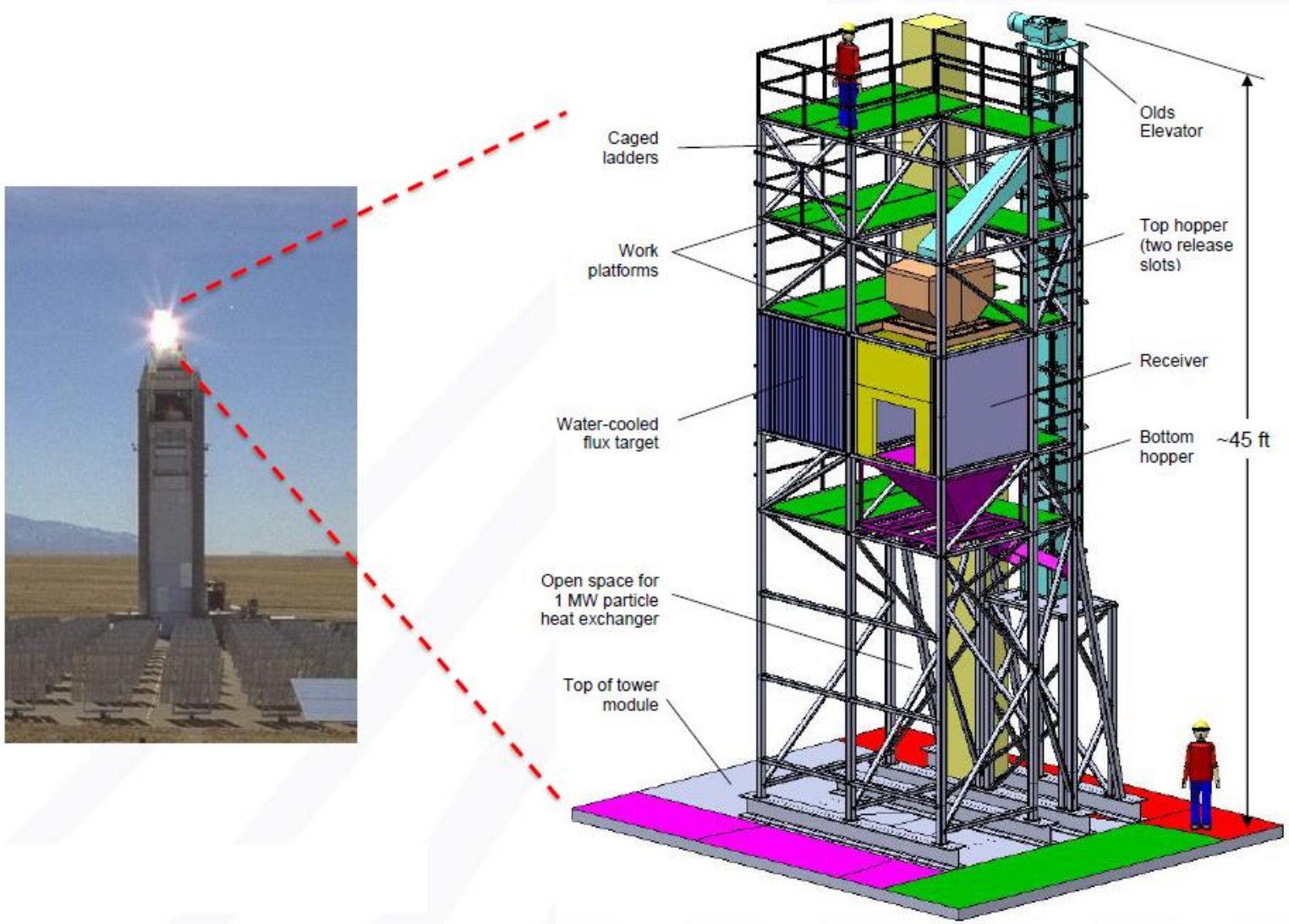
Respirable Crystalline Silica: Recent Experiences in Protecting Workers Against Silica Dust in a Small Foundry

