 66.6% of the bioaerosol samples collected from the WMS as shown in Figure 2. The entire positive samples fell within a PCR cycle threshold (*Ct*) value of 30-37 which indicates a moderate amount of target nucleic acid in the samples and the rest recorded *Ct* values <29 indicating a weak reaction due to the inverse relationship between *Ct* values and the concentration of targeted nucleic acid in a sample (Pfaffl, 2012).

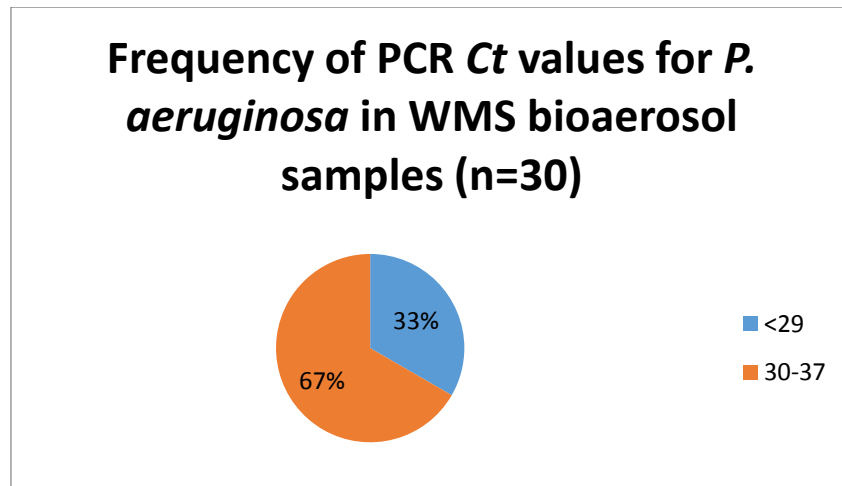


Figure 4 Occurrence of *P. aeruginosa* in bioaerosol samples (n = 30)

#### 4.2.2. Water samples

The most prevalent microorganism isolated from water samples was *Thermophilic Amoeba spp.*, followed by *P. aeruginosa* and *Legionella spp.*, with *L. pneumophila* (2-14) being more prevalent than *L. pneumophila* (1) as shown in Figure 3.

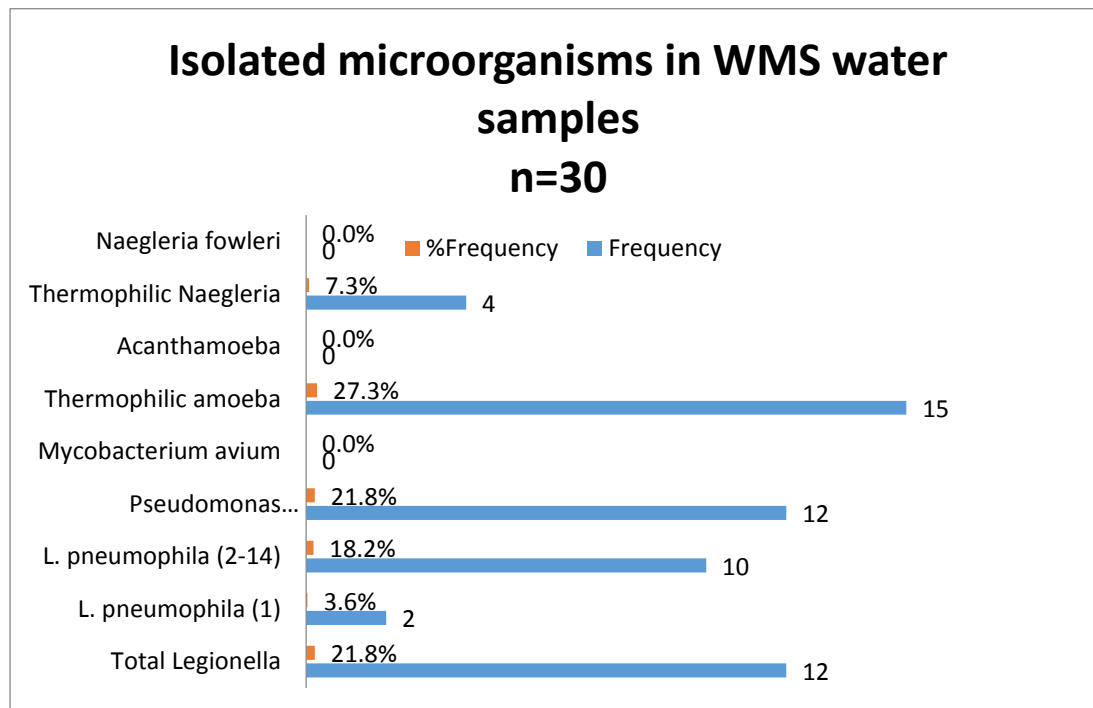


Figure 5 Occurrence of microorganisms in WMS waters (n=30)

Of the 5 OPPPs investigated in this study, only *Legionella spp.* and *Pseudomonas aeruginosa* were isolated from water samples as shown in Table 4.

Table 8 Frequency of OPPPs detected in water samples collected from WMS in Feb, May and Aug/Sep 2019

OPPP	Number	% Frequency
<i>Legionella spp.</i>	12	50.00%
<i>Pseudomonas aeruginosa</i>	12	50.00%
<i>Mycobacterium avium</i>	0	0.00%

<i>Acanthamoeba</i>	0	0.00%
<i>Naegleria fowleri</i>	0	0.00%
Total	24	100.00%

#### 4.2.3. Biofilm samples

In addition to all OPPPs idetected in water samples, *Acanthamoeba* was isolated in 3 biofilm samples collected from WMS as shown in Figure 4.

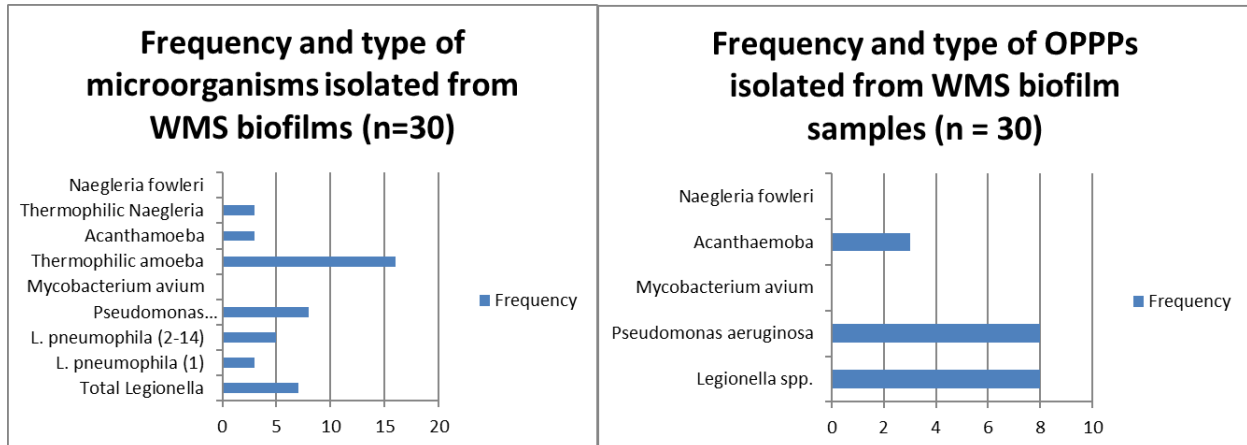


Figure 6 Frequency of total microorganisms and OPPPs detected in biofilm samples collected from WMS in February, May and August/September 2019 (n = 30)

