# Silica Hazard Awareness


OHTA Occupational Hygiene Training Association

AIOH AUSTRALIAN INSTITUTE OF OCCUPATIONAL HYGIENISTS 40 YEARS
CELEBRATING OVER 40 YEARS OF PROTECTING AUSTRALIAN WORKER'S HEALTH

# Objectives

- Define occupational safety and health
- Provide background on what silica is and where it is present
- Discuss where and how exposure to silica occurs
- Describe the health effects related to silica
- Discuss how you measure it
- Describe how you control it

# Occupational Safety and Health

Occupational Safety and Health ( OSH)

- Occupational (Industrial)  Hygiene-the anticipation, recognition, evaluation, control and prevention of hazards from work that may result in injury or illness
- Occupational Medicine-branch of medicine concerned with the maintenance of health in the workplace
  - Includes prevention and treatment of work-related injuries and illnesses
  - Secondary focus on maintaining and increasing productivity

Occupational (Industrial) Hygiene  Occupational Medicine  Occupational Health

# Why is OSH Important?

- Globally, 6,300 people die as a result of occupational injury or work-related disease every day
  - More than 2.3 million deaths per year
  - Tremendous impact on the global community- individuals, families, and employers
  - Many injuries and diseases are preventable

# Work related respiratory diseases

- Occupational airborne particles and inhaled cancer-causing agents (i.e. carcinogens) are an important cause of death and disability worldwide
- Silicosis, lung damage caused by scarring from silica dust, is the world's oldest known occupational disease (around 400 B.C.)


DANGER
SILICA DUST
HAZARD

# What exactly is silica?

| Word | Definition |
|---|---|
| Silicon (Si) | Second most abundant element |
| Silica ($Si + O_2$) | Combination of silicon and oxygen |
| Silicates ($Si + O_2$ + metal) | Combination of silicon, oxygen and one or more metals |
| Silicone | Synthetic polymer with properties like rubber |

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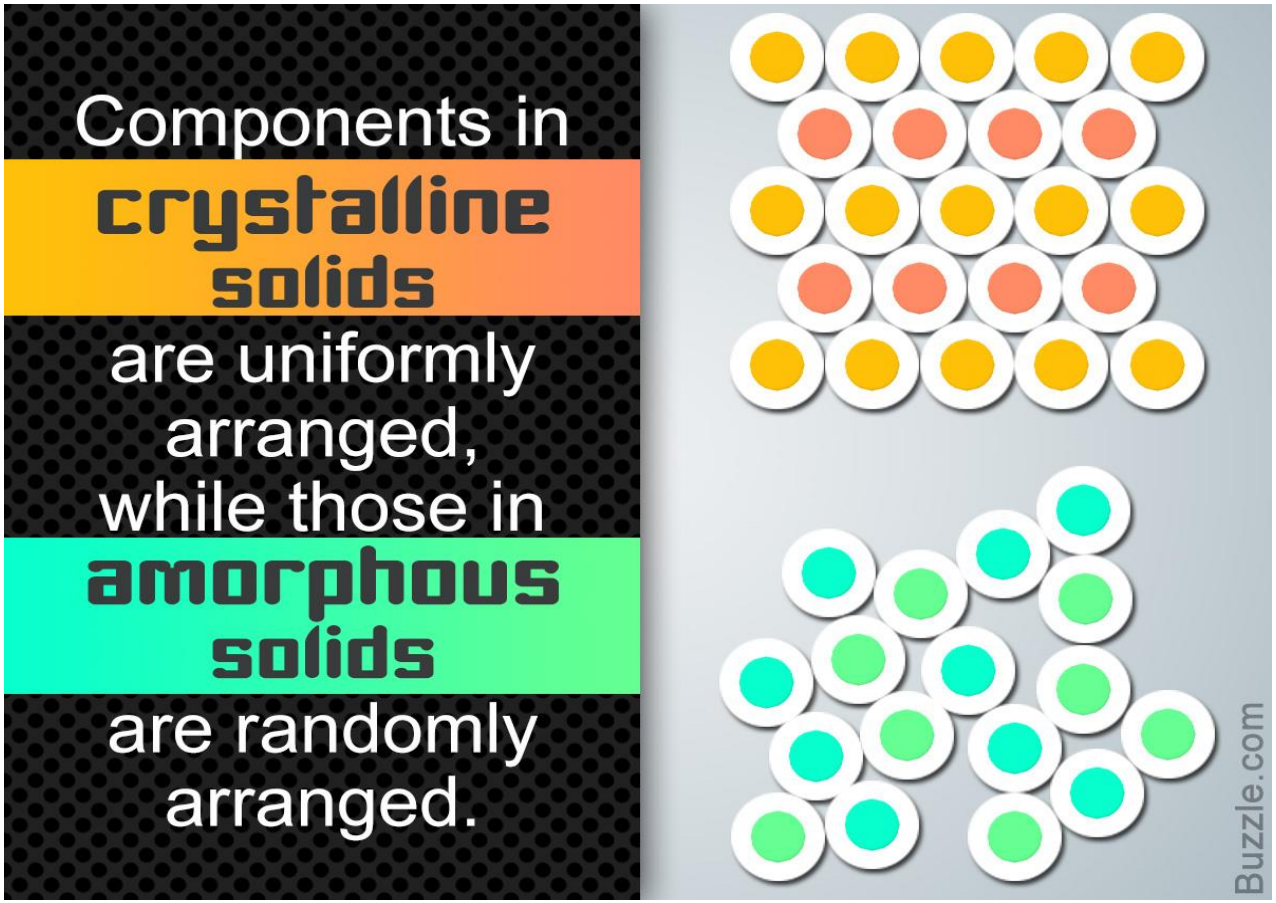
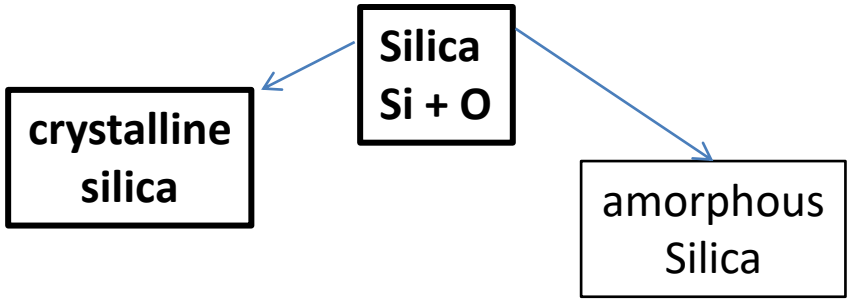
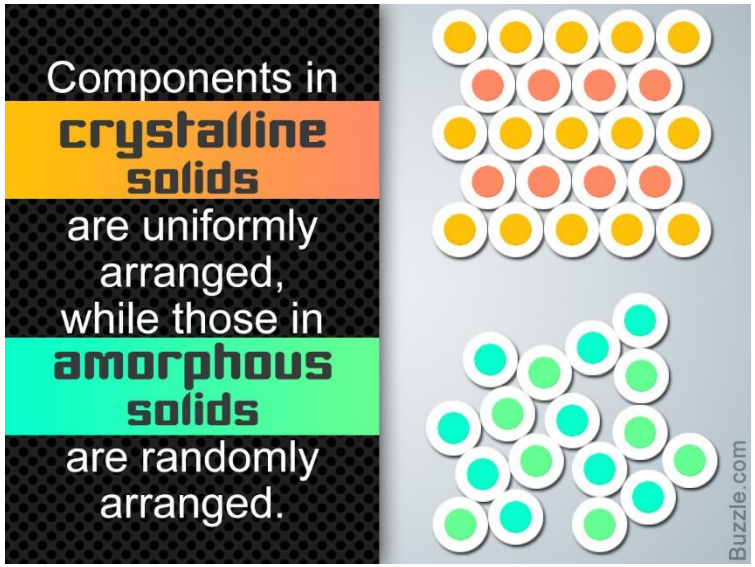
# Forms of silica



