Managing Ventilation

Roles and Responsibilities

- **Ventilation Engineer -** plan the ventilation systems and conduct a weekly audit and review of the ventilation system on all sites in consultation with the Project Manager (or nominated SPE) and/or Superintendent. Agree actions and timeframes at close out meeting before issuing report within 24 hours.

- **Project Manager -** Ensure that the ventilation system design is implemented and maintained as well as ensuring that regular ventilation monitoring is conducted. The Project Manager is responsible for implementing corrective actions if monitoring results indicate there is a ventilation issue.

- **Superintendent -** Allocating the resources to install and maintain the ventilation system, as well adjusting work activities or sequence to respond to a ventilation issue.

- **Site Supervision**

- **Engineer and/or Site Safety**

- **Site Safety**

Critical Risks in Tunnel Construction

Statistics released by Safe Work Australia demonstrate that each year over 2000 workers will die from an occupational disease.

Previous studies have demonstrated tunnel construction workers had the highest silica dust exposures in the construction industry, therefore, strict controls must be implemented to limit exposure.

As such, a new Workplace Exposure Standard (WES) has been introduced to reduce exposure to RCS and improve workers safety.

The WES is the amount of a certain substance which must not be exceeded. It is typically measured over an 8-hour shift but is adjusted to cover longer working hours.

For example, the new WES for Respirable Silica reduces from 0.05mg/m3 for an 8 hour shift to 0.03mg/m3 over a 12 hour shift.

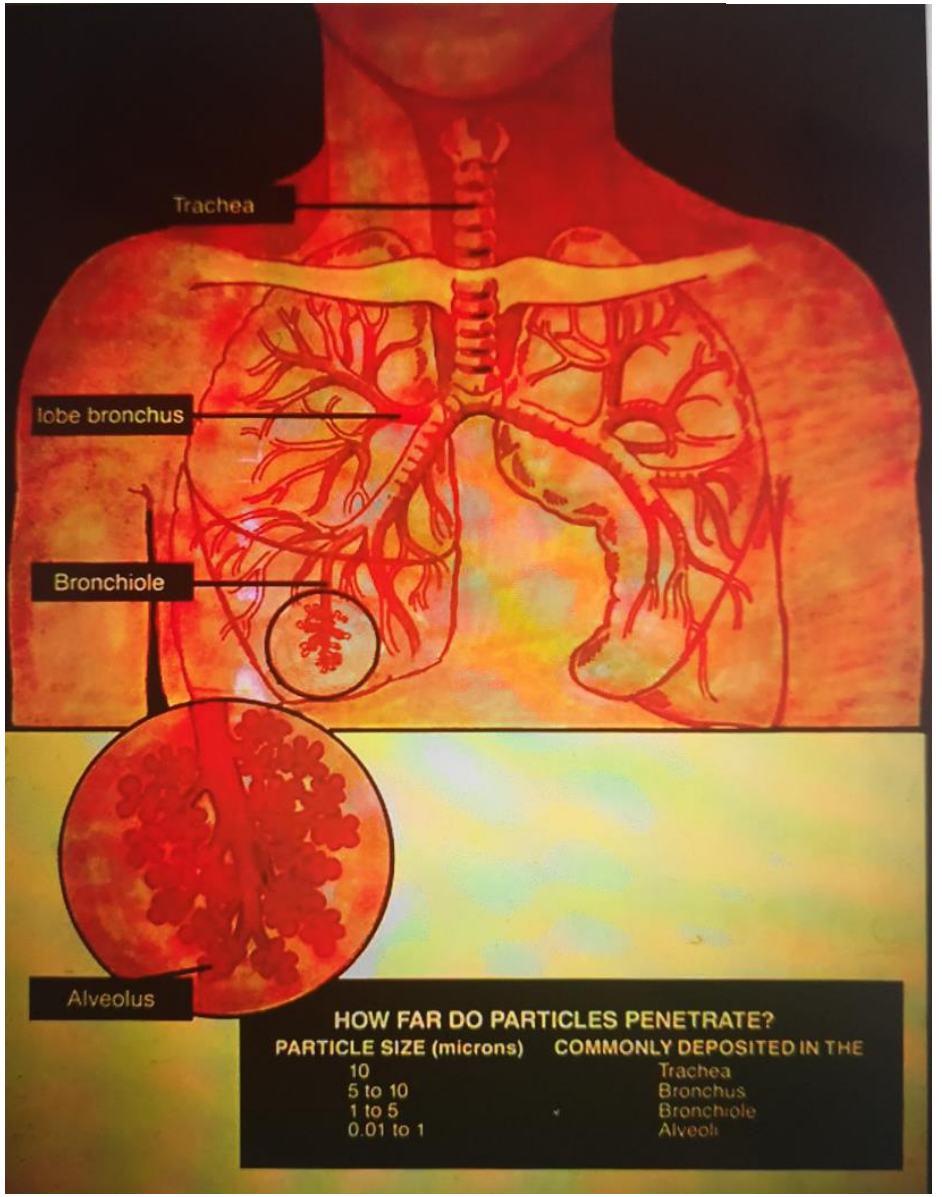
Picture: approximately how much dust the WES represents over 8-hours.