A Kruskal-Wallis H test conducted found no statistically significant differences in temperature between *Legionella* and *Pseudomonas* occurrence in water H statistic 0.0974 (2, N =90). No significant difference was found between pH and *Legionella* and *Pseudomonas* occurrence in water, H statistic 4.23 (2, N =90) and between TOC and *Legionella* and *Pseudomonas* occurrence in water, H statistic 2.83 (2, N =90). However, significant differences were found between temperature and *Legionella* and *Pseudomonas* occurrence in water, H statistic 18.41(2, N = 90) and between TDS and *Legionella* and *Pseudomonas* occurrence in water H statistic 53.13 (2, N = 90). Significant differences were also observed between temperature and Thermophilic amoeba occurrence in water, H statistic 44.26 (1, N = 90), pH and *Thermophilic amoeba* in water, H statistic 44.26 (1, N = 90) and between TDS and *Thermophilic Amoeba* in water, H statistic 44.26 (1, N = 90). All water profile parameters showed significant differences between them and the occurrence of *Legionella*, *Pseudomonas* and *Thermophilic amoeba* in biofilms (H statistic 12.59 (1, N = 90), H statistic 9.64 (1, N = 90) and H statistic 44.26 (2, N = 90) respectively. Similar significant differences were found between TDS and the occurrence of *Legionella*, *Pseudomonas* and *Thermophilic amoeba* in biofilms.

## 5. DISCUSSION

The low residual chlorine concentrations observed in the WMS during the 3 sampling occasions (0 -0.76mg/L) can be attributed to factors such as poor knowledge and maintenance practices by the operators as well as the high temperatures typical of the Pilbara region. Although no significant differences could be determined between the occurrence of OPPPs and residual chlorine, probably due to the small sample size, inadequate chlorine disinfection has been associated with the regrowth of OPPPs in similar plumbing systems (Storey and Kaucner, 2009, Lee et al., 1988, Zhang and Edwards, 2009). The high water temperatures which averaged 29°C during the whole sampling period fall within the growth zone of most OPPPs such as *Legionella* and has been associated with the occurrence of this pathogen in drinking premise plumbing (Mathys et al., 2008, Falkinham et al., 2015c). The strong statistical significance shown between temperature and the occurrence of *Legionella*, *Pseudomonas aeruginosa* and *Thermophilic amoeba* confirm the importance of this variable in promoting the growth and survival of these pathogens in WMS, in the same manner that it has been linked to high OPPPs in other premise plumbing systems (Falkinham et al., 2015a). The number and type of OPPPs detected and quantified in this study compares with other studies on premise plumbing (Bates et al., 2000, Anaissie et al., 2002, Declerck et al., 2009, Falkinham et al., 2015c). This study did not isolate *M. avium* or *N. fowleri* in the WMS. This is contrary to the findings of similar studies on drinking water systems and rain water tanks (Waso

et al., 2018, Lecuona et al., 2016, Marciano-Cabral et al., 2010). The study detected higher levels of *L. pneumophila* (2-14) in WMS as compared with *L. pneumophila* (1). This finding correlates with several studies of plumbing systems which have confirmed this phenomenon (Bates et al., 2000, Kim et al., 2015, Schlech et al., 1985). The occurrence of high numbers of *Thermophilic Amoeba* in water and even higher levels in biofilms of WMS agrees with the findings of several studies on the role played by free living amoeba as hosts of OPPPs (Garcia et al., 2013, Marciano-Cabral et al., 2010, Cateau et al., 2014). *P. aeruginosa*, a common OPPP was detected in 66.7% (n=30) of bioaerosol samples at Ct concentrations (30 -37), indicating moderate levels of this pathogen. Considering that one of the route of exposure for this pathogen is inhalation, and that it affects people with compromised immunity such as the sick, young and the old, its impact could be significant (Wang et al., 2012, Falkinham et al., 2015c).

## 6. CONTRIBUTIONS OF THIS STUDY

In addition to adding knowledge and understanding the growth of OPPPs in WMS used as a cooling intervention in public places, this study has also identified the need for adequate training of WMS operators in the safe operation of these premise plumbing systems. These finds open the discussion on a possible regulation of WMS used for cooling public places in the interest of public health.

## 7. LIMITATIONS

The generalization of the findings of this study may be affected by the small sample size of WMS studied as well as their limited geographical location. Furthermore, significant financial costs associated with sample collection, transportation and analytical work limited the sampling events to 3 from the 4 originally planned to draw an even bigger sample for the study and fully represent the operating conditions throughout the year.

## 8. CONCLUSION

This study of 10 WMS used in the Pilbara region of Western Australia between January to August 2019 involved 3 sampling events carried out in February, May and August. The main objective of this study was to assess the health risks associated with use of these WMS.

Bioaerosol, biofilm and water samples were collected and analysed by a NATA accredited laboratory for the detection and/or enumeration of *L. pneumophila*, *P. aeruginosa*, *M. avium*, *Acanthamoeba* and *Naegleria fowleri* which are premise plumbing pathogens already known to affect people with compromised immunity. The water profile of WMS was determined by the measurement of residual chlorine, temperature, pH, TDS and TOC. The relationship between occurrence of OPPPs in WMS and the water profile parameters was also investigated.

Several conclusions could be established from the findings of this study namely:

- 1) The water quality of WMS used as a cooling intervention in the Pilbara can promote the colonization and regrowth of OPPPs, particularly the pathogenic *L. pneumophila* (2-14), *P. aeruginosa* and *Acanthamoeba*;
- 2) High water temperature, pH, and TDS are the critical factors associated with the colonization and regrowth of OPPPs in WMS used as a cooling intervention in the Pilbara region;
- 3) A moderate to strong correlation was observed between high water temperature, TDS and the occurrence of *Thermophilic Amoeba* which may host and mask other OPPPs;
- 4) Moderate levels of *Pseudomonas aeruginosa* cells were detected in respirable bioaerosols generated by WMS used as a cooling intervention, hence posing a health risk for immune compromised people.