# Types of silica dust in air



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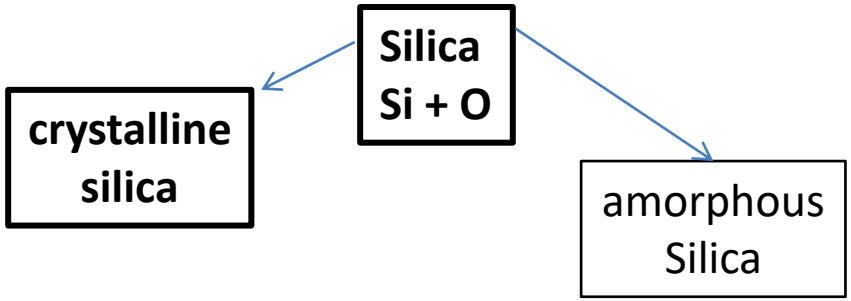
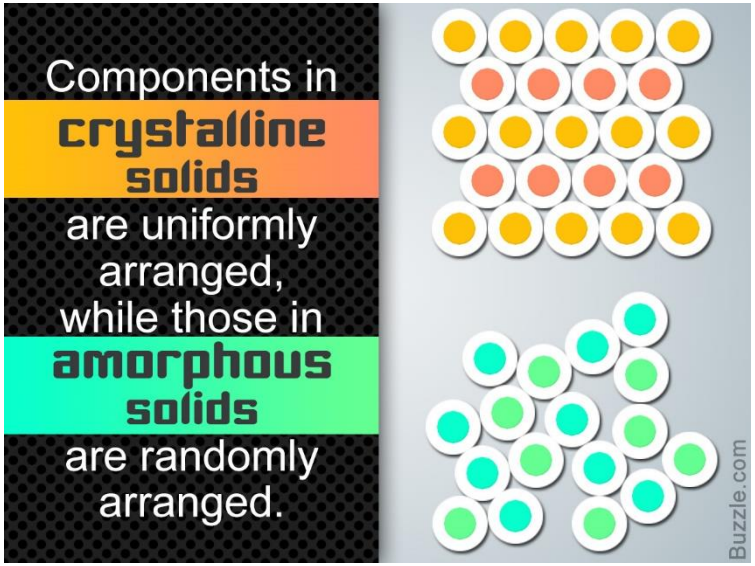



**Does not cause silicosis**



# Types of silica dust in air

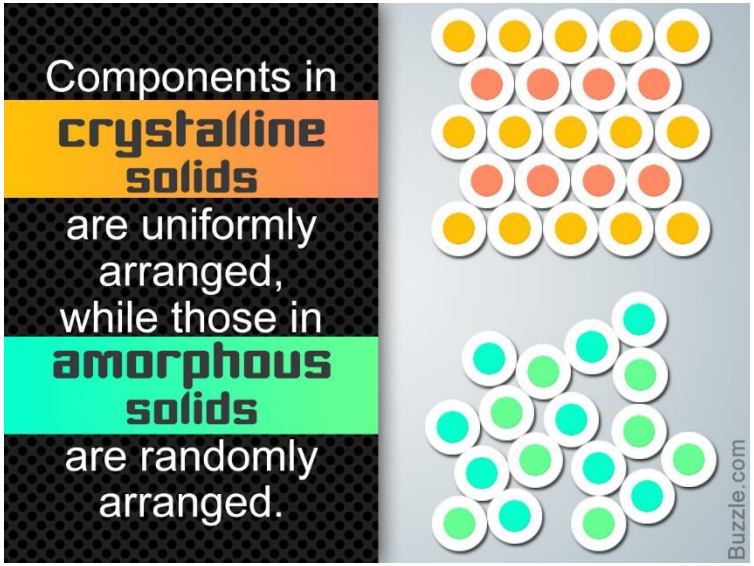
**Silica**
**Si + O**

**crystalline silica**

amorphous Silica

| cristobalite (less common) | tridymite (less common) | **quartz (common)** |
|---|---|---|