Health Risks – Exposure to Silica

Silica dust is more than 15 times smaller than a piece of human hair and is very difficult to see underground. It's small enough to reach the alveolar regions of the lung.

It can stay suspended in the air for many hours after larger dust particles have settled out.

The respirable fraction is broadly defined as particles having a diameter of 10 µm or less.



Dust related diseases

Over exposure to silica dust can cause a lung disease known as silicosis, chronic obstructive pulmonary disease (COPD) and lung cancer.

These diseases have no cure.

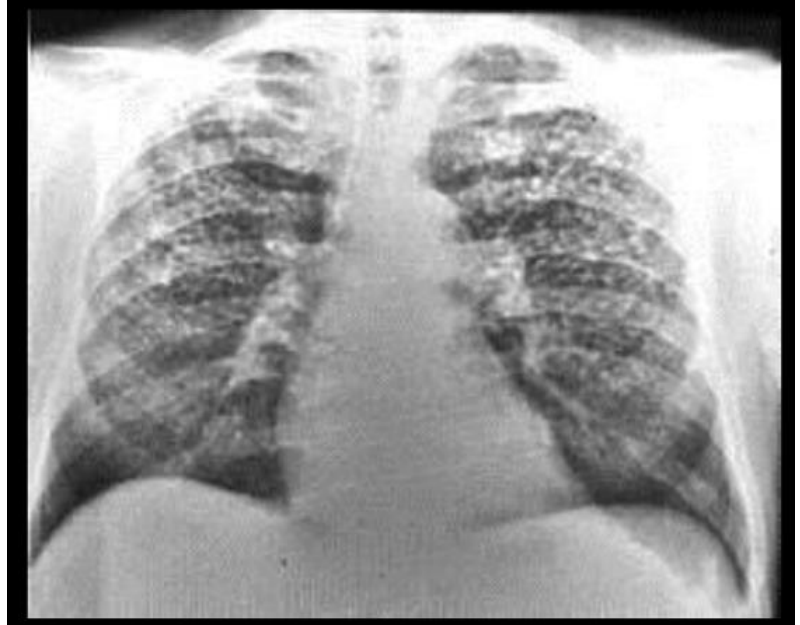
Symptoms of silicosis include chronic dry cough and shortness of breath with exercise.

Silicosis usually results from chronic low level exposure, however an acute form is also known which can be fatal within months.

Silicosis may progress even after removal from silica dust exposure.

It is estimated that 230 people develop lung cancer each year as a result of past exposure to silica at work.

Normal x-ray



X-ray showing silicosis

Exposure to Diesel Particulate Matter (DPM)

Diesel emissions contain Carbon dioxide (CO2), Carbon monoxide (CO), Oxides of Nitrogen (NO, NO2, NOx), Sulphur dioxide (SO2) and Diesel Particulate Matter (DPM).

DPM is a component of diesel exhaust and includes diesel soot and solid aerosols such as organic carbon compounds, ash, metallic abrasion particles, sulphates and silicates.

In 2012, International Agency for Research on Cancer (IARC), part of the World Health Organization, upgraded the existing classification of diesel exhaust from “possibly carcinogenic” to “definitely carcinogenic” to humans.

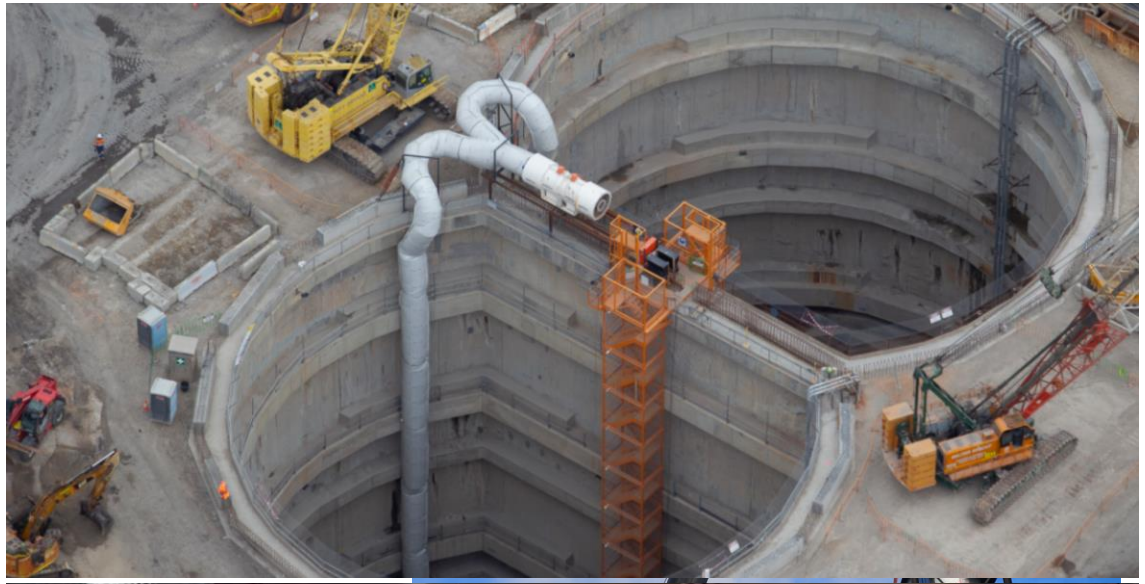
Engineering – Tunnel Ventilation

Ventilation is provided to remove dust and dilute contaminants like DPM and gases from the air.

