Controlled Primary Ventilation Recirculation and Re-use with Reconditioning

A Strategy for Deep Mines

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Defining the problem

- Increasing depth = increasing trucking fleet
- Ageing ventilation infrastructure
- Extending past installed ventilation infrastructure capacity
- Capital constrained due to short mine life
- Cost - shafts is significant
- Raise boring projects risks - cost overruns, geotechnical risks, rig availability

Definition of re-use vs. recirc

- Controlled Recirc. – taking some of the exhaust air, reconditioning it and then injecting it back into the intake.

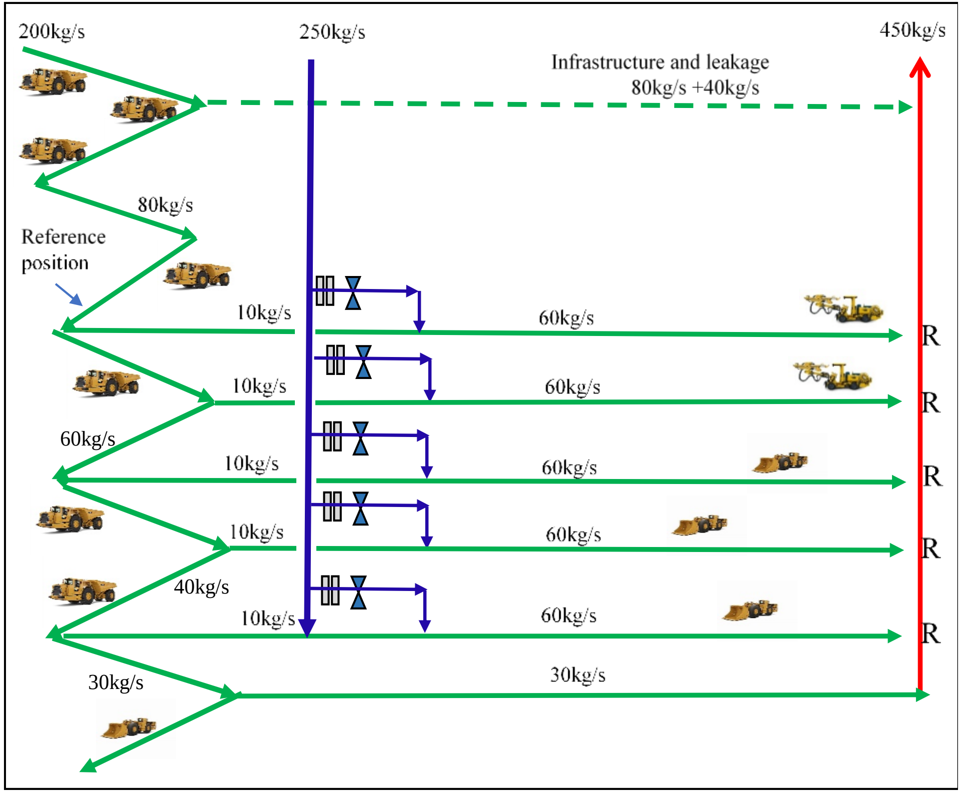
- Re-use - ventilating two distinct areas in series by re-using a portion or all the air from one area in another area.

History of re-circulation systems

Paper by:	Mine	Use of system
Marks & Shaffner, 1989	Homestake	Distribution of cooling
Van den Berg, 2012	Palabora	Recondition and re-use crusher air for development
Bluhm, 2013	Taquari Vasouras	Shortage of primary vent and manage heat