**Does not cause silicosis**

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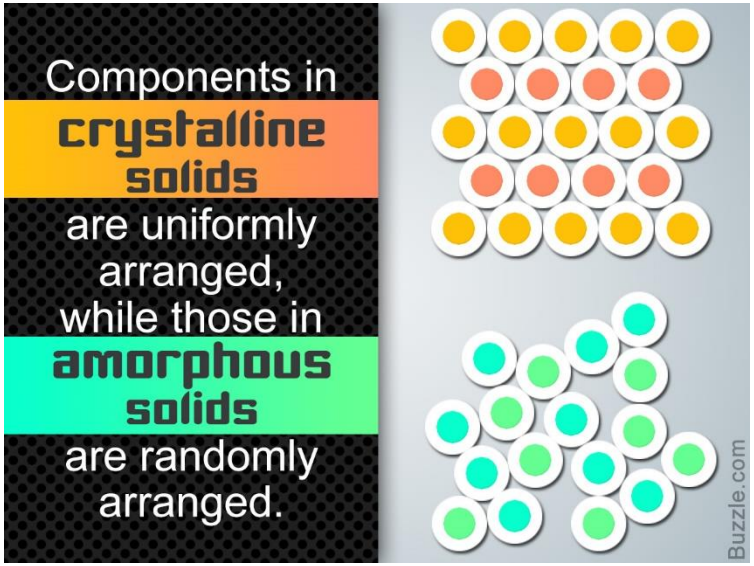


large particles

**small (respirable) particles <10um**

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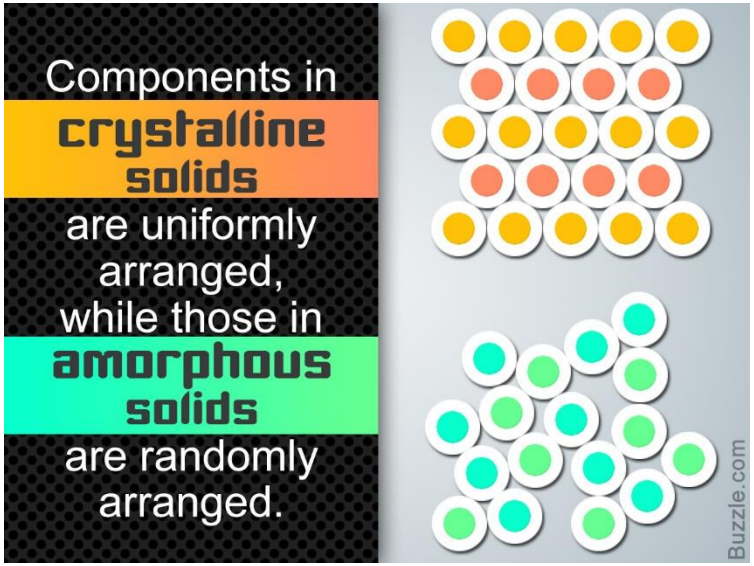
# Types of silica dust in air

**Silica**
**Si + O**

- **crystalline silica**
  - cristobalite (less common)
  - tridymite (less common)
  - **quartz (common)**
    - large particles — no problem
    - **small (respirable) particles <10um** — **PROBLEM!!!**
- amorphous Silica — **Does not cause silicosis**



# Silica

- Crystalline silica is one of the most common minerals found in the earth's crust
  - Naturally-occurring

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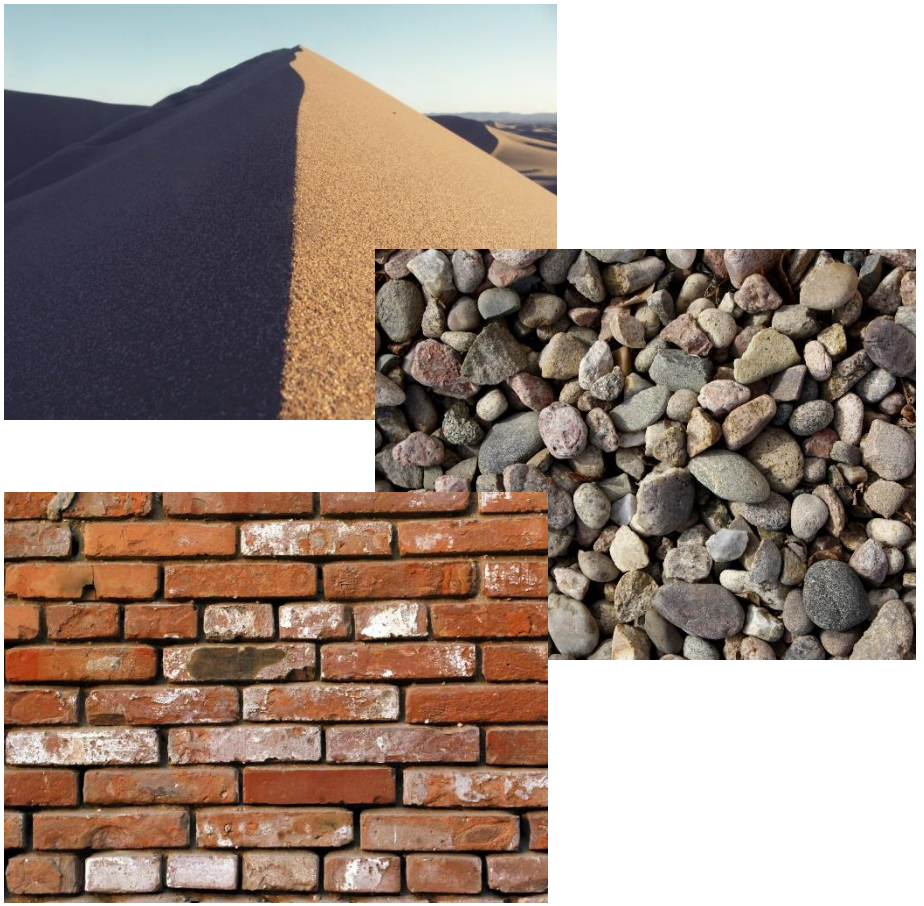
  - Incorporated into manmade materials



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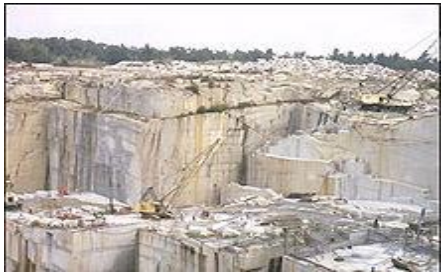
- Crystalline silica is one of the most common minerals found in the earth's crust
  - Naturally-occurring
  - Incorporated into manmade materials
  - Used to manufacture products
- Silica is EVERYWHERE!