Fresh air is provided through fans to keep the dust at the tunnel face, maintain a safe temperature and disperse harmful gases.

There are two key factors used to quantify ventilation in the tunnel which are Air Velocity (m/s) and Air Quantity (m3/s).

Air velocity is the speed of fresh air supplied from the surface and air quantity is the measure of air that is extracted from the working face.

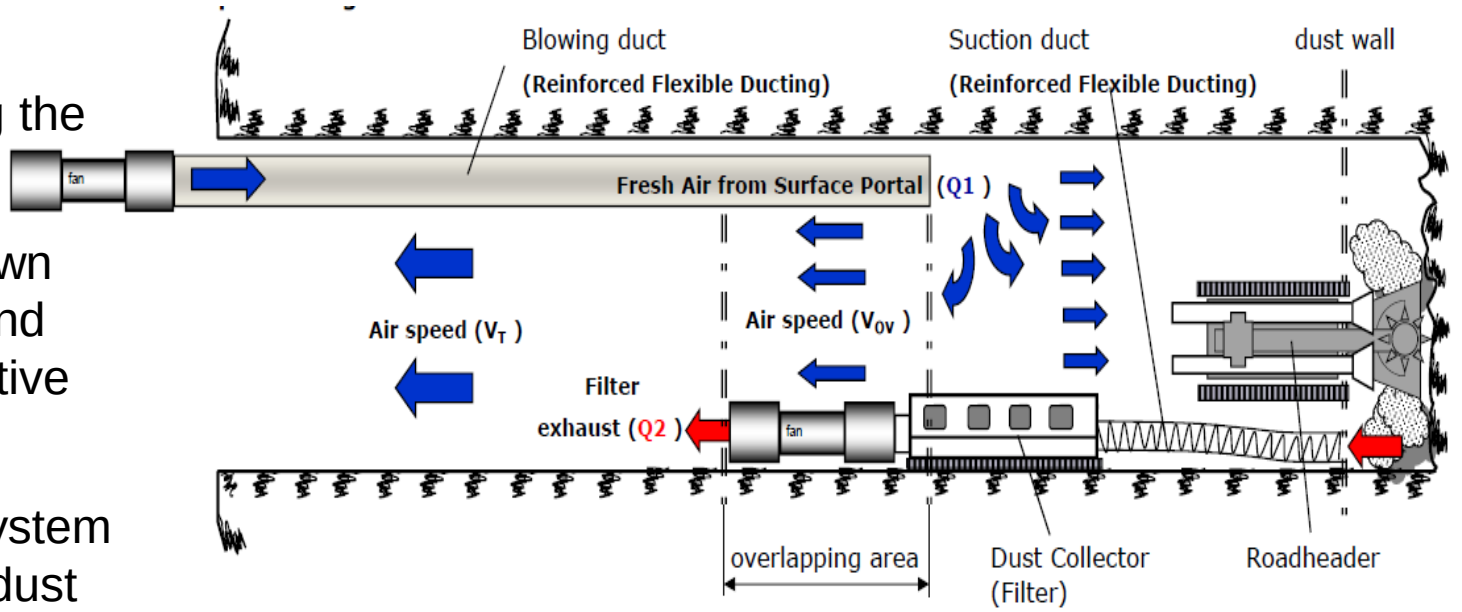


Engineering – Tunnel Ventilation

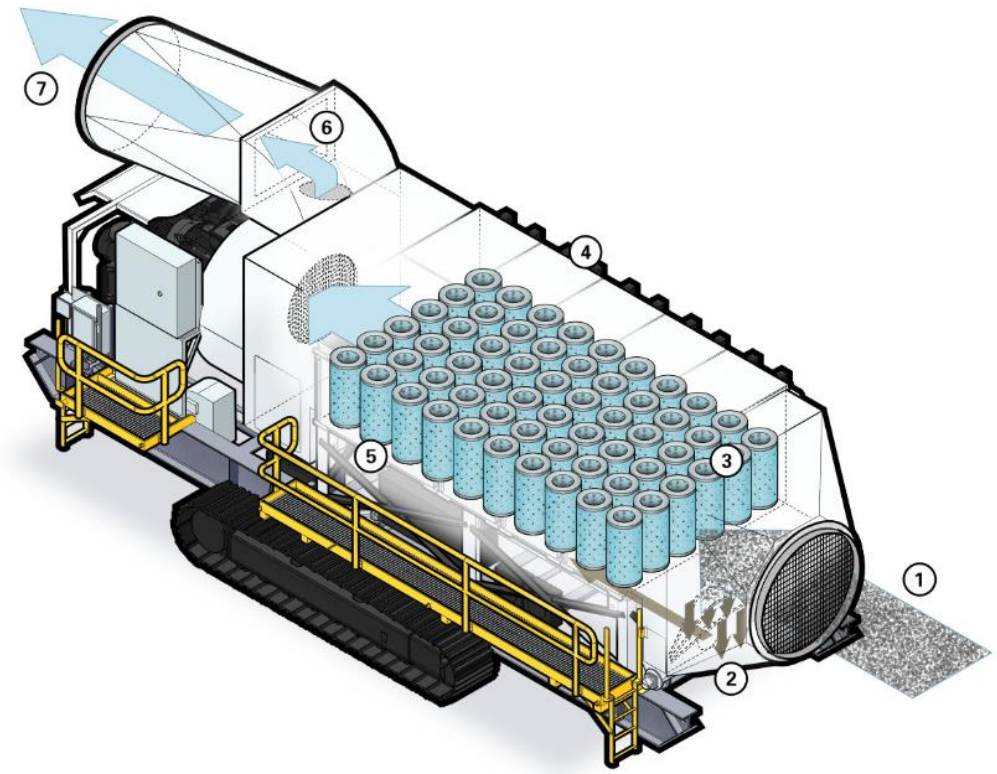
In a typical set up, fresh air is drawn from the surface and pushed through the tunnel while a scrubber pulls air from the face before expelling the clean air back behind the work area.

This provides a continuous loop of fresh air drawn from the surface to the working face, cleaned and then extracted back down the tunnel using positive pressure.