Opportunities

- Increasing decline airflow rates
- Ventilating satellite ore bodies

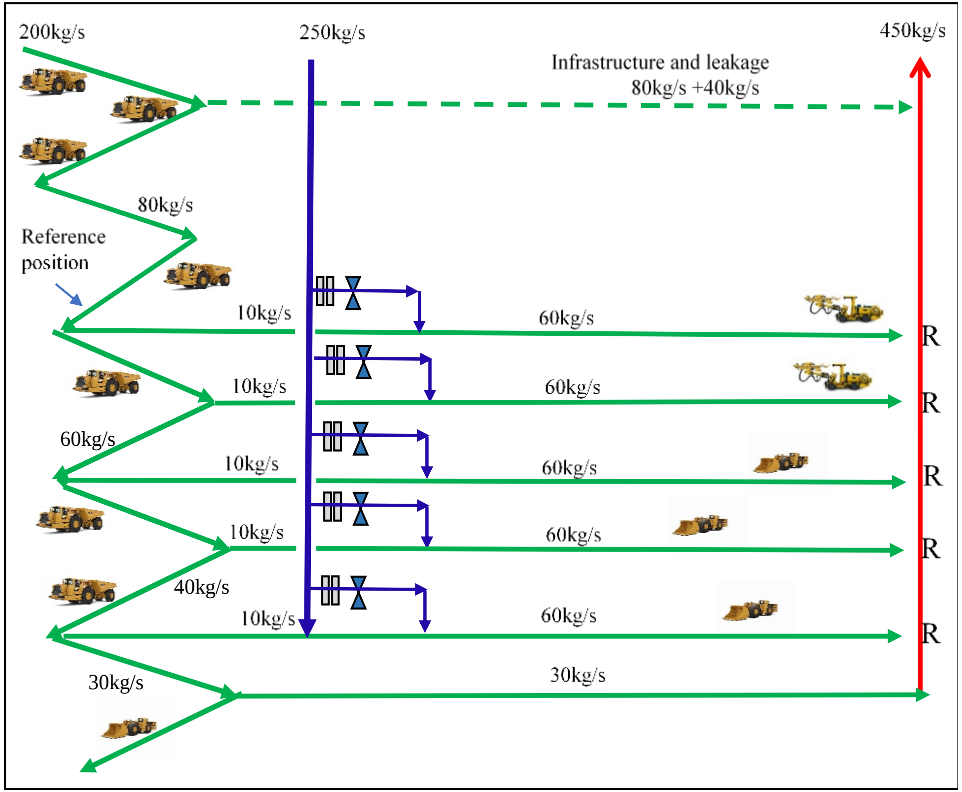


Modelling

- Base case with a fresh air intake raise, a return air exhaust raise and a single decline.

Production Levels	5
Depth	1.5km
Trucks	7 x 600kW
Loaders	4 x 300kW
Surface Temp	20°C wet bulb
Geothermal gradient	2.5°C/100m
CO concentration	1500ppm max at tailpipe
NOx concentration	1000ppm max at tailpipe