# International Concern over Silica

- At least 227 million workers are employed in high risk industries worldwide
  - Over 1 million children in these industries
- Exposed people are often the most vulnerable, disadvantaged and medically underserved
- Respirable crystalline silica (RCS) particles have been classified as an **occupational airborne particulate of worldwide concern**

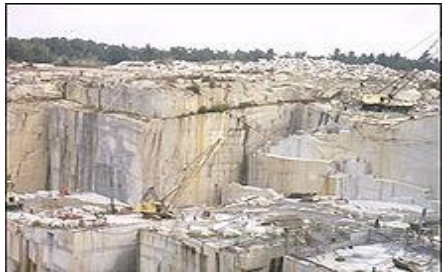
# How do people get exposed?

# Industries where Exposures Occur



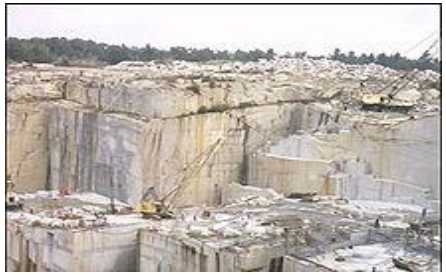
- Mining & Quarry work

# Industries where Exposures Occur



- Mining & Quarry work
- Construction

# Industries where Exposures Occur



- Mining & Quarry work
- Construction
- Manufacturing

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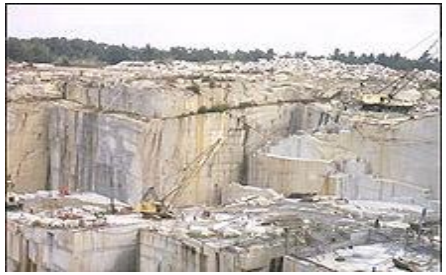
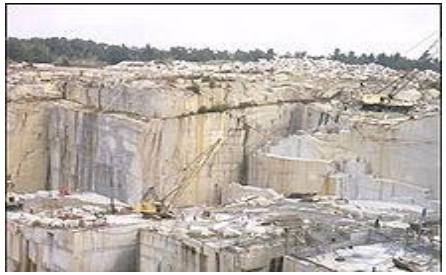


- Mining & Quarry work
- Construction
- Manufacturing
- Ceramics

# Industries where Exposures Occur



- Mining & Quarry work
- Construction
- Manufacturing
- Ceramics
- Brick making

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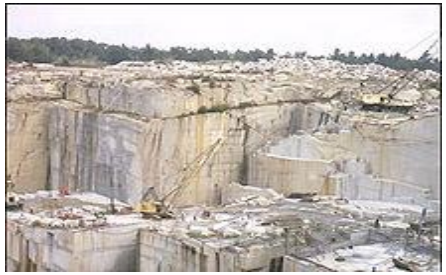
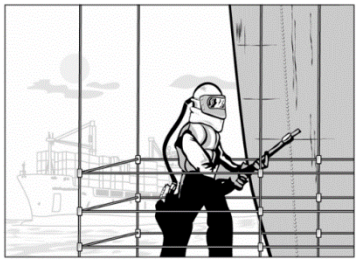


- Mining & Quarry work
- Construction
- Manufacturing
- Ceramics
- Brick making
- Shipyards
- Others



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# Some Tasks with Airborne Exposure

| Industries | Job Tasks |
|---|---|
| Manufacturing | Abrasive blasting, glass making, making soaps & detergents |
| Ceramics | Manufacturing clay, pottery |
| Construction | Sandblasting, rock drilling, masonry work, jack hammering, tunneling |
| Foundry work | Grinding, molding, shaking, core room |
| Mining | Cutting stone, drilling through rock |
| Railroad | Setting/laying track |
| Stone cutting | Sawing, abrasive blasting, chipping, grinding |

# Exposure routes for silica

- Primarily people are exposed by inhalation
  - Skin exposure or ingestion (i.e. eating, drinking) are not of concern
- Breathed in through the nose and mouth and can stay in the lungs for years
- Smallest particles enter deep into the lungs

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# Visible-vs-Respirable Dust

- Visible dust contains large and small particles
  - Tiny, respirable-sized particles (those that can get deep into the lungs) containing silica pose the greatest hazard and are **not** visible.
  - Largest dust is trapped in the upper airways
- ***If you see visible dust, respirable dust is also likely present!!!***

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Think about your work environment.