Care must be taken to overlap the ventilation system and keep the air velocity at a speed where the dust does not roll back into the tunnel.



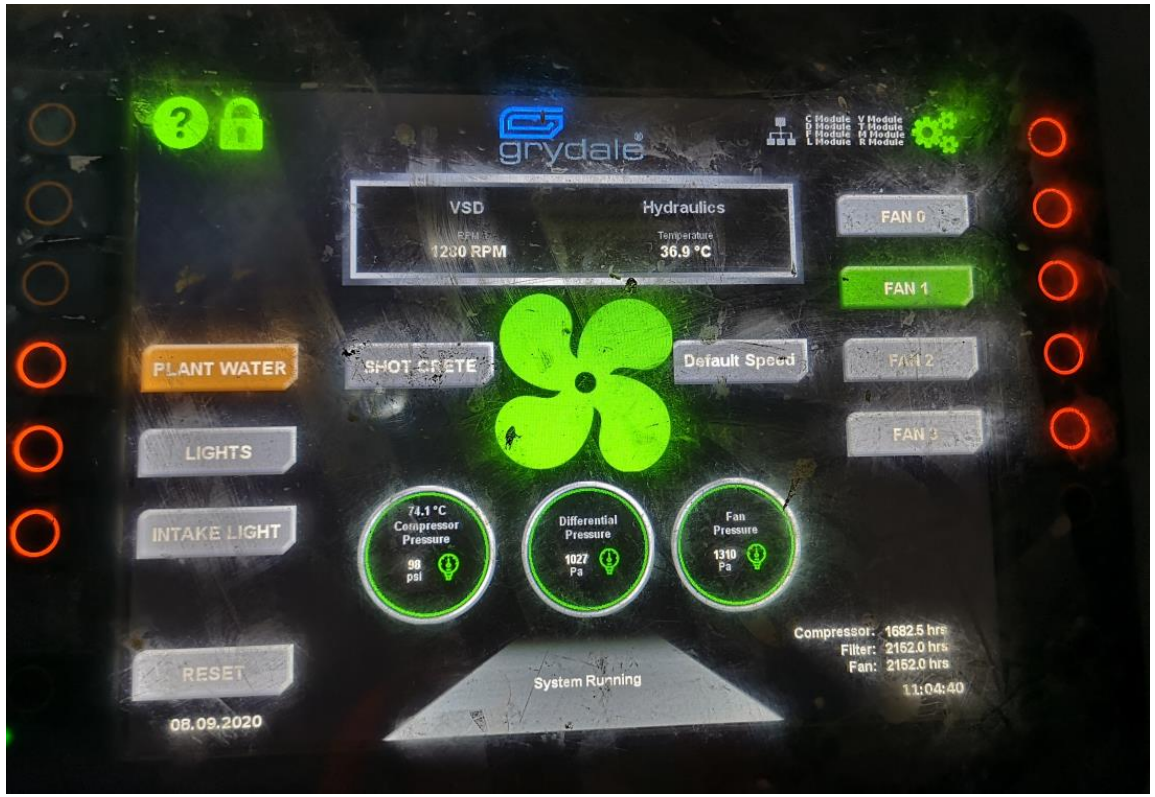
Engineering - Scrubber System



1. Air is pulled through the dirty air intake by the Centrifugal Fan
2. Larger dust particles drop through the Drop Out Box and are separated from the air stream.
3. Dust and fumes are trapped on the filters forming a cake on the surface as air passes through the filter house.
4. Reverse pulse filter cleaning system cleans the filters.
5. Dust particles are discharged from the machine via the augers and rotary valves.
6. The velocity probe monitors air speed and then turns the centrifugal fan up / down to maintain air volume.
7. Clean air exhausts from the machine with a filtration efficiency of 99.99% at 0.067 micron.