Base Case – no recirculation



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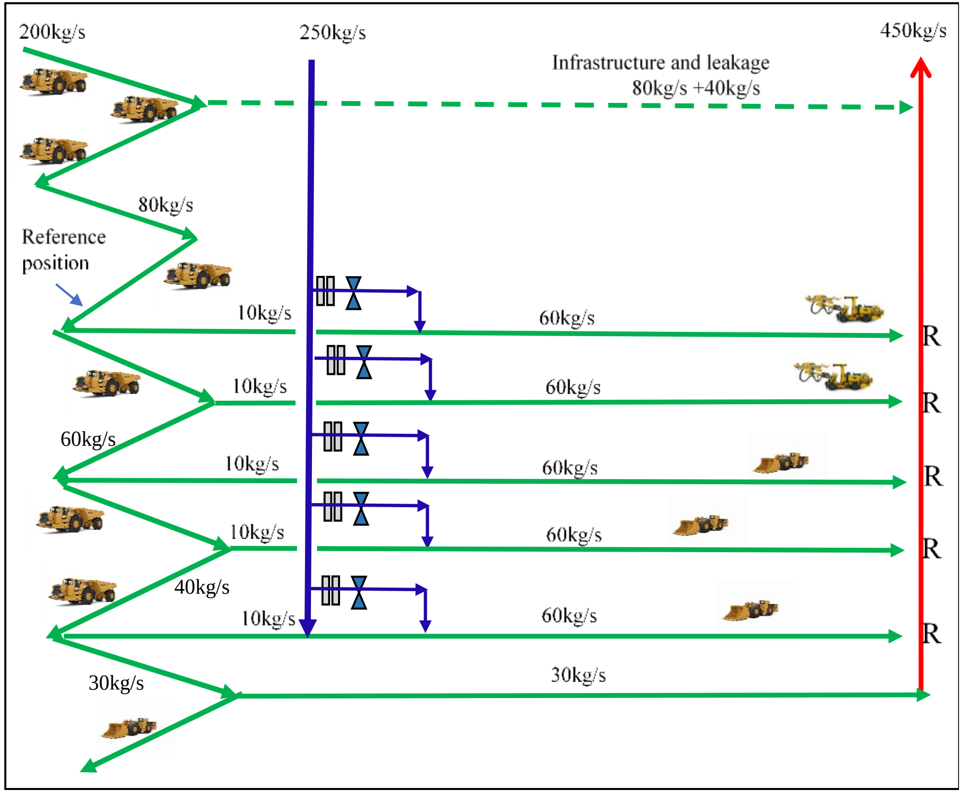
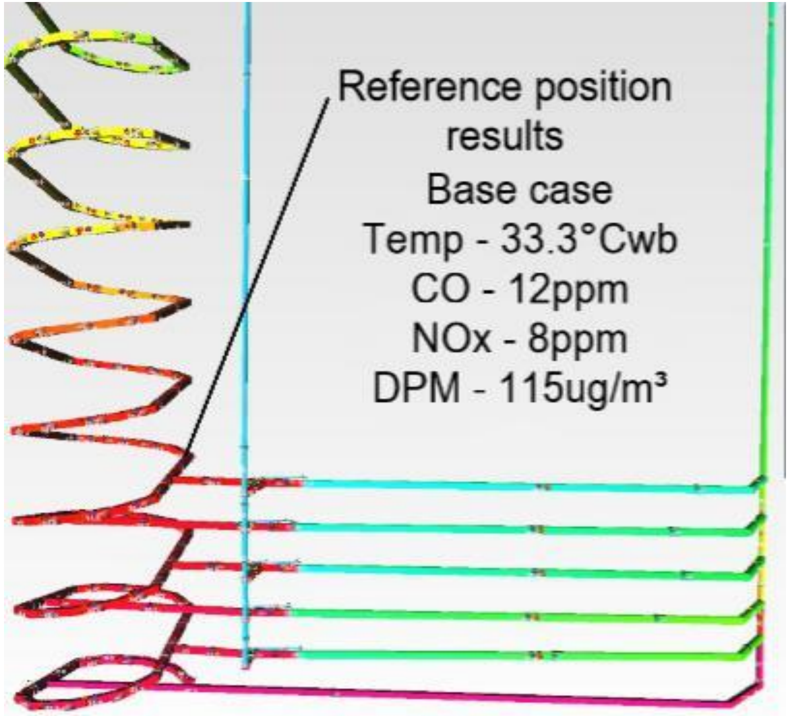
Base Case – no recirculation





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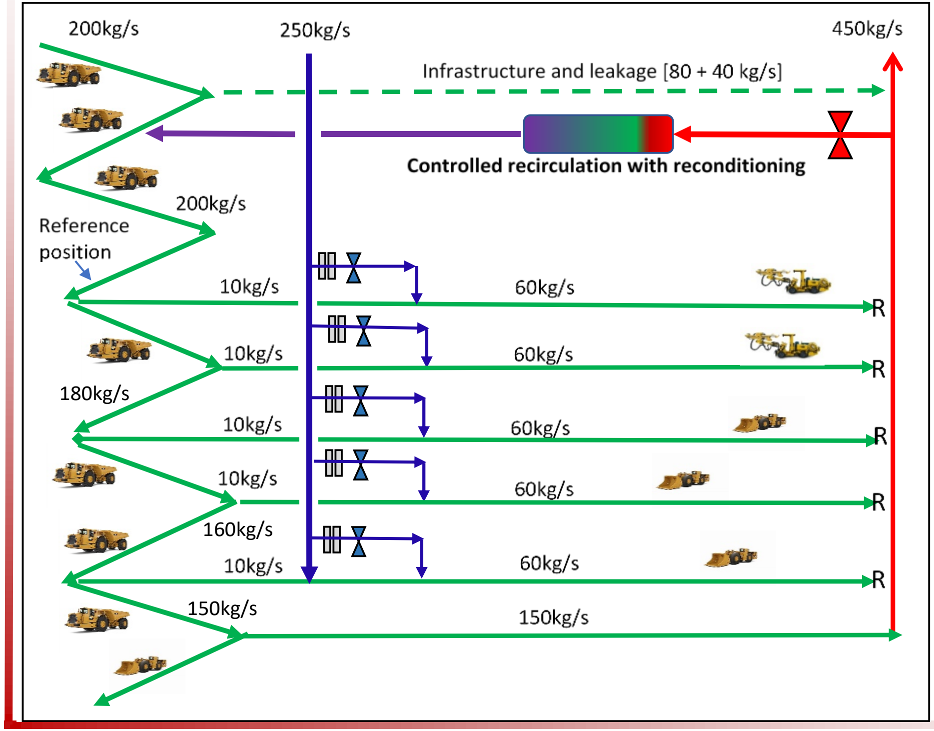
Scenario’s

