ISSUES IN USE OF INERTISATION OF FIRES IN AUSTRALIAN MINES

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AIM

Under ACARP supported project examine the use of modern inertisation approaches and particularly look at use of GAG in conjunction with fire simulation using the program VENTGRAPH for preplanning for the consequences of mine fires.

MINE INERTISATION

Inertisation accepted as important tool in Australia.

- Two Queensland GAG units; various incidents since 2003 have underlined need for more information on their application.
- The NSW Mine Shield nitrogen apparatus dates to the 1980s and has been used a number of times.
- The Tomlinson boiler owned by a number of mines; production tool to inert sealed goaf.
- Pressure Swing Adsorption and Membrane units are available and in use particularly for inerting sealed goafs.

INERTISATION & MINE VENTILATION

Inertisation units interact with the complex ventilation behaviour during fire. Aspects worthy of examination include

- Location of the unit for high priority fire positions; eg portal docking positions, special boreholes
- Time required for inertisation output to interact with and extinguish a fire.
- Effects of seam and other gases on fire behaviour with inertisation present
- Changes which can be safely made to the ventilation system during inertisation including switching off some or all fans
- Complications; underground booster fans & spontaneous combustion.

Queensland Gorniczy Agregat Gasniczy (GAG) unit

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Mine Shield

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Tomlinson

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Floxel Membrane nitrogen unit

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Characteristics of the outlet flow of the GAG, Mine Shield, Tomlinson and Floxal inertisation units.

	Flue Gas Generator (Tomlinson Boiler)	Mineshield Liquid Nitrogen System	GAG unit	Membrane System AMSA Floxal Unit
Inert Gas Output Quantity Range, m^3/s	0.5	0.2 – 4.0	14 – 25	0.12 – 0.7
Suggested Default Quantity, m^3/s	0.5	2.0	20	0.5
Delivery Temperature, °C	54	Atmospheric	85	20
Oxygen, %	2	0	0.5	3
Nitrogen, %	81.5	100	80 – 85	97
Carbon Dioxide, %	15.3	-	13 – 16	-
Carbon Monoxide, ppm	0	-	3	-
Water Vapour, %	1.2	-	some	-
Water droplets			significant	

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DOCKING POSITION OF GAG

Positioning of the inertisation units is a major determinant of potential success for most efficient suppression of a specific fire.

- Traditionally in Queensland GAG docking points have been placed on intake ventilation headings (either travel roads of conveyor belt roads).
- Some mines have prepared docking points on boreholes or ventilation shafts at various points across mine workings.
- Multiple use of access holes for ventilation, services, escape and inertisation.
- Optimum inertisation docking positions depends on a number of considerations including the location of the fire, the relative distance from the inertisation docking portal location and the attributes and complexity of the mine ventilation network.
- Operation of a GAG unit requires preplanning in terms of infrastructure requirements for a GAG surface portal docking station and access for operating personnel, fuel, water and other operating requirements.

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Effectiveness of GAG delivery

Code	Description	Results out of 35 scenarios simulated	Percentage %
A	GAG exhaust delivered efficiently (without significant dilution) to fire.	0	0
B	GAG exhaust reaches fire with no fan changes but diluted and not fully effective.	7	20
C	GAG exhaust reaches fire only after fan change and potentially effective after ventilation air (incl. fire fumes) local reversal across fire.	16	46
D	GAG exhaust will never reach fire.	5	14
E	GAG exhaust only reaches fire after fan change and working section methane and ventilation air (incl. fire fumes) reversal across fire.	7	20

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EFFFECTIVENESS OF GAG DOCKING POINTS

Simulation exercises undertaken with a wide range of Australian mines focuses attention to the situation that many potential underground mine fire sources cannot be successfully inertised with the GAG docked at the current specified point. This inability to deliver GAG output is particularly so for fires in extended areas of workings or in panels. Important conclusions are:-

- Successful delivery of GAG output must consider delivery conduits directly into workings near the fire through existing or purpose drilled boreholes.
- During a fire the stopping of the main surface fans will lead to rebalancing of pit ventilation and in some cases potential explosions through air reversals bringing poorly diluted explosible seam gases or fire products across the fire site.