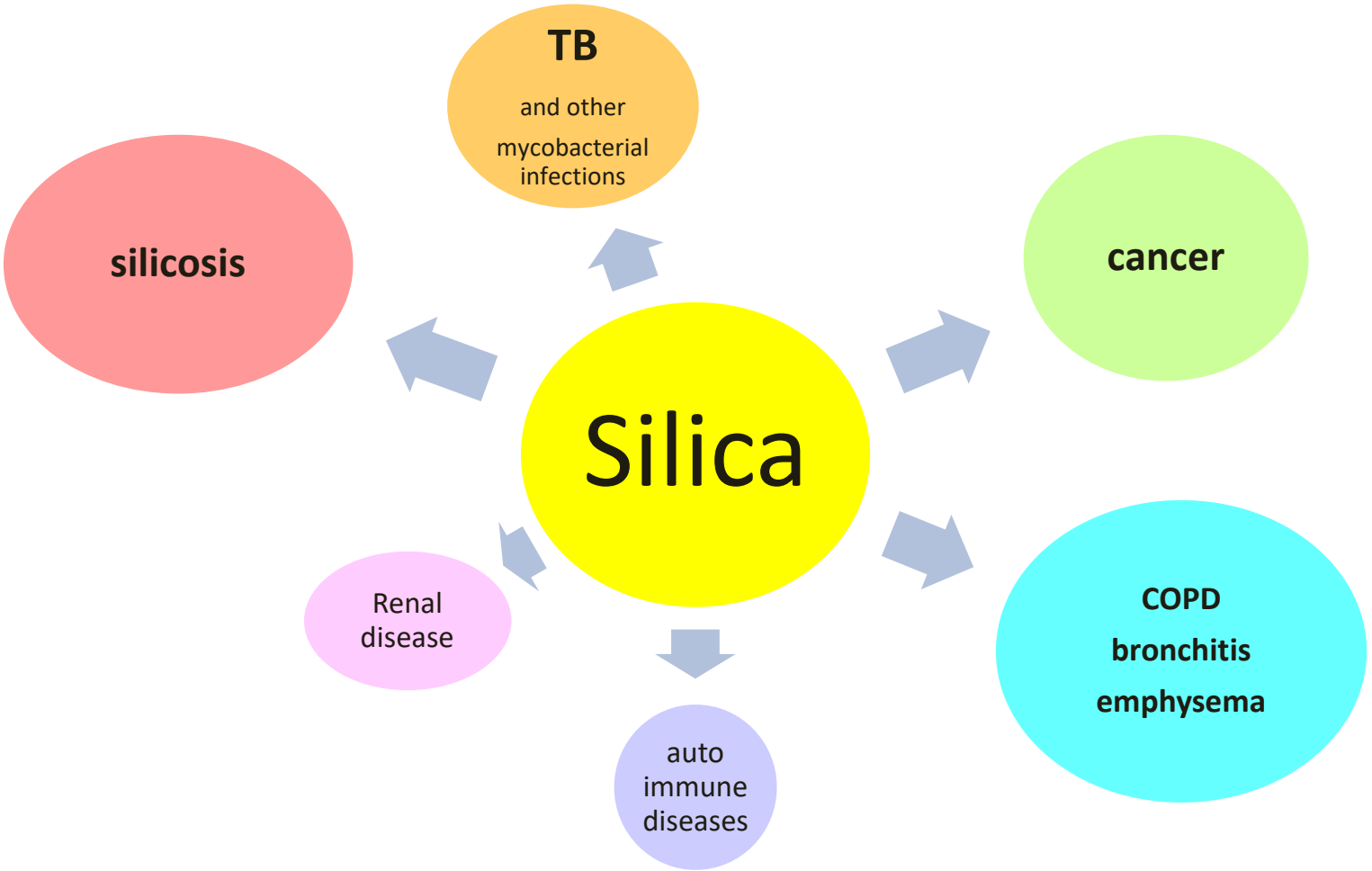
Do silica exposures occur ?

# What happens to people if they get exposed?

# The big, small problem: small particles

- Inhaling very small ("respirable") silica particles, causes multiple diseases, including silicosis
- Silica also causes lung cancer and chronic obstructive pulmonary disease (COPD)
- Exposure is also associated with kidney disease, autoimmune disease and contracting tuberculosis (TB)

# Diseases associated with Silica



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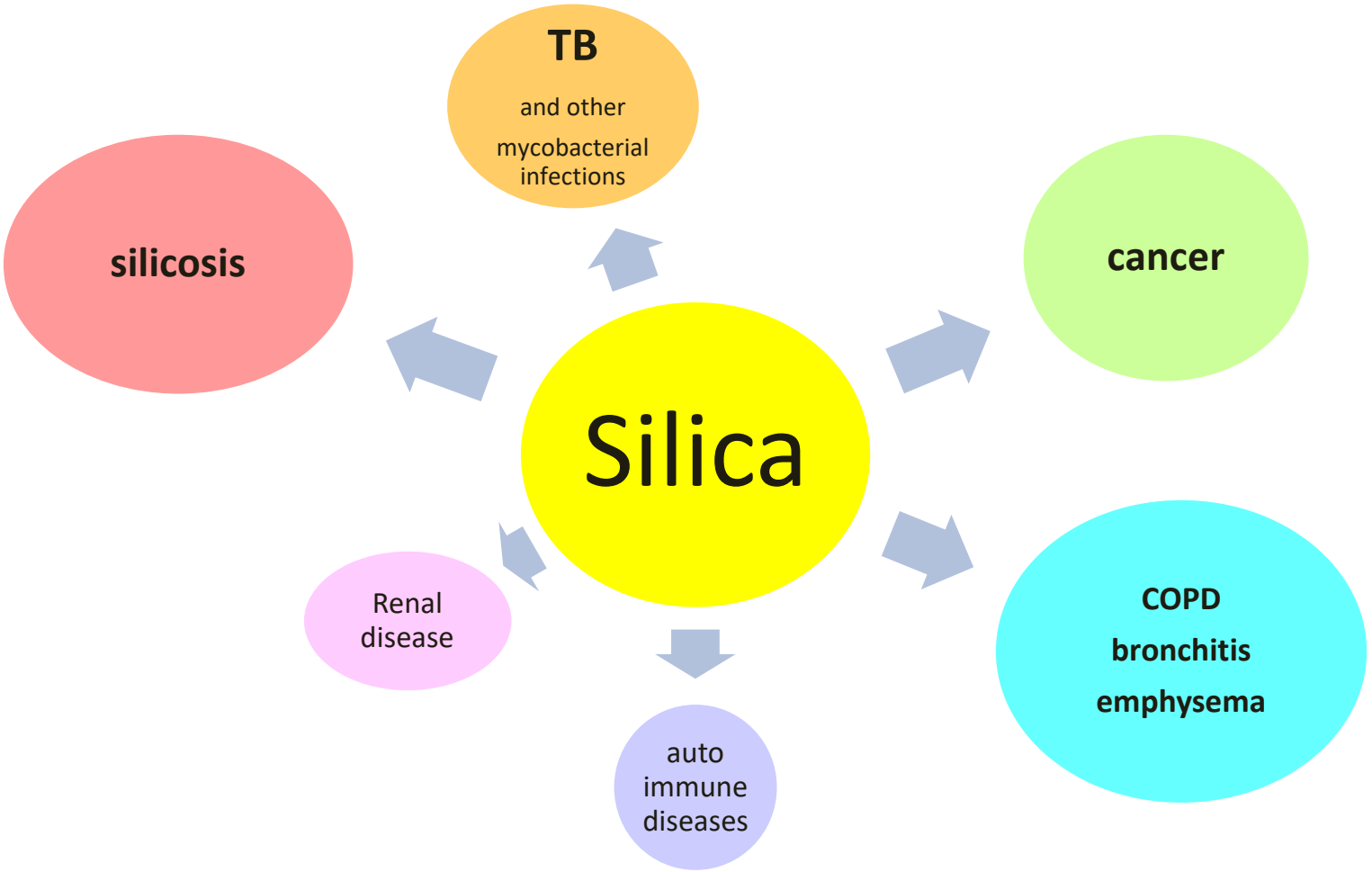



Disease may occur YEARS to DECADES later!!!