- Scenario 1: 120kg/s recirculation with 3.5MW spray chamber
- Scenario 2: 120kg/s recirculation with 3.5MW spray chamber and high efficiency scrubber stage

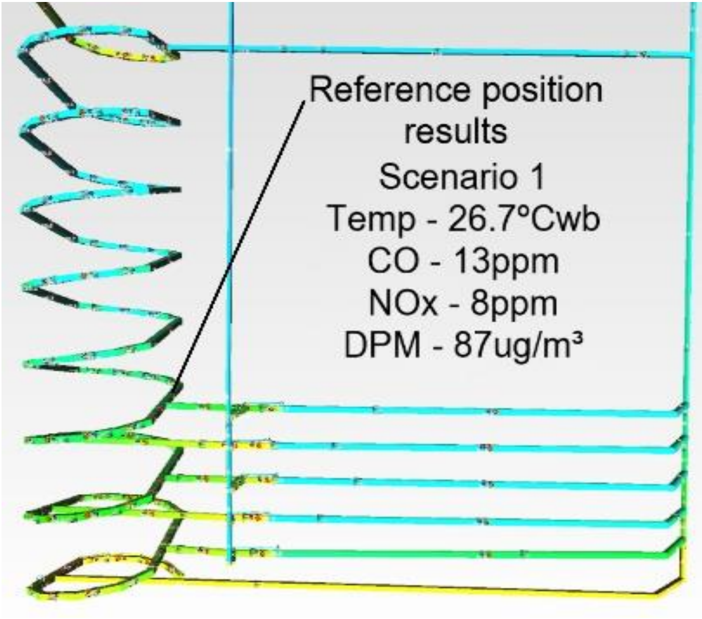
Assumptions

- Scenario 1 will have 0% efficiency in eliminating CO and NOx and 15% efficiency at eliminating DPM.
- Scenario 2 will have theoretical efficiencies of 25% for CO, 85% for NOx and 80% for DPM.