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WHAT IS “BIOTOXIN ILLNESS” AND WHO IS RICHIE SHOEMAKER? REPORT ON THE PARLIAMENTARY INQUIRY INTO  
BIOTOXIN-RELATED ILLNESSES IN AUSTRALIA

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*Brad Prezant*

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**BIO**

Brad Prezant, MSPH, MBA, CIH, COH, CPE (CPE retired 2012) is an evidence-based public health scientist, occupational epidemiologist, and occupational hygienist. The majority of his career has been spent as a consultant in private practice; his University experience includes full-time employment and faculty status at several universities (University of Washington, Seattle, WA, USA, and Massey University, Wellington, NZ), where he initiated as well as contributed to occupational health research. Mr. Prezant holds Masters Degrees in Public Health and Business Administration, both from the University of Washington, Seattle, Washington, USA.

Mr Prezant is certified by the American Board of Industrial Hygiene (ABIH) as a Certified Industrial Hygienist (CIH) in Comprehensive Practice & sub-specialty Indoor Air Quality, and the Australian Institute of Occupational Hygienists as a Certified Occupational Hygienist (COH)

**ABSTRACT**

In the 1990s, a family physician saw numerous fishermen with profound CNS symptoms. They were exposed via inhalation of sea aerosols to biotoxins produced by a marine dinoflagellate, *Pfiesteria*. This physician - Dr. Richie Shoemaker - later saw patients reporting with similar symptoms as the fishermen - persons with exposure to water-damaged buildings.

From these experiences, he defined a syndrome - Chronic Inflammatory Response Syndrome (CIRS), starting with an exposure to a biotoxin (such as indoor dampness but could be other biotoxins), and resulting in disruption of multiple body systems, with profound debilitating health symptoms among affected individuals. According to Dr. Shoemaker’s theory, following biotoxin exposure in genetically susceptible individuals (25% of the population), the innate immune system releases inflammatory molecules that signal the adaptive system, but the latter does not “see” these, and, with repetitive signalling, higher and higher levels of inflammation result. “Brain on fire” is one descriptor. Dr. Shoemaker has created a case definition and a multi-step precise treatment protocol. His theories are popular among both MDs and integrative medicine practitioners, with at least 15 health care providers in Australia using modified versions of his protocols.

Biotoxin-related Illnesses in Australia

A 73 page report was issued by this parliamentary committee in October 2018. Submissions were received from 142 individuals, professional organisations, physicians, and companies including the AIOH. The prevalence and geographic distribution of biotoxin-related illnesses in Australia, particularly related to water-damaged buildings, was addressed. The reports lists 7 recommendations.

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## CLANDESTINE DRUG LABORATORIES - PEROXIDE REMEDIATION

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WorkPlace Environment Consultants Pty Ltd

### 1. ABSTRACT

Clandestine drug laboratories can be found in houses, hotel rooms, caravans, factories, motor vehicles, bush settings and public land. The Australian Crime Commission has issued *Clandestine Drug Laboratory Remediation Guidelines* in response. Contamination by methamphetamine, MDMA, MDA and other substances can be remediated by washing with alkaline detergent, washing with a caustic solution, oxidation with activated hydrogen peroxide, oxidation with chlorine bleach, use of shellac sealants, or by demolition. The peroxide method uses an irritant (but not corrosive) chemical that is effective against high residue levels, requires less demolition (therefore reducing the cost), can be applied by fogging (to difficult locations such as inside air ducts), and can be safely used on many items of contents (in addition to building materials). This paper presents some hard-won remediation experience.

### 2. INTRODUCTION

#### 2.1 Clandestine Laboratories

Clandestine drug laboratories can be found in houses, hotel rooms, caravans, factories, motor vehicles, bush settings and public land.

#### 2.2 Australian Guidelines

The Australian Crime Commission has issued *Clandestine Drug Laboratory Remediation Guidelines* in response. There are surface guidelines for precursors (pseudoephedrine, safrole, and isosafrole), illicit drugs (methamphetamine, MDMA, MDA, and PMA), chemical reagents (ammonia, boron, bromides, iodine, lithium, inorganic mercury, phosphorous, and organic solvents), other indicators of chemical use (pH, and total petroleum hydrocarbons).

#### 2.3 Remediation Methods

Contamination can be remediated by washing with alkaline detergent, washing with caustic solutions, oxidation with activated hydrogen peroxide, use of shellac sealants, or by demolition.

### 3. METHODS

#### 3.1 Standard Cleaning

As a general rule, standard cleaning methods are not efficient, or even effective, at reducing methamphetamine contamination to less than the Australian investigation level. Standard window cleaners are able to remediate easy-to-clean surfaces such as glass, but household detergent products may not be able to remove contamination from surfaces such as painted (or unpainted) plasterboard, or are not cost-effective for contractors who charge by the hour.

#### 3.2 Alkaline Detergent

Alkaline detergents are effective at rinsing away contaminants, but are inefficient, and multiple washes are required. Hard-to-reach surfaces are hard to decontaminate with this method. As a result, many commercial contractors will often resort to demolition at relatively low levels of surface loading.

#### 3.3 Caustic Solutions

Washing with a caustic solution is a more efficient cleaning process, but is still not able to treat hard-to-reach surfaces. These corrosive solutions can cause permanent blindness & skin damage. Some products sold as alkaline detergent might be better described as a caustic solution.

### 3.4 Activated Hydrogen Peroxide

This method uses activated hydrogen peroxide – peroxide-only is not efficient – activation is required to improve reactivity. An intermediate peroxide is formed using an organic compound supplied with the multi-part product. Ask for product and performance data – it is possible for products to be formulated with peroxide for marketing purposes, but not for cleaning purposes. Suitable products are irritant (but not corrosive) chemicals that are effective against high residue levels, require less demolition (therefore reducing the cost), can be applied by fogging (to difficult locations such as inside air ducts), and can be safely used on many items of contents (in addition to building materials). Inspired by bacterial spore control, the first products were developed for application by foam, with a dwell time of 1 hour. With advice, treatment times can also be much shorter than 1 hour. The best techniques use a trained and experienced contractor with a combination of alkaline detergent and peroxide, because peroxide decontaminants will not penetrate oily surface layers (including, but not limited to kitchens).

### 3.5 Chlorine Bleach

Washing with chlorine bleach can be an effective surface treatment, but it will whiten fabrics, damage mirrors, and promote the corrosion of steel. These corrosive solutions can cause eye damage & skin damage. Chloramine emissions are strong respiratory irritants.

### 3.6 Sealants

Shellac products such as *Zinsser B-I-N* will rarely be the primary method of remediation, but have a role when other methods have been used to reduce surface loadings, but the final cleanup goal has not been achieved with reasonable efficiency. Hard-wearing epoxy sealants can be used on floors.

### 3.6 Demolition

Demolition, or part demolition, will be necessary if the final cleanup goal cannot be achieved, or cannot be achieved with reasonable efficiency. All demolition must be complete before cleaning.