Engineering - Scrubber System

- **Fan 0**
- **Fan 1**
- **Fan 2**
- **Fan 3**



When switching back from shotcrete mode – ensure water is turned back on

Fresh Air Fans

Engineering – Ventilation

The selection of a scrubber is normally based on the size of the tunnel to be ventilated.

The minimum air quantity required to ventilate the tunnel face will depend on the minimum velocity (air speed) requirement.

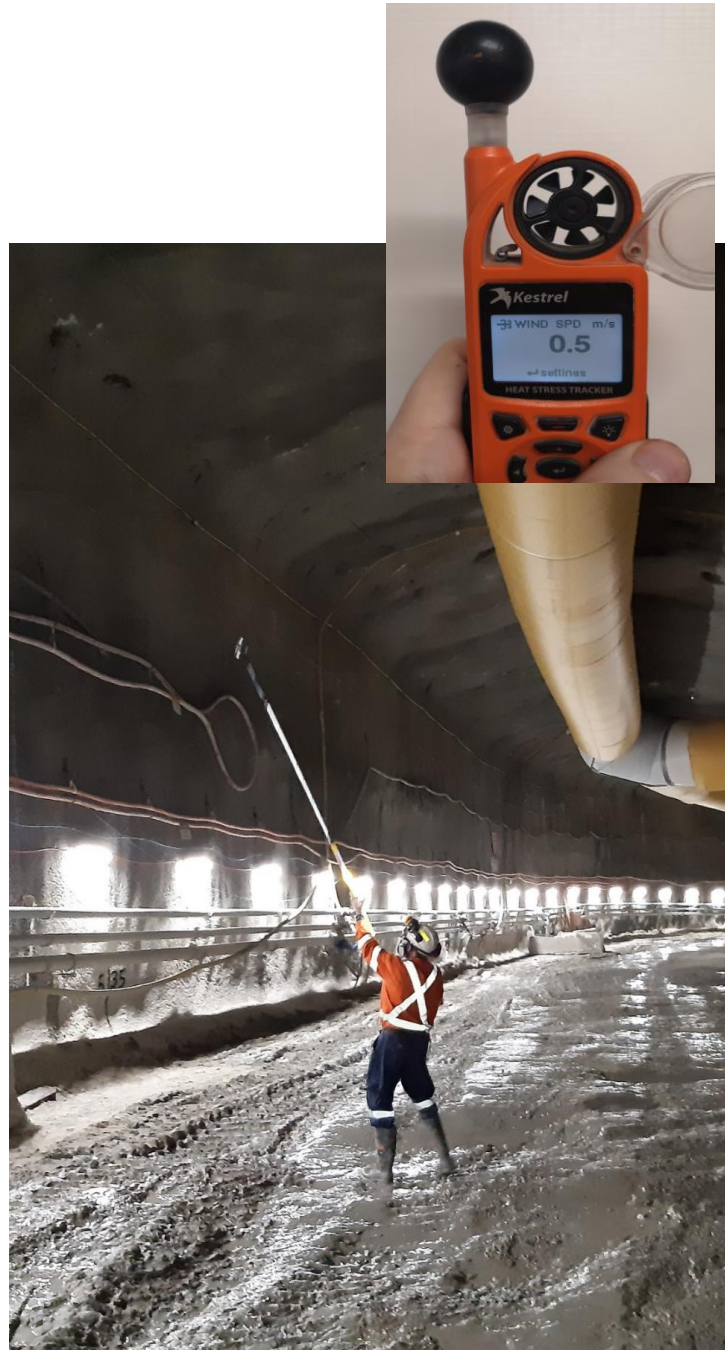
Typically, 0.3 m/s is the minimum air velocity needed for effective ventilation.

The quantity of air required is calculated using the following formula:
$Q\ m3/sec = A\ (m2) x\ V\ (m/s)$

As an example, if the tunnel face size is 85 m_2, then the minimum quantity of air required could be calculated as follows:
$85\ m2\ x\ 0.3\ m/s = 25.5\ m3/sec$

This is the minimum size of the scrubber required to ventilate the area.