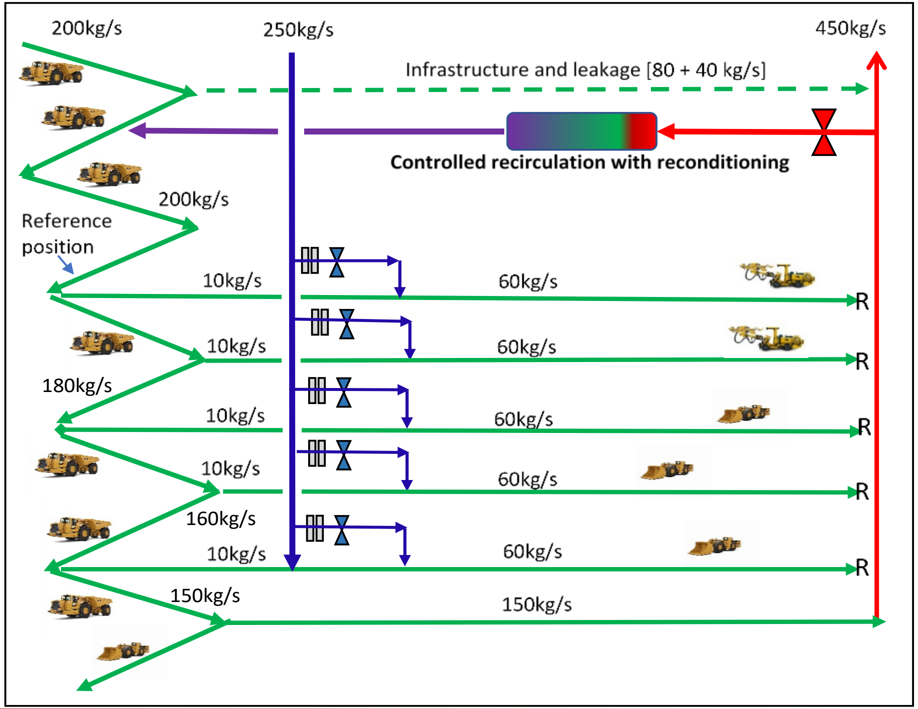
Scenario 1 - reconditioning for heat

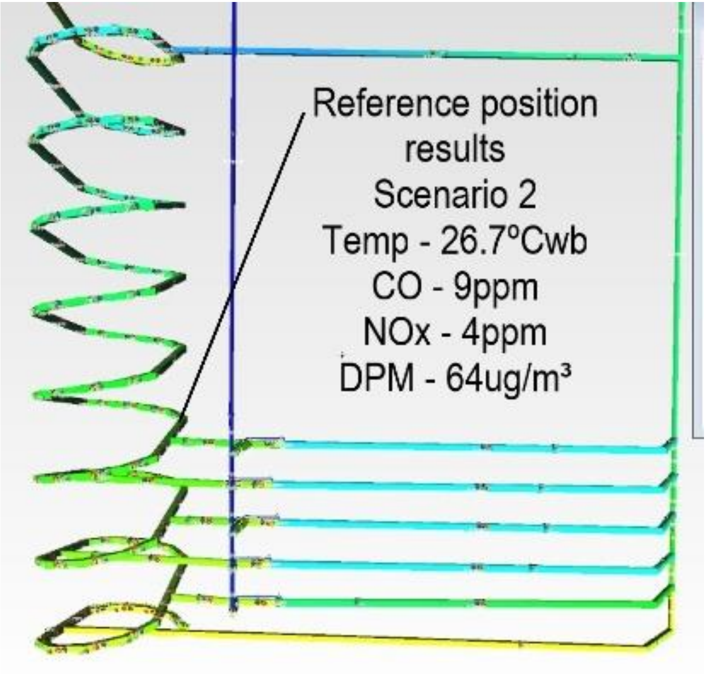


Reconditioning chamber at 1km depth



Scenario 2 – reconditioning for heat and contaminants