## 4. RESULTS

### 4.1 Legal Issues

Ensure you have lawful access to the property, and a commitment to pay your fees. Goods left behind must be dealt with lawfully, which can present logistical issues, such as a tenant on remand.

### 4.2 Attempted Remediation by Painting

Tell your clients not to paint before cleaning. After the use of standard wall paint, methamphetamine levels can be reduced by repeated cleaning with oxidants (and then repeated cleaning all over again), but paint stripper, shellac sealing and/or demolition might also be needed.

### 4.3 Peroxide Decontamination of Plasterboard

The peroxide method has been used to clean up to 500 µg/100 cm<sup>2</sup> on plasterboard and up to 3800 µg/100 cm<sup>2</sup> on stainless steel, with a single pass. Use a contractor with training and experience – check behind the entry door – check the wall with the entry door – check plastic components. Peroxide will damage poor coats of paint - good coatings will not be affected.

### 4.4 Fans, Coils, Exhaust Fans, Plastics

Fans and exhaust fans often have higher residue levels. In one property, the plasterboard was 2 µg/100 cm<sup>2</sup> and an exhaust fan was 70 µg/100 cm<sup>2</sup>. Exhaust fans are easily cleaned, or the appliance changed for low cost. Higher residues are also found on plastics (power points, video & telephone jacks). Removal is often more economical

### 4.5 Kitchens & Other Areas with Greasy Surfaces

Residues are harder to remove from greasy surfaces – pre-cleaning with alkaline detergent should be part of standard protocols. Disposal of kitchen range hoods is often more economical than cleaning.

#### **4.6 Unfinished Timber, Oiled Timber, Varnished Timber**

Residues on these surfaces are easily knocked down, but it can be hard to reach the final investigation level. Use of a shellac sealant, or demolition, as last steps may be required.

#### **4.7 Air-Conditioning Systems**

Ducts and coils are hard-to-reach surfaces. They can be readily treated with by fogging with peroxide decontaminant. One air grille at 1000 µg/100 cm<sup>2</sup> before fogging was less than 0.5 µg/100 cm<sup>2</sup> after fogging. Coils can also be cleaned be treated with commercially-available caustic products - some are applied as a foam.

#### **4.8 MDA**

MDA residues are easily knocked down, but it can be hard to reach the final investigation level. Use of shellac sealant may be required as a last step – or an epoxy sealant on concrete floors. MDA is not detected by on-site tests, or less expensive (single-substance) laboratory testing – testing for a full-suite of contaminants (at a higher price) is required. The Australian investigation level is not found in Appendix 1 table – look on Page 17.

#### **4.9 Expired Decontaminant**

One lightly-contaminated property required an unexplained second peroxide treatment. An investigation revealed old stock, and new product was effective

#### **4.10 Iodine Stains**

Alcohol hand sanitiser gel and water will rinse away small iodine stains. Severe staining by iodine may need demolition.

#### **4.11 Other Challenges**

Carpets are best disposed of, but can be used to protect the floor during cleaning - dispose of when wet to prevent re-deposition of dust. If contaminated, roof space insulation is best replaced. Tabletting powders repel water-based cleaners – the use of surfactants sealants and/or demolition may be required. Asbestos, lead paint and mould might be present. If a formal notice has been issued, ensure you have read every requirement.

#### **4.12 Cleaning More than the Building**

Don't forget septic tanks, soil (including burn pits), and dams (on rural properties). A licensed hazardous waste contractor may be required, including for empty (but not purged) drums and tampered gas cylinders.

#### **4.13 Cleaning More than the Guidelines**

Properties should look clean as well as be clean, by cleaning grease from concrete slabs, removing fingerprint dust, removing corroded metal fittings, removing or sealing stains, and removing rubbish. Peroxide can cause permanent patches of yellow staining on melamine - removal of the affected timber is then the only option. There should be no odours (from iodine, chemicals, or drains). Peroxide treatment can leave residual odour, measurable immediately after application by photo-ionisation detector (PID), which dissipates with time.

#### **4.14 Mould Warning**

Thoroughly dry the property afterwards after the use of any liquid cleaner, with mechanical assistance if required, or mould will develop. Fog or spray application of activated peroxide is now recommended as means of reducing secondary damage (including mould growth) caused by too much water.

## **5. DISCUSSION**

### **5.1 Guidelines for Methamphetamine**

In 2018 report entitled *Methamphetamine Contamination in Residential Properties: Exposures, Risk Levels, and Interpretation of Standards*, the Chief Science Advisor in New Zealand, Professor Sir Peter Gluckman recommended an increased cleanup level of 15 µg/100 cm<sup>2</sup> for buildings other than clandestine laboratories (such as those used only for smoking). The cleanup level of 1.5 µg/100 cm<sup>2</sup> for buildings used as a laboratory remained. There have been no changes to Australian investigation levels.

## 5.2 Guidelines for pH

The Australian *Clandestine Drug Laboratory Remediation Guidelines* pH guidelines (6.5-8.5) may apply to treated drinking water, but cannot apply to other drinking water (pH range 5-10), household products (pH range 2.5-12), or soil (pH range 4-10.5). My pH guidelines are 1 or less and 11 or greater. Iodine stains have a typically pH of 9.

## 5.3 Background Briefing

On 17 March 2019, the ABC radio current affairs programme *Background Briefing* accused some testing services of alarmist tactics, and inappropriate testing procedures.

## 6. CONCLUSIONS

Clandestine drug laboratories can be remediated by oxidation with activated hydrogen peroxide. The method is effective against high levels of exposure, for a reduced cost.

## 7. ACKNOWLEDGMENTS

Thank you to the clients who have authorised the publication of data obtained at their premises, for the sole purpose of professional education.

## 8. REFERENCES

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- Environmental Risk Sciences (2009) *Derivation of Risk-Based Investigation Levels, Clandestine Drug Laboratory, Site Investigation Guidelines*
- Government of Western Australia, Department of Health, WA Police Service (2015) *Clandestine Drug Laboratories*
- Government of Western Australia, Department of Health *Guidelines for Notification and Risk Management after Detection of a Clandestine Drug Laboratory*
- Health Protection NSW (2015) *Remediation Guidelines for Clandestine Drug Laboratories and Hydroponic Drug Plantation*
- NZS 8510 (2017) *Testing and decontamination of methamphetamine-contaminated properties*
- USEPA (2013) *Voluntary Guidelines for Methamphetamine Laboratory Cleanup*

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MEASURING HEARING THRESHOLD SHIFT: DIRECTIONS AND CONSIDERATIONS WHEN MONITORING HEARING IN  
HIGH NOISE WORKPLACES

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*Glenn Johnson*

Principal Occupational Audiologist | AIOH Audiology Australia ANZ Society of Occupational Medicine

**BIO**

Glenn Johnson is Director and Principal Occupational Audiologist at The Hearing Company, a business specialising in assisting organisations to deliver quality occupational audiometry services. Glenn oversees the delivery of diagnostic audiological services for large companies and has designed and presented occupational audiometry training courses to over 1,000 students in Australia and the region. As a consultant and trainer, Glenn has accumulated considerable knowledge of occupational audiometry practice and is passionate about empowering companies to manage the risk of workplace hearing loss. He lectures in occupational audiology to university Masters students and has contributed to revisions of workplace audiometry legislation and Australian Standards.