# Diseases of Silica: Silicosis

- Silica particles cause scarring and hardness of the lungs
  - Scarring makes it hard for lungs to expand, making it difficult to breathe
- Patients have cough, shortness of breath (SOB), weakness and tiredness
  - May lead to death
- Diagnosed by a work history and chest X-ray (CXR) +/- pulmonary function testing (PFTs)
  - Often misdiagnosed as TB

Normal CXR

Small parenchymal opacities

Large parenchymal opacities

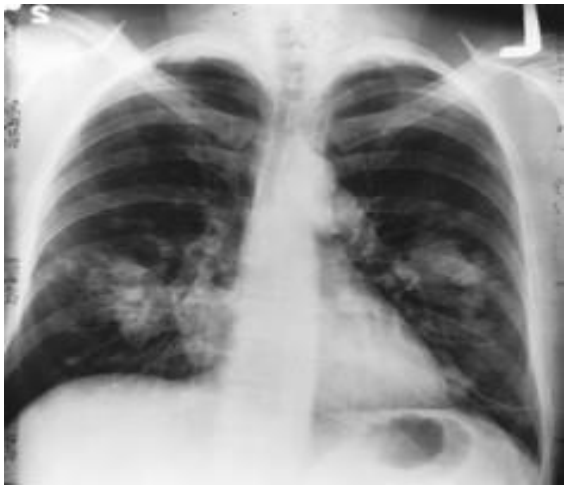
# Diseases of Silica: Silicotuberculosis

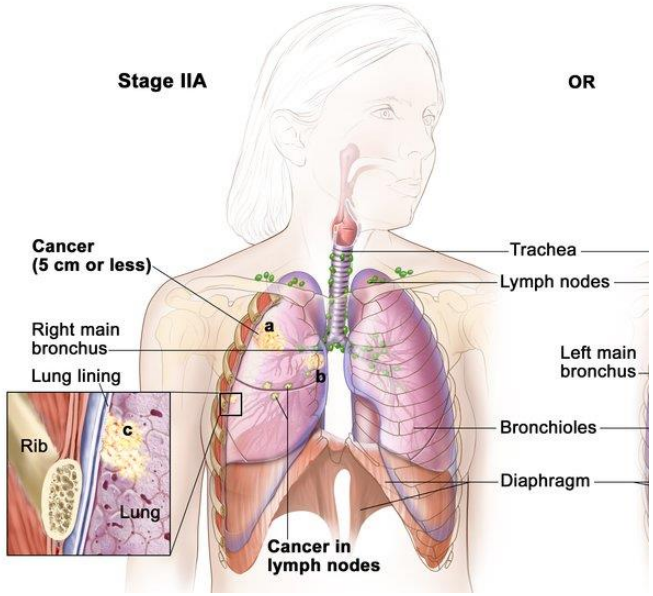
- TB is a highly contagious disease
  - Silicosis increases the risk of TB by four times
- Patients have cough (sometimes with blood), chest pain, SOB, and tiredness
  - Deadly if untreated
- Diagnosed by CXR or Sputum

Silicosis  Tuberculosis  Silicotuberculosis

# Diseases of Silica: Lung Cancer

- International Agency for Research on Cancer (IARC) classifies silica as a known human carcinogen
- Patients have cough, SOB, chest pain, coughing blood, tiredness, weight loss, etc.
  - May lead to death
- Diagnosed by symptoms and imaging
  - CXR or Chest CT





# Diseases of Silica: COPD

- Air is obstructed from getting out of the lungs, leaving less room to bring in oxygen
- Patients may have a chronic cough, phlegm production, SOB and wheezing
  - Often leads to exacerbations and infections
  - Causes long-term disability and may lead to death
- Diagnosed by medical and occupational health history as well as Pulmonary Function Tests (PFT) (preferred, if available)

# Smoking & Silica

- Cigarette smoking exacerbates lung damage caused by silica, and contributes significantly to the development of lung disease.

# Diseases of Silica: Non-Lung Diseases

- Some evidence that exposure increases risk of kidney disease
- Some evidence that exposure increases risk of scleroderma
  - Patients may have thickened skin, stiff joints, tiredness, and poor blood flow

# Review of health effects

- This video is a good review of how breathing in silica dust can cause permanent damage to the lungs.
- https://www.youtube.com/watch?v=R_sC2wX9Uwc

# Could this exposure cause health effects ?

# How do you know which employees are being exposed?

# Risk Assessment

- Hazard-anything that may cause harm
- Risk-severity and likelihood that exposure to a hazard will cause injury or disease
- Risk assessment includes
  - Determining how likely something is to cause harm?
  - What actions can protect you?