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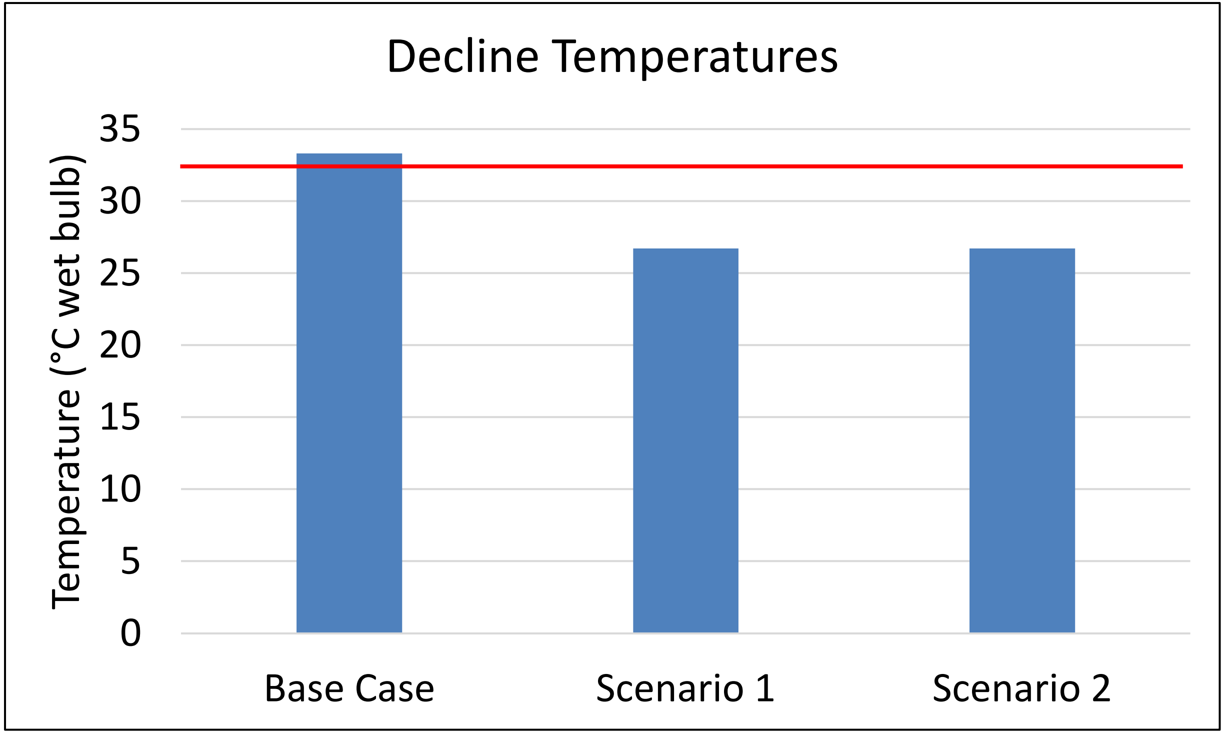
Modelling Results - Temperature



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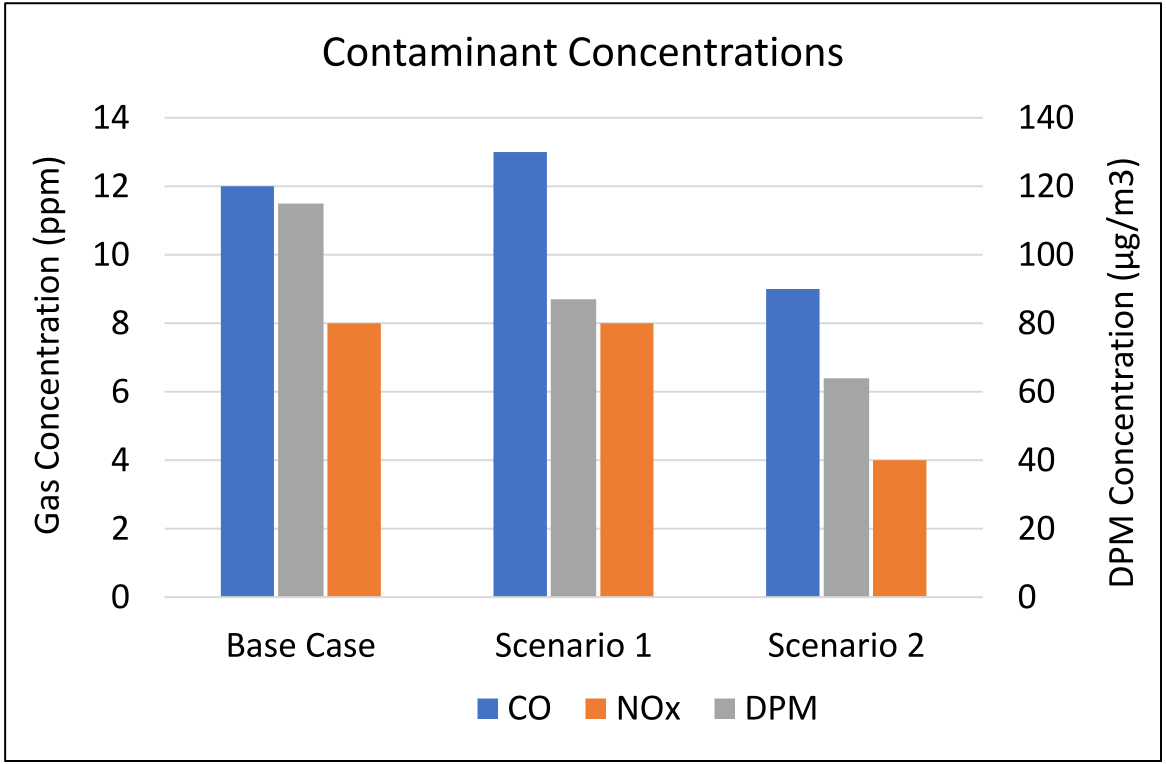
Modelling Results - Contaminants