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ROLE OF GAG

There is potential for an increased role for the GAG built on experience gained in the use of the GAG and other inertisation units in recent years. This can encompasses

- How GAG docking to boreholes can improve delivery of GAG inert gases to high priority potential fire locations particularly in working panels.
- How GAG docking to boreholes can be used to economically inert goaf spontaneous combustion incidents. Five Australian collieries has experienced major goaf heatings in recent years and the small inert gas units have generally not been of sufficient capacity.
- How GAG docking to boreholes can be used to inert goafs on sealing to avoid explosible atmospheres and movement of atmospheres into the "Coward Triangle".

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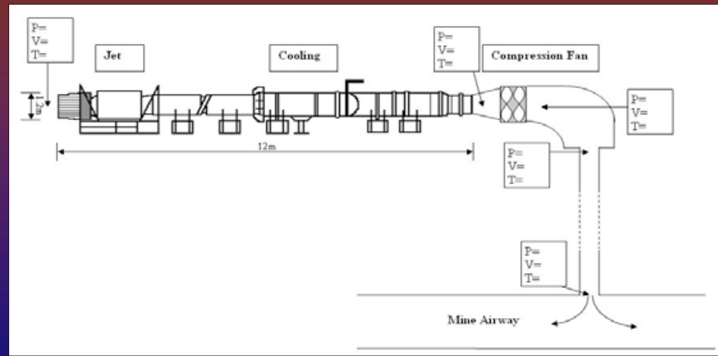
INERTISATION THROUGH BOREHOLES

Inertisation exhaust flow in deeper or smaller diameter holes faces significant back pressure. A variable pressure fan placed in line with the GAG flow could overcome substantial back pressure to allow holes of economical dimensions to be utilised.

A primary requirement is to examine attainable designs for panel boreholes under Australian conditions with current drilling technology. Part of this is to calculate design considerations for a variable pressure fan that can assist flow against back pressure. There is a limit to the contribution a variable pressure fan can make to assisting flow. Categories are

- Hole designs (diameters and depths) that can deliver directly without assistance of any fan,
- Hole designs that can deliver with assistance of a fan and the pressure required for this delivery to be attained, and
- Specifications of boreholes design parameters that cannot achieve delivery even with fan assistance.

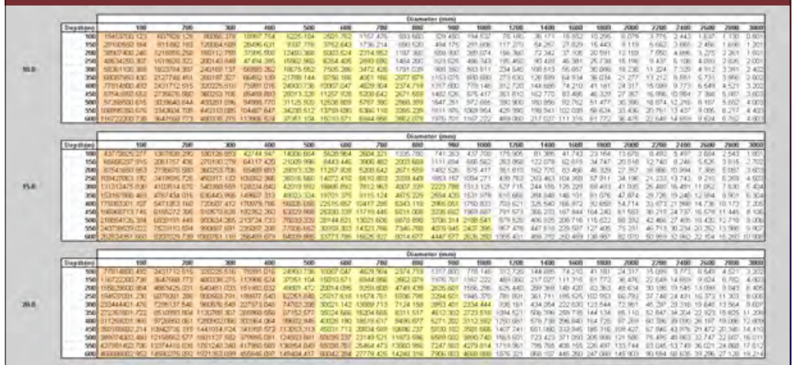
FAN ASSISTANCE TO OVERCOME BOREHOLE BACKPRESSURE



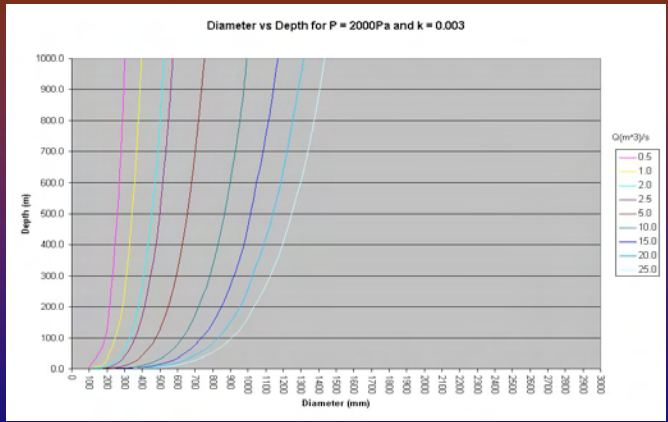
BOREHOLE DESIGN CONSIDERATIONS

- Borehole design parameters must be based on the complex fluid flow theory that describes the dynamic, hot, pressurised exhaust carrying a superheated vapour.
- Steady flow energy equation based on Bernoulli's equation made applicable to compressible flow can be put in a form to describe the behaviour of GAG exhaust fluid being pushed down the borehole.
- Equation will follow the form:-