# Workplace Exposure Limits

- Workplace Exposure Standards (WESs) help to assess and communicate risk
- A WES is an acceptable upper limit of exposure
- Sampling requires testing with pumps and analyzing samples at a laboratory
  - Expensive and few laboratories offer the proper analysis
  - Must use size-selected results to compare to an WES
- Rule of thumb: ***If you see dust, there is likely respirable dust and you have a problem!!!***

# Measurement of the concentration of silica

- Can be used to assess the performance of controls
- It will identify where the exposures are the highest
- Enable the improvement of the controls using the hierarchy :
  - Elimination
  - Substitution
  - Engineering
  - Administrative
  - PPE – Respiratory protection
- Resulting in the improvement of the health and productivity of the workforce

# Measuring exposure to silica

- Dust particles from the air are pulled into a sampling device using a pump and collected onto a filter
- The smaller sized respirable particles must be separated from the larger particles when measuring exposures using a size-selective device
  - Traditional Cyclone
- Need to take multiple samples due to variability

# Air sampling for silica

- The flow rate of the sampling pump must be carefully calibrated to
  - make sure that it is collecting the correct size
  - calculate the total volume of air sampled
- The filters will be sent to a laboratory and analyzed for crystalline content using either methods
  - Infrared analysis (IR)
  - X-Ray diffraction (XRF)
- The filter is also weighed before and after sampling to determine the total weight of respirable dust
- Only in the U.S., you must find the percentage of crystalline silica by calculating the weight of the crystalline silica content divided by the total weight of the dusts

# Proper sampling for silica

- The sampling pump should be worn for the entire duration of the work shift
  - Those results can be compared to workplace exposure standard

- The Safe Work Australia, workplace exposure standard (WES) is  0.05mg/m3, 8 hour time weighted average

# Sampling Procedures for Silica

- There are some videos to show the different types of sampling available
  - Calibration with an aluminum cyclone: https://www.youtube.com/watch?v=LqiY2acDIgM
  - Assembly and Collection of silica with cyclones: https://www.youtube.com/watch?v=O5knJEGGa7k
  - NIOSH Sampling with Aluminum Cyclone: https://www.youtube.com/watch?v=9LPzWn9GchQ
  - Parallel Particle Impactor (PPI): https://www.youtube.com/watch?v=Mrc7uQC7VAY

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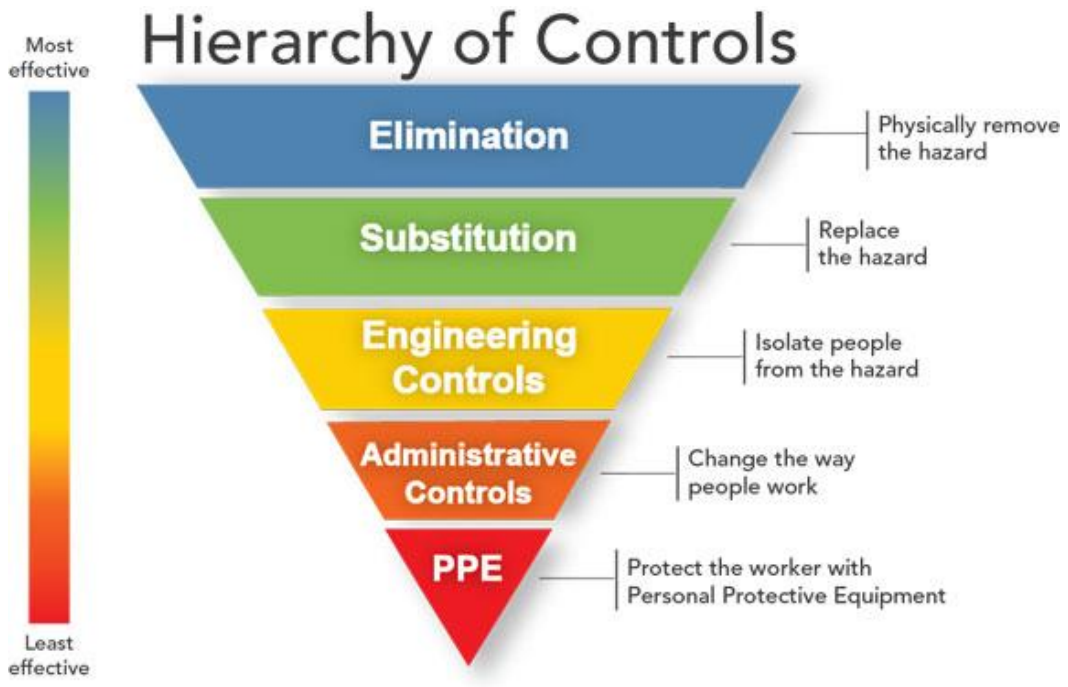
# Recommendations

- “There can be no intelligent control of the…danger in industry unless it is based on the principle of keeping the air clear from dust and fumes.” – Alice Hamilton
- Occupational hygiene and air sampling is the backbone of occupational health, driving recommendations
- WES are often the basis for assessing risk, making recommendations, and instituting controls

# How do I prevent people from being exposed?

# Hierarchy of Controls

- Elimination
- Substitution
- Engineering controls
  - WWwet methods
  - Isolate the process
  - Isolate the worker
- Administrative Controls
- Personal protective equipment



# Elimination or Substitution

- Elimination - Abrasive blasting with sand (sandblasting) has been banned in Australia starting in 1959 in NSW
- Substitution - with other material for the sand, such as:
  - Metal beads, steel shot
  - Chemicals can be used to remove surface coatings
    - Be aware of the hazards of the chemical
  - High pressure water
    - Used in bridge deck refurbishing

# Substitution: Tragedy of the Jeans

- Manufacturers of jeans in Turkey
- Used sandblasting for a “weathered” look
- Sand was used to blast jeans without controls
  - Over 50 workers died
  - Many more suffered irreversible lung disease
  - **Could have all been avoided by substitution!**

# Engineering Controls

- Change the process to reduce exposure
  - Retrofitting or purchasing equipment capable of wet methods for cutting, sawing, etc.
- Enclosing the process to remove the worker from the hazard
  - Glove box
  - Covers on conveyor belts
  - Ventilation
  - Cabs for construction/mining equipment
- Visual dust emissions indicate that a control is needed
- Engineering controls (primarily wet methods) found to be the most cost-effective silica control strategy in developing and developed countries

# Engineering controls resources

- Some of the most effective and feasible engineering controls are
  - Wet  Methods (requires Water most effective)
  - Dry Methods (requires ELECTRICITY)
- Here is a link to several videos showing engineering controls

https://www.silica-safe.org/whats-working/controlling-silica-dust-learning-from-each-other

# Engineering Controls: Wet Methods

- Wet methods can significantly reduce exposures, but require pre-planning
  - Cutting with saws equipped with water basin
  - Drilling with water pump through the drill stem
  - Grinding and hammering on pre-wetted surfaces
  - Fogging or steaming to suppress dust in areas where dust is generated

    water spray misting is important to reduce exposure to smaller particles

# Engineering Controls: Wet methods

Dry sawing concrete

Wet sawing concrete water is added at saw blade

Notice puddle at feet of wet saw operator. It contains the same amount of dust as seen in picture of dry saw operator. What happens to the dust when puddle dries?