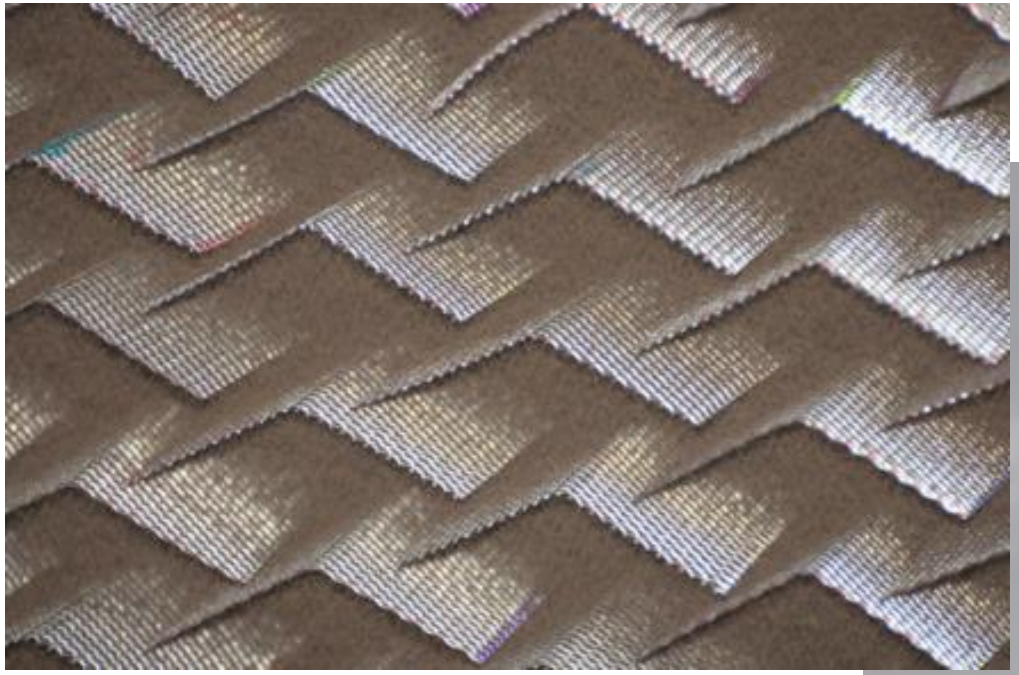
Robert Olds (Managing Director), Dr William Olds
Olds Engineering, Maryborough, Qld
Australian Foundry Institute Conference 2022


OLDS

Olds Elevator

Solar Thermal Power Generation





Introduction

- We are a small operation, foundry operations requiring 2 staff with approx. 50% time in foundry.
- We are all surrounded with hazards in foundries. It is easy to see RCS as “just another hazard”.
- We thought we were OK regarding RCS due to our size.
- Foundry work: Approx. 29 tonnes fine silica sand (22 cubic metres) used per year.
- We do not reclaim sand.

Disclaimer

- We are not lawyers, medical professionals or occupational hygienists!
- Your RCS levels will be different, based on your own materials and work processes.
- Your controls will need to suit your unique hazards and work environment.
- We are sharing our RCS levels in “good faith”, to raise awareness of RCS and its hazards in the foundry industry.

Overview

- Silica
- RCS Monitoring – Our Experiences
- Controlling RCS Exposures
- Summary
- Recommended Resources

Silica

- Highly recommend webinar of Assoc Prof David Bromwich (Health Lungs Forum 2019, Qld WHS website).
- Very practical guidance about industrial ventilation and silica.
- 1930s USA – silica was already identified as a major problem in tunnelling and mining.

Silica:

- Abundant, natural material making up about 50% of Earth's crust.
- Crystalline form is quartz (SiO_2).
- Occurs in most rocks, sands and clays.
- Products such as cement, mortar, bricks, pavers, fibre-cement sheet, tiles, as well as natural and composite stone benchtops.
- Content varies drastically, from ~10% in some stones to 95-100% in most sands and sandstone.