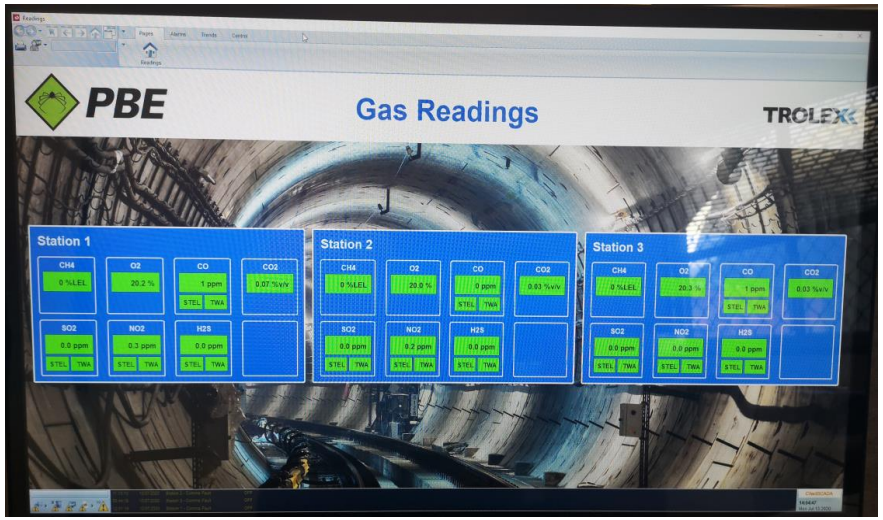
Face Ventilation velocity helps in preventing the roll-back of dust into workings behind the face. Generally, the higher the velocity of air moving towards the scrubber, the better. Roll-back can also occur if the fresh air bags are too close to the face.



Atmospheric Monitoring

The tunnel must be monitored to ensure the air velocity is sufficient, the ventilation system is set up correctly, the temperature and humidity are within safe levels and that there is no build up of RCS or DPM gases.

This involves the use of real time gas monitors, mobile hand held monitors and kestrels.



Daily Ventilation Monitoring (VAR)

Daily monitoring of the tunnel is completed to ensure the ventilation is working correctly, the wind speed is at minimum .03m/s and that there is no build up of gas from plant.

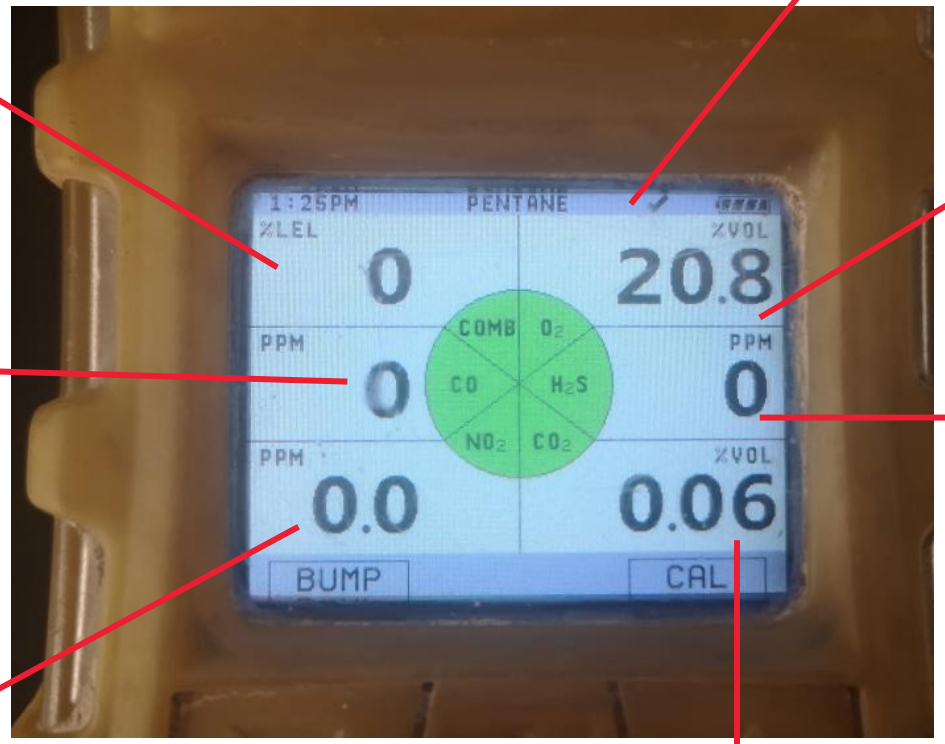
It is important to demonstrate we are consistently monitoring the environment and ensuring the vent system is operating as it should be. This is the responsibility of the engineering team with support from the safety team and Mick Shearer.

Gas measurements include Carbon Monoxide, Carbon Dioxide, Nitrogen Dioxide that make up diesel emissions and the levels of oxygen.

Daily Ventilation Monitoring (VAR)

Gas detector should be bump tested prior to use – tick will confirm

This detects an atmosphere with flammable vapours – increase the risk of fire



Oxygen level – should always be around 20.8

Carbon Monoxide – component of diesel – can cause vomiting and nausea – if high enough unconsciousness or death

Hydrogen Sulphide found in wastewater treatment and sewers - poisonous, corrosive, and flammable.