ATTAINABLE BOREHOLE SIZES FOR FREE AND FAN ASSISTED DELIVERY; Q=10, 15 and 20 m^3/s



BOREHOLE DESIGN FOR FREE DELIVERY



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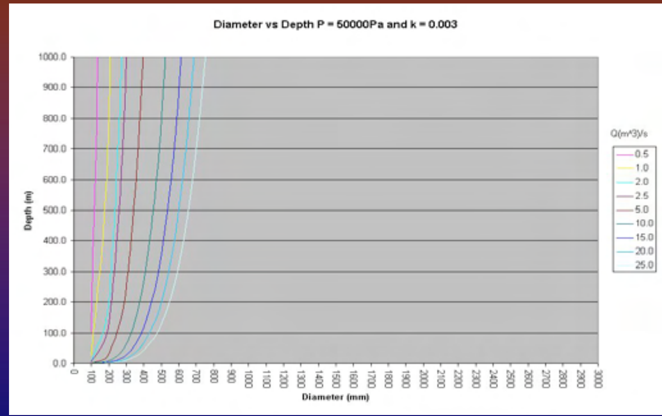
BOREHOLE DESIGN FOR FAN ASSISTED DELIVERY



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Impact of the Segregation Quality on GAG Effectiveness

Ventgraph simulations using a fully segregated belt heading with a range of segregation stopping resistance values.

- The belt way had a regulator placed outbye to reduce airflow and cause leakage flow into it from surrounding headings.
- A GAG unit was connected to the beltway drift and run at 11 000 rev/min to give an exhaust stream with an oxygen level less than 5 per cent.
- Cut-throughs were spaced at approximately 50 m intervals.
- Scenario kept simple; no doors included and no fire was actually placed in the drive. Mine fans were kept on throughout simulations.

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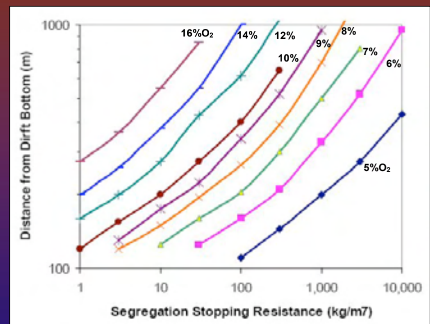
Dilution of inert gas at varying segregation qualities and distance



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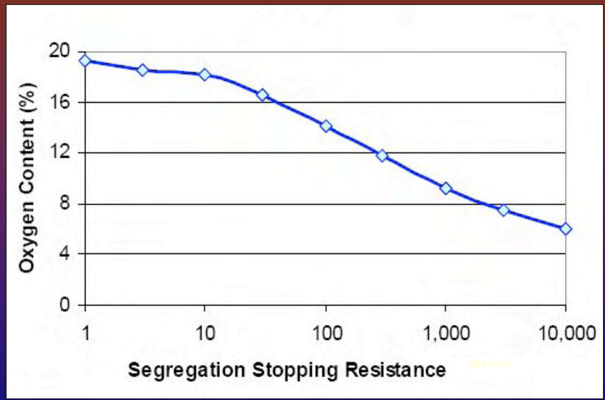
Dilution of inert gas at 1.0 km from drift bottom



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Conclusions

- The fire simulator is a tool for preplanning of what may happen in the event of a mine fire at different underground points and under varying types of fires and conditions.
- Under ACARP Grants a number of mines have established calibrated mine models and developed fire scenarios to aid emergency management planning.
- The models have capability to investigate many questions that present on how inertisation can be used safely and effectively in event of an incident and this is the current focus of research.

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Acknowledgements

- The cooperation of the developers of VENTGRAPH, Wacek Dziurzynski, Waclaw Trutwin, Jerzy Krawczyk and Teressa Palka of the Strata Mechanics Research Institute of Polish Academy of Sciences in assisting the introduction of fire simulation to Australian mines.
- The cooperation and support of Andrzej Wala of the Univesity of Kentucky in visiting Australia, visiting Australian mines and sharing his practical experience in fire simulation.
- The support of ACARP, the University of Queensland, Queensland and NSW inspectorates, Australian mining companies, mine rescue organisations, the CFMEU and others in supporting this new endeavour.

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