Respirable Crystalline Silica (RCS)

- RCS is the small, invisible particles that you can breathe in when working with any material that contains silica.
- Gravity has little effect on smaller particles.
- < 10 microns diameter is respirable dust, and at the limit of what the eye can see.
- Especially created by high-energy processes that can crack silica grains.
  - Cutting, crushing, sawing, polishing, grinding, drilling, etc.
- RCS may already be in silica-containing materials and become released when handled, during housekeeping, etc.

Health Effects

- Exposure is strictly controlled.
- In line with national guidelines, Queensland halved its Workplace Exposure Standard in July 2020. Now 0.05 mg/m^3, 8-hour time-weighted average (TWA).
  - TWA is based on an 8-hour day, 5-day working week. WES may be adjusted down for different working arrangements, eg longer shifts, or where a 16-hour recovery period isn't possible. The method for adjustment is determined by an occupational hygienist.

Health Effects (cont'd)

- Exposure to RCS adds up over time.
- A WES is not a dividing line below which workers will receive no ill effects.
- Anyone who works with silica can suffer ill health effects.

Silicosis

- **Silicosis** of the lung is the most widely noted health effect.
  - Chronic – 10 to 30 years
  - Accelerated – 1 to 10 years
  - Acute – 1 year
- Small silica particles get trapped in the deepest parts of the lungs.
- Over many years, they cause fibrosis and scarring. This condition, silicosis, is incurable.
- Workers may not present with any symptoms at time of diagnosis.
- Damage to health can continue, even after exposures stop.

Lung Cancer

- **RCS causes lung cancer.**
- The International Agency for Research on Cancer (IARC) declared RCS a carcinogen (Group 1) (1997).

Other Health Effects

- Other cancers, emphysema, chronic bronchitis, chronic obstructive pulmonary disease (COPD) and renal failure.
- Smokers and workers with poor lung health may have extra problems.

Stone Benchtop Industry in Qld

- Rise in accelerated silicosis cases (1 – 10 years), which was once rare.
- WHS Qld audited 10 businesses, finding very high RCS exposures and that workers were at significant risk of developing silicosis
  - Cutting and polishing operations especially dangerous
- Queensland has led Australia in publishing a Code of Practice in 2019 for managing RCS exposure in the stone benchtop industry.
- Generally speaking, its recommendations can be transferred to the foundry industry.

Foundry Sources

- Check safety data sheet (SDS) and technical data sheet (TDS) to find out crystalline silica content.
- For example, our silica sand: 106 – 425 microns diameter, minimum 95% silicon dioxide (SiO_2).
- Refractory cement.