**ABSTRACT**

The requirement for companies to conduct health surveillance in hazardous workplaces is long-standing. In WA and other jurisdictions, the introduction of new government requirements presents an opportunity to refocus our attention on monitoring a key sense – hearing.

A key element in any hearing surveillance program is to use effective tools to identify changes in hearing in noise-exposed employees. Regulations and Standards state that it's not enough to simply conduct a hearing test, tick the box and file the results.

Effective monitoring of hearing requires planning, analysis and technical rigour; clearly an undertaking that should involve an Occupational Hygienist! We present for discussion several methods for measuring changes in hearing used in organisations around Australia. The presentation will offer Occupational Hygienists and other Occ Health professionals the opportunity to recalibrate their knowledge around the purpose and means of conducting effective workplace audiometry. The session will include examination of temporary and permanent threshold shift, differences in requirements between baseline and monitoring tests, pre-test noise exposure conditions and examples of best practice.

Is hearing loss caused by workplace noise exposure still an issue? The presentation reveals some recent large scale, epidemiological data on noise exposure across Australian industries and trends in the use of hearing protection on WA mines sites.

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ASSESSMENT OF ILLICIT DRUG CONTAMINATION IN RESIDENTIAL ENVIRONMENTS AND THE CRITICAL ROLE OF  
OCCUPATIONAL HYGIENISTS'

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*Paul Newell FRACI CCHEM*

Department of Water and Environmental Regulation

**BIO**

Paul is an Australian and internationally recognised expert in illicit drug manufacture and drug contamination and is a subject matter expert for the 'United Nations Office on Drugs and Crime' (UNODC). Paul is a co-author of the UNODC guidelines for the Safe Handling and Disposal of Chemicals from Illicit Drug Manufacture, and the principal author of the UNODC Illustrated Disposal Guide for the management and disposal of illicit drug related chemicals in remote and non-secure environments. Paul is also the principal author of the Australian national guidelines for the 'Remediation of Clandestine Drug Laboratory Sites' and is a contributing author to the Western Australian Clandestine Drug Laboratory Management Guidelines as well as a number of specialist operational safety and technical procedures for illicit drug related environments ranging from meth labs to hydroponic cannabis grow operations.

**ABSTRACT**

With the increasing community awareness and testing of residential properties for illicit drug contamination, more and more properties are being identified as being impacted by illicit drug contamination. This presentation will look at this trend and delve into the facts vs fiction when it comes to illicit drug contamination within residential environments, and the critical role of occupational hygienists in the assessment and management of this contamination. Presented by Paul Newell, a forensic chemist, nationally and internationally recognised illicit drug expert and principle author of the 'Australian National guidelines for Remediation of Clandestine Drug Laboratory Sites', Paul will discuss current and emerging drug trends, drug manufacture, the significance of drugs as residual contaminants and the importance of assessment by suitably qualified and experienced professionals.



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REBRAND YOUR PROFESSIONAL LINKEDIN PRESENCE & RAISE YOUR PROFILE

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*Jo Saunders*

Marketing strategist | Wildfire Social Marketing

**BIO**

Jo Saunders is a leading international LinkedIn expert, marketing strategist and social media educator who has been helping people connect and communicate since the early 90s.

Known as Australia's LinkedIn Demystifier, Jo guides individuals and teams through the complexities of LinkedIn and social marketing tools, to communicate your brand message, showcase your talent, build thought leadership and relationships.

Jo is a certified trainer and has spoken on local, international and virtual stages, resulting in training thousands of people around the world. She ranked #4 on Klout's LinkedIn expert list, was named one of the top 200 LinkedIn practitioners in the world and is the only Australian LinkedIn expert to be invited to speak at Social Media Marketing World, the biggest social media conference in the world.

- 2019 Top 50 Social Media Marketing Influencers by TopRank Marketing,
- #2 LinkedIn Expert in Asia Pacific for 2018 by the Social Media Marketing Institute.

**ABSTRACT**

With seconds to capture attention, does your online presence create the right digital first impression? This overview is designed to show you the key features of LinkedIn to build your personal, professional and organisational brand. It can increase brand awareness and engagement within LinkedIn via your network and in Google search results.

With over 10 million users around Australia, your strategic partners, stakeholders, clients, and industry leaders are not only on LinkedIn, they are ready to engage. This 40 minute overview will cover;

- 1.Crafting a professional profile – the essential elements to a well set up profile
- 2.Connecting – finding the right people and good practice relationship building
- 3.Content - build brand awareness and thought leadership

Be sure to have the LinkedIn app on your mobile device to follow along.

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URBAN LEAD IN DUST EXPOSURE – GOOD WORK PRACTICES, LEADING TO REDUCTION OF DEMOLITION WORKERS'  
LEAD IN BLOOD LEVELS

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*Farzad Jalali*

Occupational Hygienist | EHO Consulting Pty Ltd

**BIO**

I have over 18 years experience within the hazardous materials industry, initially specialising in asbestos. Over the last six years I have broadened my skills set into other occupational hygiene and environmental monitoring disciplines. I have held various positions within my field, such as senior hazmat consultant, occupational hygienist and project, technical, quality and laboratory manager. In a previously held position I was a senior project manager overseeing a team of twenty asbestos assessors, laboratory staff and occupational hygiene technicians. I have recently set up my own business, EHO Consulting Pty Ltd and am working on an ongoing project with NSW Fair Trading. My future aspirations are to provide a consultancy with a dynamic, friendly and vibrant environment for a motivated team to work and develop.

**ABSTRACT**

This presentation will present the outcomes from a lead dust remediation programme within an urban environment during demolition and remediation work. The study aims to identify any correlation between initial surface lead in dust levels, airborne inhalable lead in dust (Static samples, not exposure) and lead in blood samples. There is relative scarcity of biological exposure monitoring in an occupational setting and relative exposure levels to urban lead dust. This study hopes to demonstrate that exposure can be minimised as far as reasonably practicable by implementation of good work practices and worker awareness. The approach adopted includes an initial investigation into lead in dust contamination of the subject site, prior to works commencement. Control air monitoring during lead remediation within the works area and approximately 18 month's of lead in blood samples, monitoring the demolition and remediation worker's exposure levels. High concentrations of lead in dust is found throughout the Sydney metropolitan area due to its industrial history and vehicular / aviation fuel additives. As a result, most buildings and dwellings within the metro have highly accumulated lead in dust concentrations within their roof, floor and wall voids. Exposure to lead in dust often occurs during renovation or demolition works, with the demolition workers most at risk, followed by secondary exposure to other trades involved in the project. Implementation of good hygiene practices, such as availability of hygiene facilities and lead awareness training, as well as controlled removal of lead dust and the use of PPE, resulted in a general reduction of lead in blood for workers.