Nitrogen Dioxide – component of diesel – can cause wheezing and reduced ling function

Carbon Dioxide – component of diesel – exposure can cause dizziness, high blood pressure

Alarms Triggers & Actions

On the detector one flashing red light is the low alarm, 2 flashing red lights is the high alarm.

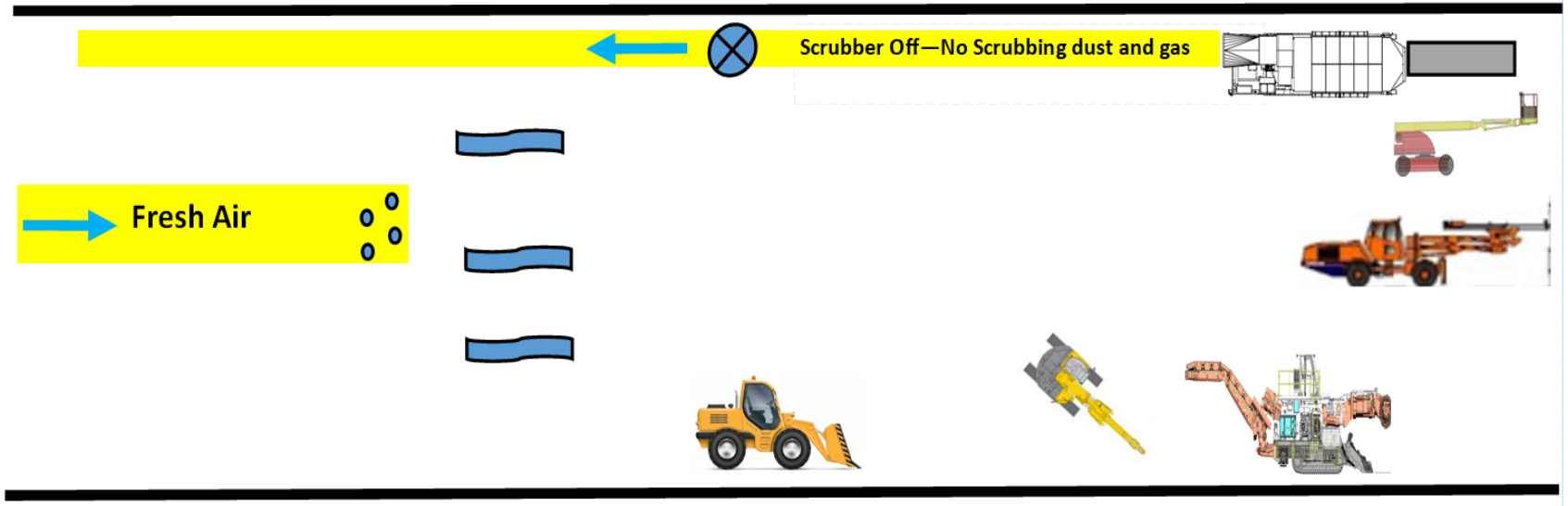
	Level-1 (Low alarm 19.5%) 19.5 - 20.5% OR 20.9-23.5%	Level-2 (High alarm 23.5%) < 19.5 % OR >23.5%
Oxygen	**Investigate Further** Check fans are running, notify Superintendent/Supervisor and Safety	**Evacuate area until gas detector reads acceptable levels** Notify Superintendent & Project Manager. Oxygen levels must be restored before normal work can continue
	Level-1 (Low alarm @ 5%) 5-10 % of LEL	Level-2 (High alarm @ 10%) 10% and above of LEL
Combustible LEL	**Investigate Further** Check fans are running, notify Superintendent/Supervisor and Safety. Superintendent/Supervisor to prepare a plan to identify and complete any works to reduce the gas levels. Activities in the tunnel may be suspended under advice from Project Manager.	**Evacuate area until gas detector reads acceptable levels** Notify Superintendent & Project Manager. Gas levels must be restored before normal work can continue and re-entry approved by the Project Manager
	Level-1 (Low alarm 0.5%) 0.5 % to 3 % (5000 – 15000 ppm)	Level-3 (High alarm 3%) >3 % (>30000 ppm)
Carbon Dioxide (CO2)	**Investigate Further** Check fans are running, notify Superintendent/Supervisor and Safety. Superintendent/Supervisor to prepare a plan to identify and complete any works to reduce the gas levels. Activities in the tunnel may be suspended under advice from Project Manager.	**Evacuate area until gas detector reads acceptable levels** Notify Superintendent & Project Manager. Gas levels must be restored before normal work can continue and re-entry approved by the Project Manager
	Level-1 (Low alarm 20 ppm) 20-35 PPM	Level-2 (High alarm 35 ppm) >35 PPM
Carbon Monoxide (CO)	**Investigate Further** Check fans are running, notify Superintendent/Supervisor and Safety. Superintendent/Supervisor to prepare a plan to identify and complete any works to reduce the gas levels. Activities in the tunnel may be suspended under advice from Project Manager.	**Evacuate area until gas detector reads acceptable levels** Notify Superintendent & Project Manager. Gas levels must be restored before normal work can continue and re-entry approved by the Project Manager
	Level-1 (Low alarm 1st number in range below) 1.7 ppm - 5 ppm for NO_2 2 ppm - 5 ppm for SO_2 2 – 15 ppm for H_2S	Level-3 (High alarm value below) High Limit Alarm (>5 ppm for both SO_2 and NO_2) High Limit Alarm (>15 ppm for H_2S)
- NITROGEN DIOXIDE - HYDROGEN SULPHIDE - SULPHUR DIOXIDE	**Investigate Further** Check fans are running, notify Superintendent/Supervisor and Safety. Superintendent/Supervisor to prepare a plan to identify and complete any works to reduce the gas levels. Activities in the tunnel may be suspended under advice from Project Manager.	**Evacuate area until gas detector reads acceptable levels** Notify Superintendent & Project Manager. Gas levels must be restored before normal work can continue and re-entry approved by the Project Manager