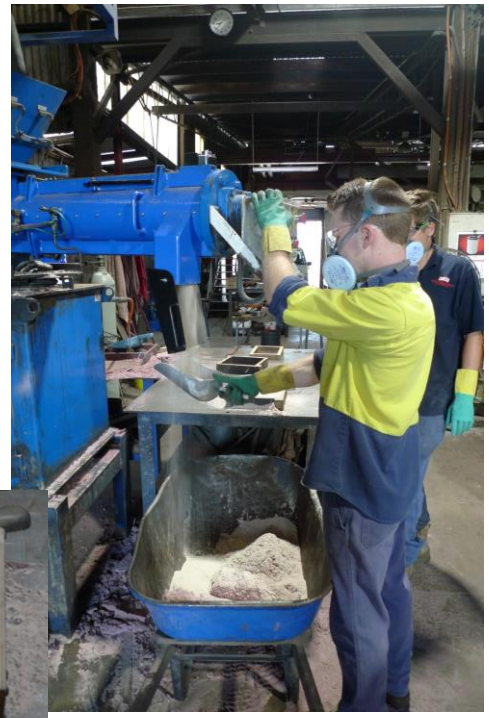
RCS Monitoring – Our Experiences

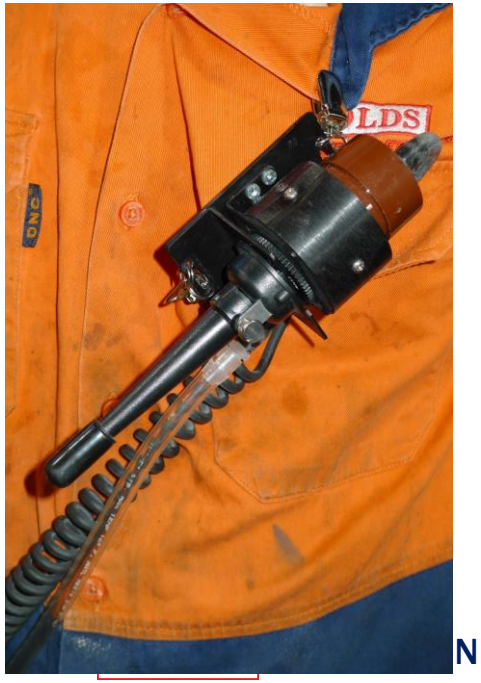
- In November 2021, we engaged a Certified Occupational Hygienist (Aust. Institute of Occupational Hygienists Inc)
- Aim: Assess exposure to dust and RCS in relation to relevant legislative requirements and determine appropriate control strategies if required.

Our Foundry Processes

Well ventilated, sealed floors in preparation area, silica sand floors surrounding furnaces.

1. Unloaded from 1m^3 bulk bags into uncovered floor hopper (gravity).
2. Flows into intake hopper.
3. Lifted with Olds Elevator.
4. Flows into overhead hopper (gravity).
5. Sand dispensed into WES Omega mixer, binder and catalyst dosed automatically and mixed with the paddle mixer inside arm.
6. Slightly damp sand ejected on demand.
7. Mould made.
8. Loose/waste sand brushed away, or if not possible, blown with compressed air.
9. After pouring, cold moulds broken open outside (hammers, chisels, etc).
10. Castings brushed and sprayed with high-pressure water cleaner.
11. Clean-up: hard sand chipped/scraped from mixer paddles, vacuum (H-class industrial vacuum cleaner), no dry sweeping.
12. PPE: half-face reusable respirator, with P2 particulate filter.





Method

- Both respirable dust and crystalline silica were measured. A laboratory later measures the percentage RCS in the whole sample to calculate RCS exposure.
- AS 2985:2009
- Four personal exposure samples were taken using worker-worn devices (vertical cyclone elutriators).
- Included 2 workers in machine shop, away from foundry.
- 1 static sample was taken, mounting device on a tripod next to the sand mixer.

Method (cont'd)