## POSTER ABSTRACTS

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### RE-CALIBRATING OCCUPATIONAL NOISE EXPOSURE USING TASK BASED AND FULL SHIFT MEASUREMENT COMPARISONS

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*David Lowry*

Superintendent Occupational Hygiene | MAIOH, COH

**Introduction:** The main purpose of this study was to determine if a combination of area noise measurements and task activity diaries give a reasonable estimate of full-shift dosimeter measurements in a cohort of utility workers. Few studies have been conducted to evaluate the efficacy of using task based noise exposures to estimate full shift time weighted average (TWA) noise exposures. **Methods:** Estimates of full shift time TWA noise exposures for a group of utility workers (n=224) were calculated using dosimeter measurements. Task based noise measurements using a sound level meter were used to recreate the TWA for each personal dosimetry sample based on detail provided in the task activity diary for each sample. Full shift TWA noise exposures were compared to corresponding area noise measurements using simple linear regression analysis. **Results:** Associations between full shift TWA measurements and task-based area measurements were closely associated, with R<sup>2</sup> values above 0.72 for all job roles. **Discussion:** Task-based noise exposure analysis has the potential to be widely used in the utilities industry, particularly for roles with fairly stable tasks. While full-shift monitoring to determine TWA exposures is useful, the changing work environment, variability in tasks and equipment, and varying workday hours, limit the ability of the 8-hr TWA to accurately characterise the exposures and associated health risks for utility workers.

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### MANAGING FORMALDEHYDE EXPOSURE IN MODERN UNIVERSITY ANATOMY LABORATORIES: HOW LOW CAN WE GO?

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*Lachlan McPhail*

Health and Safety Advisor Tertiary Education Sector | University of Wollongong

Lachlan McPhail<sup>1</sup>, Linda Apthorpe<sup>1</sup> & Jane Whitelaw<sup>1</sup>. University of Wollongong with substantial information available regarding controlling formaldehyde exposure, modern University anatomy laboratories are likely to have formaldehyde exposure within acceptable limits when compared to the current Australian workplace exposure standards (WES) of 1ppm Time Weighted Average (TWA) and a Short-Term Exposure Limit (STEL) of 2ppm. There is substantial evidence classifying Formaldehyde as carcinogenic to humans, namely strong evidence of nasopharyngeal cancer and leukaemia (IARC, 2012). However, ongoing research challenges the original conclusions about formaldehyde being a human carcinogen (Swenberg et.al, 2013); (Marsh et.al, 2016); (Kwon et.al, 2018) and further identifies exposure associations with other health conditions, such as adverse reproductive health risks (Wang et.al, 2015). As further research develops, there is a drive to set workplace exposure standards lower than previously determined. The American Conference of Governmental Industrial Hygienists (ACGIH, 2017) have recommended lowering the Threshold Limit Value's (TLV) a to 0.1 ppm (TWA) and 0.3 ppm (STEL) to minimise the potential for sensory irritation in the eye and upper respiratory tract with consideration also to upper respiratory tract cancer. This study focussed on formaldehyde exposure assessment of research and teaching activities within recently constructed anatomy laboratories, using the American Industrial Hygiene Association (2015) exposure assessment strategies, to address baseline exposure assessment and ascertain compliance to a lower exposure standard. It was anticipated some tasks and activity may exceed the conservative exposure standards recommended by the ACGIH (2017) prompting further action to embrace new technology and recalibrate our targets to minimise exposures as low as reasonably practicable.

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## RE-CALIBRATING CONTROL VERIFICATION – A QUANTITATIVE EVALUATION OF OPTIMAL WATER CART DUST SUPPRESSION ON MINING HAUL ROADS

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*Monika Buys*

Occupational Hygiene Advisor | Rio Tinto

Excessive dust generation from heavy vehicle haul roads is an issue experienced by many mining operators. Water cart utilisation is a common form of dust suppression used on unsealed mining haul roads, and yet there is limited data available in the literature to assess the performance of this as a control. The main aim of the paper is to evaluate the efficacy of water cart dust suppression on unsealed mining haul roads to determine an optimum water frequency regime. The research will provide a collaborative framework with which to perform health risk control verification linking the occupational hygiene process with the operational requirements of a mining operation. The methodology adopted will consist of a combination of real time dust monitoring and gravimetric inhalable monitoring downwind of a known 'dusty' haul road to track dust levels over time following disturbance and dust suppression interventions. The effectiveness of dust suppression will be compared against a control where no rainfall or watering has been conducted for a minimum of 12 hours. A portable meteorological station will monitor temperature, humidity, wind speed and wind direction. The soil surface will be analysed to determine particle size distribution and moisture content, and traffic volumes, vehicle types and visible dust observations will be recorded. Once all data is collected, a statistical two-way ANOVA parametric analysis will be performed to establish whether there is a significant difference between dust suppression and frequencies, and a linear regression curve will be plotted to determine optimal water spraying frequencies.

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## FINE PARTICLE EMISSIONS GENERATED BY LARGE SCALE COMMERCIAL FOOD PROCESSING

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*Sharna Walsh*

Student | Edith Cowan University

Cooking emissions generated from the use of gas appliances to perform three different cooking activities were measured in a commercial catering facility. The facility was catering for approximately 700 people, providing three meals per day. The cooking activities included gilling, deep frying and utilising a bratt pan for braising and stir frying. The maximum PM<sub>4</sub> and PM<sub>10</sub> emissions recorded on each equipment type was respectively, 2.1mg/m<sup>3</sup> and 2.28 mg/m<sup>3</sup> when braising lamb curry in two bratt pans, 37.1mg/m<sup>3</sup> and 48.1 mg/m<sup>3</sup> when grilling chicken and fish portions on two flat grills and 0.643mg/m<sup>3</sup> and 0.655 mg/m<sup>3</sup> when deep frying potato chips in two deep fryers. When compared to a maximum of 0.032mg/m<sup>3</sup> of PM<sub>4</sub> and 0.054 mg/m<sup>3</sup> of PM<sub>10</sub> recorded in the dining room away from any cooking activities, this clearly demonstrates the cooking activities increase the levels of particulate matter present in the air significantly, with grilling meat products recording the highest peak concentrations. When grilling meat products, the particulate matter generated also consisted of up to 99% of PM<sub>1</sub>. An association between the cooking temperatures for different food types and particulate matter generation was also made, with a low grilling cooking temperature used to cook eggs generating the lowest amount of particulate matter. Further investigation of events causing peak emissions would be beneficial as well as an investigation into the chemical composition of the particulate matter to further understand the risk of adverse health effects for individuals performing the cooking activities.