Occupational limits (NOHSC TWA):

CO: 30ppm

NOx: 25ppm

DPM: 100μg/m^3



Existing Reconditioning Systems – UG Cooling

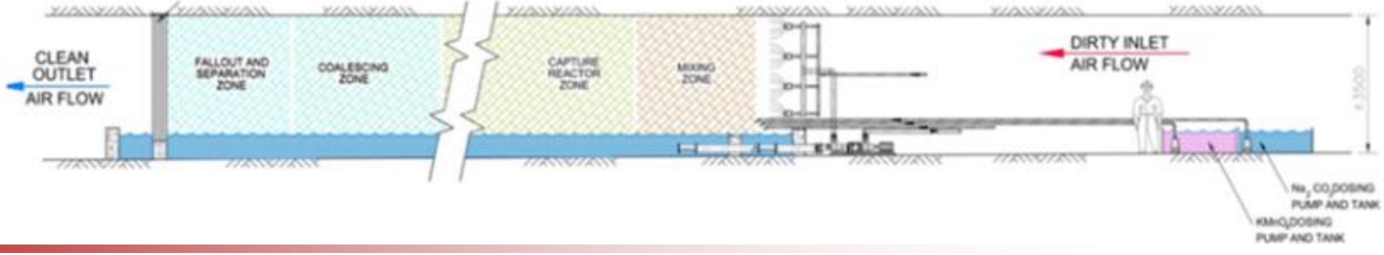
- Conventional UG spray chamber
- Already in industry
- Existing technology
- Captures nuisance dust

Next Gen Reconditioning Systems?

- Ultrafine atomised spray systems with chemical additives
- Remove respirable dust fraction and some contaminants

Conventional cooling spray nozzles

Atomised scrubbing spray nozzles



Managing Risk

RISKS

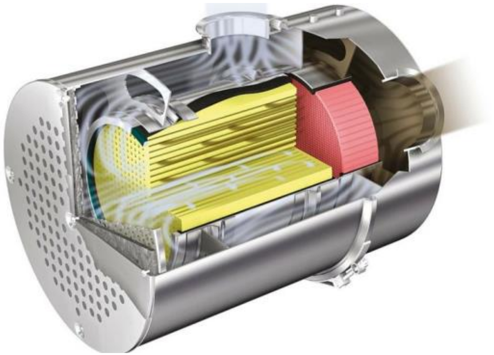
- Flammable gases
- Blast fume clearance
- Silica dust
- Diesel particulate matter

CONTROLS

- Monitoring with interlocks
- Self closing doors and automated louvres
- Design system to capture respirable fraction
- Real time monitoring and system flushing

Enabling Technologies

- Automation
- DPM Filters
- Electrical Equipment fleets



Ventilation on Demand

- Power costs increasing
- Combine with real-time underground monitoring
- Potential to significantly reduce ventilation power and costs

Immediate Applications

- Electrical equipment, no respirable silica dust, no flammable gas or radon present
- Mines with diesel equipment, but without the other critical contaminants, can consider controlled recirculation and re-use
- Indeed, a number of mechanized mines already employ significant re-use factors albeit without reconditioning

Case for R+D

- Primary upgrade - AUD$60M to $90M. inc dev, raises, fans, refrigeration
- UG spray chamber and refrigeration system capable of cooling air from 28ºCwb to 20ºCwb and scrubbing dust would cost AUD$20M to $30M.
- Significantly less and, although scrubbing capability needs proving, there is a compelling business case for this approach.

Conclusion

- Deeper with increase in trucks, diesel exhaust and heat loads on the decline.
- Localized hot zones and high contaminant areas occur.
- Recirculation strategy with reconditioning could have a huge effect on economic viability.
- Significant cost of primary upgrades, there is strong motivation for R + D into recirculation and scrubber technology.