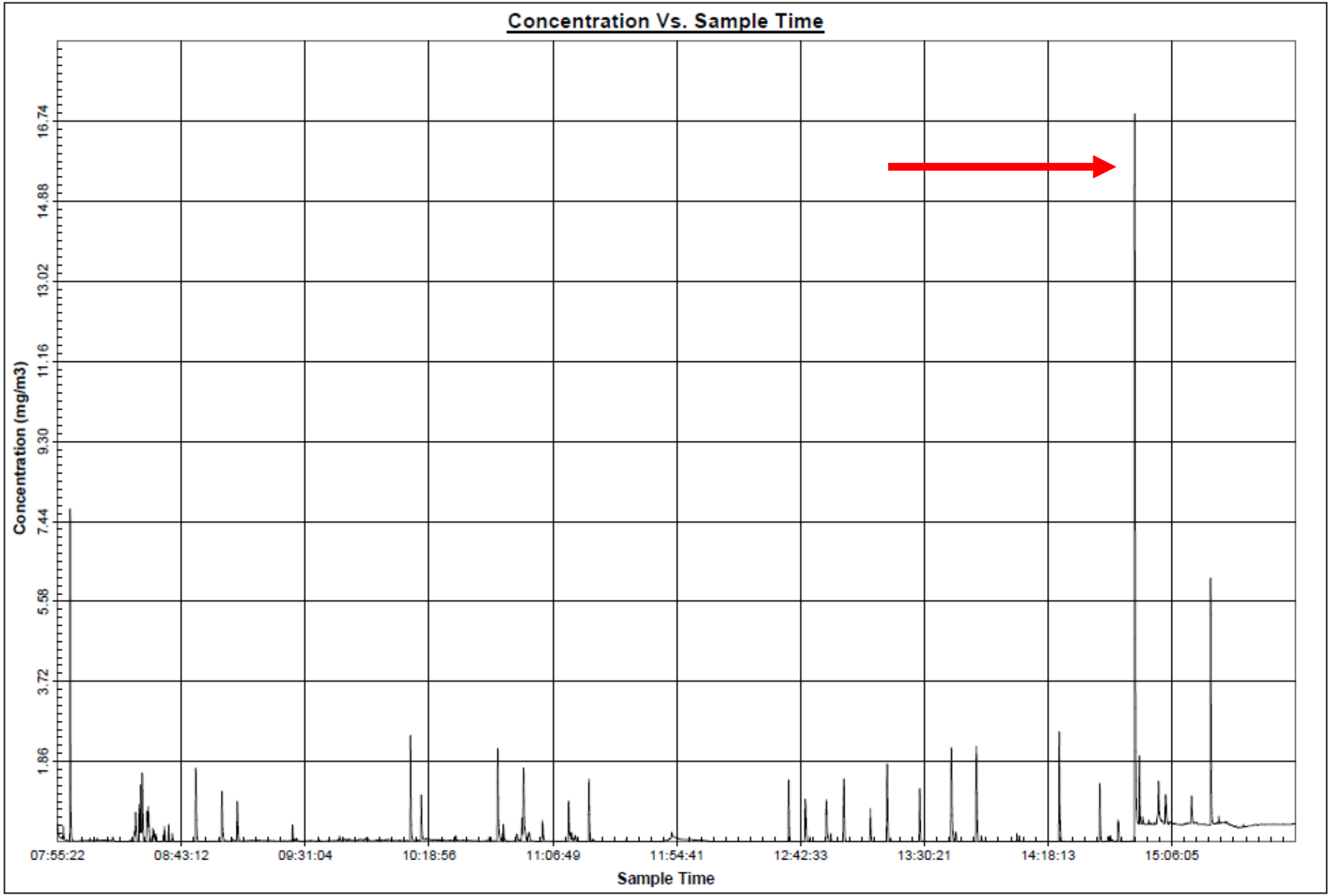
- Main foundry worker's device took real-time measurements (only one in Australia at the time) (HD-7204, 1 sample/sec).
- Full day of foundry work, including breaks (almost 8 hours).
- Infrequent tasks were included, eg unloading a bulk bag only occurs approx. every 2 weeks.
- OH will look at environment, materials, processes, talk with workers and PCBUs, consider similar operations, etc.

Results

- Medium health risk
- Wearing RPE not necessary (still needed for some tasks with chemicals).
- Health monitoring not required as below 50% of WES
- All workers' exposures were less than 20% of the WES
- 3 of 4 workers were less than limit of quantification, or <7% of WES
- Static sample less than limit of quantification
- Respirable dust exposure (other dusts) was < 5% the WES threshold limit value of 3 mg/m^3 for all workers.

Results (cont'd)

- Real-time monitor allowed work processes to be assessed on one worker.
  - Video camera ran continuously, but no correlations with peaks found.
  - Near end of day, cyclone collector fell into waste sand pile and approx. 15 mins data lost.
  - Large peak corresponds to worker reattaching collector, which was likely contaminated and so results are likely to be lower than reported 18% of WES.