Scenario – Moving Scrubber

- Multiple diesel plant items operating at the tunnel face
- Scrubber not scrubbing diesel gas and particles for up to 90 minutes or more
- As the gases diesel gases continue to generate at the face, the fresh air keeps it trapped at the face
- As the gases continue to rise, oxygen levels begin to fall as it is displaced by the other gases (carbon dioxide & monoxide)
- The area starts to get increasingly hot and dangerous due to the gas build up and lack of oxygen

Solutions:

- Careful planning sequence of works
- Turn off non critical diesel plant
- If the cuts are longer, the scrubber move takes longer – consider restarting scrubber to clear gases



Daily Ventilation Monitoring (VAR)

The kestrel measures

- Humidity – Relative humidity is the amount of water vapour in the air. High humidity causes workers to sweat
- Temperature – The temperature in the tunnel can rise very quickly when the fans are turned off and when lots of plant is operating in a close area.
- Wind speed – Minimum windspeed is 0.3m/s. If there is fresh air being supplied to the tunnel, there should be wind speed. You may need to move around the drive to find it.
- Thermal Work Limit (TWL) is a heat stress measurement and is related to the temperature and wind speed in the tunnel

Daily Ventilation Reports

- Monitoring results must be saved in the relevant site VAR folder.
- If there are any significant readings, these must be relayed to the supervisors and safety team to determine if action is necessary.

VENTILATION AND ATMOSPHERIC CONDITIONS REPORT - TUNNEL

DATE	Fri 17 July 2020						
SHIFT	Day						
INSPECTED BY	N.King	N.King	N.King	N.King	N.King		
LOCATION	**Surface**	**Intersection**	**M4TO**	**M4WO**	**M4VO**		
Time of Inspection	15:26	15:32	15:41	15:45	15:55		
Dry Bulb Temperature (°C)	22.3	24.5	24.6	22.9	23.4		
Wet Bulb Temperature (°C)	16.1	19.6	18.6	17.6	18.5		
Humidity (%)	51	64.2	56.4	59.7	62.2		
TWL	272.4	290.1	233.2	317	247.9		
Velocity (m/s)	1.2	1.1	0.4	0.5	1.1		
Direction of Flow		Outbye	Outbye	Inbye	Inbye		
GAS READINGS							
Oxygen (O2) in %	20.8	20.8	20.8	20.8	20.8		
LEL (Explosive) in %	0	0	0	0	0		
Carbon Monoxide (CO) PPM	0	0	0	0	0		
Hydrogen Sulphide (H2S) PPM	0	0	0	0	0		
Carbon Dioxide (CO2) in %	0.03	0.08	0.05	0.05	0.6		
Nitrogen Dioxide (NO2) PPM	0.1	0	0	0.1	0		
GENERAL INSPECTIONS							
Fan Speed 1	**1300**						
Fan Speed 2	**1307**						
No tears in vent bag	No						
Wet down required	No						
P2 Mask Compliance	Yes						
Fans in Sub Station ON	Yes						

Actions Based on Air Velocity Readings

If any working area of the mainline section in the tunnel / shaft has a velocity less than 0.3 m/s, this must be communicated to the Superintendent immediately.
The Superintendent will make a decision whether to increase the velocity in the area or classify this section as a non-working area and restrict access to personnel.
For personnel to be allowed to work in any section classed as a non-working area, a local risk assessment must be conducted. This risk assessment must include a detailed description of the type of work performed, the associated risks along with controls to be implemented and monitoring requirements approved by the Superintendent and Construction Manager.
Any non-working areas must be communicated to the work force and relevant stakeholders either through signposting, via prestart, emails, verbal communication or through toolbox talks.
If the fresh air fan is turned off in a drive / shaft, all diesel machines working in the area must be turned off as soon as possible. Afterwards, if the fans cannot be turned backed on in the next 30 mins, personnel must retreat to an area where there is ventilation and wait for instruction from the Superintendent.

Questions?