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## INFLUENCE OF FACIAL HAIR ON DISPOSABLE RESPIRATOR FIT TEST FACTORS

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*Brendan Warrell*

*Acting Principal Inspector - Asbestos Unit Workplace Health and Safety Queensland*

Student | Edith Cowan University

Respiratory protective equipment (RPE) is required in workplaces to manage risk associated with exposure to airborne contaminants. Half-face disposable respirators are a commonly used category of negative pressure air purifying RPE that rely on wearers to physically breathe air through the filtering facepiece to remove contaminants. To provide optimal levels of respiratory protection, RPE must be worn correctly, fit the wearer and wearers should be clean shaven. This project involves describing the influence of facial hair on fit test fit factors for persons wearing disposable respirators. Fit factors will be quantitatively measured and collected using a TSI Portacount Pro+ 8038 respirator fit tester. Sampling will be conducted at a single location with a sample size of ten (10) male subjects over the course of five (5) consecutive days. A new single model P2

classified half-face disposal respirator, 3M Aura 9332+P2, will be worn by sampling subjects for each test. On day one, all subjects will shave with a razor prior to being initially fit tested. Subjects will then allow their facial hair to grow over the course of five (5) consecutive days with fit testing being repeated each day. Facial hair length, areal density (sparse, average and dense) and texture (fine, average, coarse and wiry) will be visually estimated and recorded. The fit test will be a continuous test, consisting of seven test exercises performed for at least one minute each completed in accordance with the Occupational Safety and Health Administration (OSHA) Protocol, with an overall fit factor result  $\geq 100$  equaling a pass. The results of the fit testing will provide quantitative data to characterize the influence facial hair has on fit factors. In addition, results will assist in assessing the risk posed to persons with facial hair wearing disposal respirators in workplaces where there is a risk of exposure to airborne contaminants.

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## MEASURED PROPORTION OF QUARTZ IN RESPIRABLE DUST SAMPLES IN THE INFRASTRUCTURE SECTOR

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*Kate Cole*

Occupational Health & Hygiene Manager | Sydney Metro

Sydney Metro is Australia's largest public transport project and has served a unique opportunity to leave not only a world class transportation system, but also a legacy for future generations. A strategic element of our legacy is the development of a client-led system for worker health protection. Construction activities in Sydney commonly produce respirable crystalline silica (RCS) as Hawkesbury sandstone bedrock contains high concentrations of quartz. Expectedly, RCS exposure is one of Sydney Metro's highest health risks. However, sandstone is not the only source of RCS. Other sources exist such as cement, concrete, bricks and tile for example. As part of our occupational hygiene program, each Principal Contractor is contractually required to submit the results of occupational exposure monitoring data, which is to be collected in line with a standardised health risk assessment framework, under the governance of a Certified Occupational Hygienist (COH)<sup>®</sup>. Such data includes the results of personal respirable dust and RCS exposure monitoring. In addition to personal monitoring, the use of real-time respirable dust monitors remains a useful tool for occupational hygienists to understand key sources of exposure. A challenge exists however, in understanding the range of correction factors to apply to the respirable dust measurement to provide a respective concentration of respirable crystalline silica. Over the period of two years, a significant amount of both respirable dust and RCS exposure data has been reported to Sydney Metro (>800 individual samples). This poster presents a statistical review of measured alpha-quartz in respirable dust personal exposure samples collected during general construction, demolition, and tunnelling work activities. It provides information on a range of correction factors that can be used in similar working environments to assist occupational hygienists when using real-time monitoring devices.

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## HETEROGENICITY OF ASBESTOS CONTAINING VERMICULITE – SAMPLING AND ANALYSIS CHALLENGES

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*Laura Wilson-Dennis*

Laboratory Quality Coordinator | WSP

Vermiculite is a naturally occurring mineral that expands when heated. The lightweight, acoustic dampening and heat resistant properties of the mineral are often applied as a sprayed coating making it ideal for insulation, sound and fire proofing applications. While vermiculite itself has not been found to pose health risks, some vermiculite materials also contained asbestos, which like other asbestos containing materials may pose a serious health risk. WSP has been involved in a vermiculite sampling and testing program with the aim to safely manage the product and identify health risk to occupants. The variation in mineral sources, spray production and application techniques, means the quantity of asbestos in vermiculite is rarely homogenous, and if present, can vary greatly between and within buildings - even within a single room. These properties make it difficult to representatively sample and analyse compared to other asbestos containing materials WSP found that, when sampling vermiculite, the typical sampling methods needed to be modified to include increased number and sample sizes, composite sampling methods, and gravimetric analysis to estimate the percentage of asbestos distributed in the vermiculite. These techniques overcame the difficulties and limitations of standard presence/absence analysis methods. Improving the accuracy of identifying asbestos containing vermiculite was important in providing representative and accurate data for occupational hygienists to safely manage the material and determine risk to health.

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ASSESSMENT OF FRONT-END LOADER EXPOSURE TO OCCUPATIONAL WHOLE-BODY VIBRATION AT AN  
AUSTRALIAN PORT

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*Lisa Mills*

Student | Edith Cowan University

Operators of front-end loaders at an Australian port are occupationally exposed to whole-body vibration (WBV) and jolts and jars. WBV exposures can contribute to a number of negative health outcomes including lower back pain, nausea, stomach problems and headaches. The systematic collection of WBV data is a critical step in the occupational risk management process. Unfortunately, the cost and complexity of WBV monitoring equipment is a barrier to routine occupational exposure monitoring and there is a lack of published literature describing port front-end loader operator WBV exposures. The literature also indicates the potential for simple, cost effective mobile iOS application to be used in lieu of standard monitoring equipment. This research study will use a quantitative design to measure front-end loader operator WBV during material blending and tipping activities at an Australian port. Standard monitoring methodology using a tri-axial seat pad accelerometer, as recommended by both Australian and international standards will be used simultaneously with a mobile iOS application to measure WBV. The data from both measurement methods will be collated according to operational activity and assessed in relation to the 'caution' and 'likely health risk' guidelines as published in ISO2631-1. Upon completion of the exposure characterisation and the literature review on the health impacts of WBV, recommendations will be made in relation to control measures required to ensure port front-end loader operator exposures remain acceptable. Differences between the paired sampling data will be examined using a Bland-Altman plot test to compare the two measurement techniques and evaluate the agreement between the two. Based on the outcome of the Bland-Altman assessment, recommendations will be made in relation to the future use of the mobile iOS application for WBV exposure assessment.

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SAMPLING EVALUATION OF PHARMACEUTICAL DUST FROM PHARMACY DISPENSING ENVIRONMENT

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*Yi-Ju Lin*

Department of Occupational Safety and Health of Chung Shan Medical University in Taiwan.