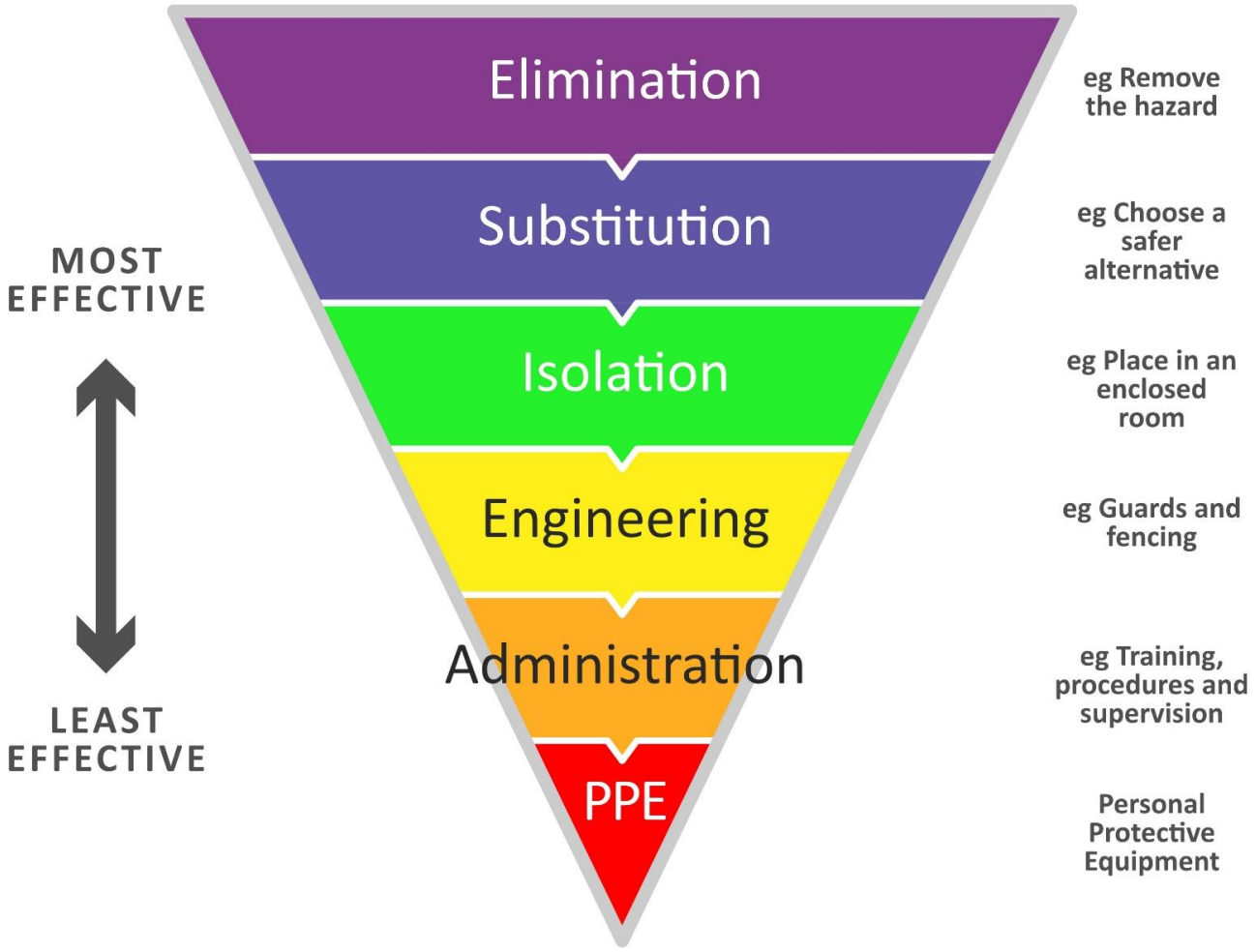

Concentration Vs. Sample Time
Concentration (mg/m3)
16.74
14.88
13.02
11.16
9.30
7.44
5.58
3.72
1.86
07:55:22
08:43:12
09:31:04
10:18:56
11:06:49
11:54:41
12:42:33
13:30:21
14:18:13
15:06:05
Sample Time

Medium Health Risk

- Determined from risk matrix and OH guidelines
- Severe consequences (5/5) – carcinogen
- Rare likelihood (lowest)
- Overall result: medium risk
- OH may require ongoing monitoring, depending on “likelihood” rating.
- Rare likelihood → monitoring not required usually.

Controlling RCS Exposures

- Use the Hierarchy of Hazard Controls
- Elimination and substitution usually not possible.
- Isolation difficult
- Engineering
  - Ventilation is highly effective!
  - Natural or forced (fans)
  - Enclose processes
  - On-tool extraction



Ventilation Design

- Blowing is much better than sucking:
  - Sucking: Face velocity decays to ~ 10% of its value at a distance equal to orifice diameter.
  - Blowing: Face velocity decays to ~ 10% of its value at a distance **30 times** the orifice diameter.
- Sucking is not directional. Blowing is directional.
- Ventilation design is a science – but the principles are simple.