Pictures from OSHA

# Engineering Controls: Wet methods

- Here is a video to show some wet methods that might be available in a construction setting: https://www.youtube.com/watch?v=f5Ec4TrzN4Y

# Engineering Controls: Dry Methods

- The most common dry collection method is vacuum dust collection and the specific filter required is H class, but may be more expensive and require electricity.
  - Cutting with a vacuum system affixed to the saw blade
  - Drilling with an enclose around where the drill enters the surface
  - Grinding with a shroud that surrounds the grinding wheel
- https://www.youtube.com/watch?v=_Ia1zp777Ik

# Example of Tool Selection during Concrete Drilling

- Wet Methods
- Pneumatic (powered by compressed air)
- High exposures

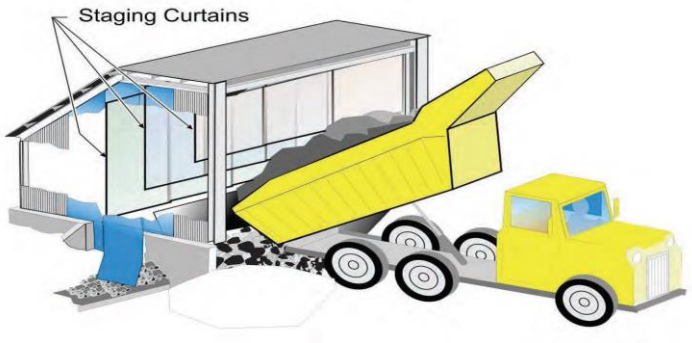
- Dry Methods
- Pneumatic (powered by compressed air)
- Higher exposures

- Wet Methods
- Electric
- Lowest exposures

- Dry Methods
- Electric
- Higher exposures

# Engineering Controls: Isolate the Process

- Using a glove box for sandblasting
- Using covers on conveyor belts and/or lowering the drop heights from conveyor belts
- Enclosure for dumping
  - Ventilation
  - Wetting (1% moisture by weight)
    - Activate with photocell or mechanical switch




# Administrative Controls

- Recommend procedures to:
  - Perform routine housekeeping to reduce the build up of dust in the work area
  - Prohibit dry sweeping and implement wet sweeping methods
  - If services are available, institute a medical monitoring program
  - In vehicles and mobile equipment, implement windows closed, door seals checked in pre-start and air con operating correctly.
- Educate and train employees on the hazards of working with RCS

# Education & Training

- It is important for employees to:
  - Be informed of the hazards of working with silica
  - Be able to recognize when the hazard is present
  - Know how to prevent themselves from being exposed
  - Know how to operate engineering controls
  - Be familiar with required PPE and how to wear it
- The Center for Construction Research and Training has good guidance on silica trainings
  - https://www.silica-safe.org/training-and-other-resources

# Personal Protective Equipment (PPE)

- Respirators may be of immediate assistance
  - Half-face
  - Full-face
  - Filtering face piece
- Respirators are a good method to prevent exposure if engineering controls aren't in place, but they have limitations, including:
  - Highly dependent on seal
  - Require regular change-out
- Respirators must be fit- tested by an accredited fit- tester to ensure they seal onto the face.
- Go to RESP-FIT website, https://respfit.org.au/

# Fit Testing of Respirators

RESP-FIT was established to improve worker health protection of those wearing tight fitting respiratory protective equipment, through reliable respirator fit testing by competent fit testers in Australia.

RESP-FIT
RESPIRATOR FIT TESTING TRAINING & ACCREDITATION
AN AIOH PROGRAM

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# What can employees do?

- Use all available engineering controls such as blasting cabinets and local exhaust ventilation.
- Do not use compressed air for cleaning surfaces.
- Use water sprays, wet methods (e.g. wet spray misting) for cutting, chipping, drilling, sawing, grinding, etc.
- Substitute non-crystalline silica blasting material.
- Use respirators approved for protection against silica; if sandblasting, use abrasive blasting respirators.
- Do not eat, drink or smoke near crystalline silica dust.
- Wash hands and face before eating, drinking or smoking away from exposure area.
- Quit smoking

# Control Banding

- Control banding is a method that uses
  - severity of the chemical
  - quantity of the chemical
  - likelihood of exposure to the chemical
- Based on those, control banding recommends a level of exposure control
  - General ventilation
  - Engineering controls
  - Containment
  - Special

# Control Banding for Silica

- Control banding for silica is typically based on the industry, and recommends controls based on the common tasks in the industry
- COSHH Essentials. To help employers reduce exposures COSHH created a series of informative guides
  - COSHH Silica Essentials Direct Advice http://www.hse.gov.uk/pubns/guidance/
  - Translated into Spanish by ILO

http://www.ilo.org/legacy/spanish/protection/safework/cosh_essentials_silica/index.htm

  - NEPSI (Noyau Europeen pour la Silice) Good Practice Guide

https://www.nepsi.eu/good-practice-guide

# Take Home Messages

- Crystalline silica is a mineral found everywhere and airborne particles are dangerous
- Cutting, grinding and other activities break down the mineral into small parts and leads to airborne dust exposure
- Inhaling very small crystalline silica particles causes multiple diseases, including silicosis, an incurable lung disease that can lead to disability and death
- Use occupational hygiene air monitoring methods to collect the fine respirable sized dust and compare the respirable crystalline silica exposure to the WES

# Take Home Messages

- ***Remember, if you working with substances containing crystalline silica - if you can see the dust then you know there is a problem AND if you cannot see the fine dust you may still have a problem***

- Apply the hierarchy of controls to minimise exposures

- Keep it wet!!!