Recent rising of Taiwanese's awareness of workplace environment safety and health, personnel in health care system has also been an important issue, especially the pharmacist exposing to drug aerosol. In the past, studies have pointed out that in addition to causing some side effects to patients, pharmacists, physicians, nursing staff and other health care workers were also threaten by chemotherapy drugs (Gaudio et al., 1998). IARC also lists some common chemotherapeutic drugs in Group1, such as Busulfan, Chlorambucil, Cyclophosphamide; 2A level like Cisplatin; 2B level like Bleomycin and Mitomycin (IARC, 2018). Some of the drug dust was inhaled during the powder milling. This study estimated the exposure of pharmacists to drug dust in the working environments through environmental monitoring. In this study, three sampling locations were selected, which were pediatric clinics, pharmacies in medical center, and chemotherapy preparation room in medical center. PM1, PM2.5, respirable dust, PM10 and total dust were monitored by Dusttrak. Combined with the general air sampling pump, area sampling of total dust and respirable dust were carried out around the drug dispensing table with same filters. In addition, pharmacist wore a sampler with an SKC 37 mm aluminum cyclone for personal sampling. Sampling was carried out during the work time for 6 hours. The environmental dust concentration of the Pediatric clinic and the individual exposure concentration of the pharmacist are higher than those of the Pharmacy of medical center and the chemotherapeutic preparation room. It is speculated that the ventilation circulation of the clinic is poor, and the dispensing space is relatively closed, resulting in higher concentration than the other two places; The concentration of the Chemotherapeutic preparation room is obviously lower, and it is considered that the site is formulated as a negative pressure chamber and is carried out in a biological safety cabinet.

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WORKSAFE WA - RCS - PROJECTS AND MORE

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*David Torr*

Senior Inspector / Scientific Officer | WorkSafe WA Department of Mines, Industry Regulation and Safety  
(DMIRS)

Presenting data, discussion and findings in relation to respirable crystalline silica monitoring, workplace inspections and related projects - previous, present and proposed. Various industries will be discussed eg Manufactured Stone Bench Tops, Construction/Chasing and Council/Verge Work. Includes illuminating on synergistic communication and collaboration networks, including use of multidisciplinary staff to give better outcomes, how improvements and information can be aimed at the local workplace level and often more holistically at the Industry and the Occupational Health and Safety Community levels.

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EVALUATION OF FIT FACTOR AND PARTICLE DEPOSITION DUE TO LEAKAGE OF N95 FILTERING FACEPIECE RESPIRATORS

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*Yi-Ting Chen*

Master student | Chung Shan Medical University

The N95 facepiece mask protection level is considered of the filter penetration and the face seal leak. Some studies show that reduce face seal leak is more efficiency than filter media (Grinshpun, 2010). But there is little known about the relationships among the face seal leak, particle leakage deposition rate and particle size distribution. Methods: The study applied a standard Taiwan labor head model wearing 3 different kinds of N95 respirators (C-pak F550, 3M 8511, and 3M 8210). The testing used the breathing simulation device and performed 3 breathing flow rate, which indicated the steady, medium, and heavy breathing condition, respectively. The fit factors (FF) were represented by 10, 30, 50, and 100, which were measured by using quantitative fit testing. The Collison nebulizer was used to produce the challenge particles of methylene blue (MB) in the test system. Different status of the head model deposited by MB (deposition rate, DR) due to leakage were then filmed and processed using the image analysis software. The particle size distributions owing to face seal leakage were measured by Fidas Frog aerosol sizer. Conclusions: The most leaking area on the face are both sides of nose wings and cheeks to nostrils. With the leakage rate increased, the particle deposition rate increased. Even though the fit factors were the same, but the deposition rate still varies by the types of the respirators. It showed that the leakage rate and the size of leakage gap had some connection with the distribution of the leakage particles.

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RECALIBRATING THE APPROACH TO RISK ASSESSMENT IN DRINKING WATER DISTRIBUTION SYSTEMS

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*Meg Brooks*

Occupational Hygiene Technician | Rio Tinto

The management of a drinking water distribution system (DWDS) in a remote environment presents many challenges, from impact of harsh environmental conditions through to the size of distribution network. In addition, the design of the water infrastructure and the makeup of water network materials may influence system performance. These factors – referred to within the paper as ‘determinants’ – may influence microbial proliferation, which in turn may present as a health risk to consumers. The paper aims to investigate the DWDS across a number of mining operations to identify relationships between microbial detection by each determinant using a multiple linear regression model. Correlational relationships may be used in an effort to ‘recalibrate’ the approach to risk assessment in potable water systems, ultimately leading to more effective preventative management strategies. The determinants to be investigated include disinfection concentration, pipe material, time of year, experience of sampler, temperature, above or below ground pipework and volume of water used. Microbes analysed within the paper include thermophilic amoebae (all species), Legionella and E.coli. Finally, the paper will explore how the occupational hygienist can apply a frequentist statistical approach to identify exceedance determinants, which is not often applied to drinking water management.

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POST REMEDIATION VERIFICATION OF A MULTI-STOREY HERITAGE BUILDING FOLLOWING A LARGE VOLUME OF WATER RELEASE

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*Cedric Cheong*

Consultant – IEQ | GreenCap

Significant water damage and subsequent mould growth was caused when fire hydrants were activated at the top floor of a multi storey heritage building in an Australian city causing a large volume of water release. The building was recently refurbished, and the water event caused significant damage to building materials including heritage protected stairs, flooring and ceilings. The extent of water and mould damage was significantly reduced due to the quick early actions of first responders enabling structural drying to occur. This paper describes the subsequent mould and water damage assessment, remediation actions and post remediation verification efforts to bring the building back to normal pre-loss conditions. The paper discusses the use of various verification techniques including ATP bioluminescence meters, micro vacuum samples, surface tape lifts, air-borne sampling and moisture meters.

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METH CLAN LABS ON THE RISE AGAIN

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*Willow Warren*

Scientific Officer Environmental Health Directorate Public and Aboriginal Health Division Department of Health  
Western Australia

Manufacture of methylamphetamine is on the increase, after 6 years of declining numbers of reports from criminal intelligence sources, across Australia. The Department of Health (DOH) led the nation in providing guidance on remediation processes for clan labs and new interim guidance on voluntary clean-up of meth smoke houses. Clan labs (clandestine drug laboratories) are sites where illegal drugs are manufactured in secret, usually with improvised equipment, chemicals and methods. Hundreds of clan labs have been discovered in recent years, mainly in the Perth metropolitan area and larger regional centres. Clan labs primarily produce methylamphetamine (such as 'speed', 'meth' or 'ice'). While most clan labs are found in rented accommodation, others have been found in bush sites or on vacant land. Clan labs in Western Australia are often smaller and pose a lower contamination risk than those found in other parts of Australia. It's time to re-synergise the public health guidance published in 2008; to refresh the service providers' knowledge and practices, including local government and allied health services - of the requirements on forensic testing procedures, reporting and validation testing for both clan labs and smoke houses. This includes a practical approach for landowners and local government authorities (LGAs) in managing public health risks in residential dwellings contaminated with illicit drug residues.





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