Vacuum Cleaning

- **It is essential to use a H-class (high hazard) industrial vacuum cleaner**
- H in “H-class” does not stand for HEPA!
- Fitted with an H13 HEPA filter
- Filtration efficiency of 99.995%

Water Suppression

- Water suppression works well – may be difficult in a foundry.
- Droplet diameter ~ particle diameter, to promote agglomeration of particles.

Administrative Controls

- Information, training and instruction for workers:
  - Training about health risks
  - SDSs
  - Operations that produce RCS
  - Workplace RCS levels – results of monitoring
  - Inductions
  - And more
- Supervision
- Signage
- Restricted access

Respiratory Protective Equipment (RPE)

- A last resort, must be used with higher order controls.
- Does not reduce the concentration of silica in the air.
- Tight-fitting respirators rely on an excellent fit, but this is very difficult to achieve.
- Facial hair growth during a shift is many times larger than silica particle diameter.
- Protection factors may be considerably lower than implied by manufacturers.
- Substandard powered RPE helmets are being sold that are NOT suitable for silica.

https://www.abc.net.au/news/2018-10-12/what-is-the-dust-lung-disease-silicosis/10365604

Respiratory Protective Equipment (cont'd)

- Comfort, fit-testing, fit-checking must be considered.

https://www.3m.com.au/3M/en_AU/p/d/v101182012/

Respiratory Protective Equipment (cont'd)

- An excellent RPE device is a powered air purifying helmet, since a tight seal is not essential.
- Minimum required protection factors (MRPFs) towards 50 x can be achieved.

https://www.3m.com.au/3M/en_AU/p/d/v000434968/

Summary

- RCS is extremely hazardous and invisible to the naked eye.
- Need to get exposures as low as reasonably practicable (and below WES).
- More work is needed to identify work processes that produce RCS in foundries.
- Engage a Certified Occupational Hygienist to measure your workplace levels (refer AIOH website).
- Get levels as low as possible before conducting air monitoring – reduce the likelihood of health monitoring and ongoing cost of monitoring.

Summary (cont'd)

- Be proactive – WES values sometimes are revised.
- Regularly review processes.
- Look out for secondary sources, eg poor housekeeping, clothing, etc.
- Inductions.
- Information, training, instruction and supervision must be provided to workers, including air monitoring results.
- Keep records of workers' exposures (30+ years) and give them access whenever requested.
- We want to make available our resources – staff training and exams, induction template, etc.

Recommended Resources

- **Industrial Ventilation: Silica (Video, Slides & Transcript)** – Assoc. Prof. David Bromwich, Healthy Lungs Forum, 2019, Queensland, www.worksafe.qld.gov.au/resources/videos/webinars/industrial-ventilation-silica
- **Silica – Identifying and managing crystalline silica dust exposure**, WHS Qld, www.worksafe.qld.gov.au/__data/assets/pdf_file/0021/17427/silica-crystalline-dust.pdf
- **Managing respirable crystalline silica dust exposure in the construction industry – Information for employers**, WHS Qld, www.worksafe.qld.gov.au/__data/assets/pdf_file/0016/30463/managing-respirable-crystalline-silica-dust-exposure-in-the-construction-industry-employer.pdf
- **Managing respirable crystalline silica dust exposure in the stone benchtop industry: Code of Practice 2019**, WHS Qld, www.worksafe.qld.gov.au/__data/assets/pdf_file/0013/32413/managing-respirable-crystalline-silica-dust-exposure-in-the-stone-benchtop-industry-code-of-practice-2019.pdf
- **Silica – Technical guide to managing exposure in the workplace: Work-related disease strategy 2012-2022**, WHS Qld, www.worksafe.qld.gov.au/__data/assets/pdf_file/0012/18111/silica-managing-workplace.pdf
- **3M Youtube channels** – Respirator maintenance, fit checking for employees, fit testing kit instructions, training videos, etc

Thank you for your attention

Robert Olds (Managing Director) & Dr William Olds

Olds Engineering

Maryborough, Qld

Ph: 07 4121 3649

sales@olds.com.au

www.olds.com.au