QMRS Inertisation Solutions

Moura No.2 Mine 1994

Pike River

Pike River - Infrastructure moved 10m

Men & Materials Drift – June 2024

Conveyor Drift

Main Fans

Inertisation Tools

Dry Ice

Water

Liquid Carbon Dioxide

Tomlinson Lo-Flo Inert Gas Generators (Boilers)

Liquid Nitrogen

Nitrogen Foam

Nitrogen plants – Floxal units

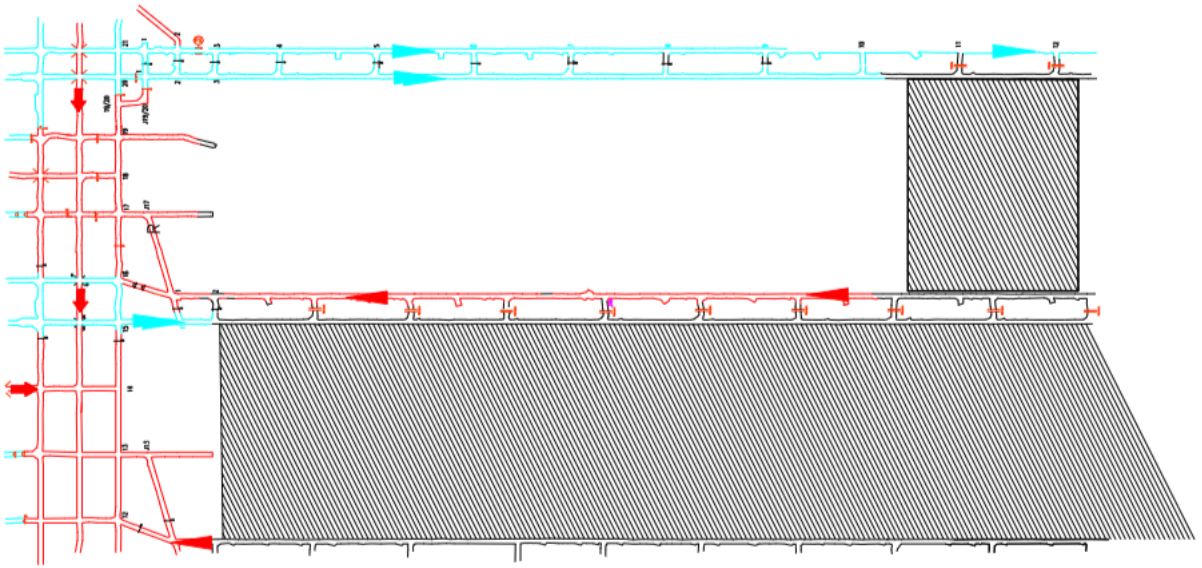
Jet engines – Gorniczy Agregat Gasniczy or GAG & G.E.

Jet engine - Mini Gag

CO2 foam

	H_2	CO_2	Ethane	O_2	CO	CH_4
7 c/t	0.40%	14.0%	0.08%	3.15%	0.13%	2.09%
5 c/t	0.43%	4.60%	0.05%	14.86%	0.12%	0.90%

Figure 1 **Longwall 3 South December 1997**



Tomlinson Lo-Flo Inert Gas Generators (Boilers)

Liquid Nitrogen

Liquid nitrogen was used for first time in 1949, to smother an underground fire at Doubrave Mine in the Ostrava – Karniva Coal Basin, Czech Republic.

Other examples include:

- In 1986, a Pressure Swing Adsorption (PSA) nitrogen generator was installed at **Lodna Colliery** in the Jharia coalfield, located in Jharkhand, India. The system delivered a total of 94,000 cubic meters of nitrogen over approximately eight months.

- **Yangchangwan Colliery** in China during 2004–2005 where liquid nitrogen injected into workings to inert methane and prevent explosions.

- **Datong Coal Mine** in China during 2010s carried out experimental injection into goaf/gob areas to reduce explosion/fire risk.

- **Shanxi Coal** mines in China during 2010–2015. Pilot-scale use in abandoned workings for fire prevention and inertisation.

Liquid Nitrogen

Liquid nitrogen (LN_2) is extremely cold (-196°C) and rapidly vaporises when exposed to mine air. When injected into mine workings, it displaces oxygen and lowers the temperature, creating an inert atmosphere that suppresses ignition of methane, coal dust, or spontaneous combustion.

LN_2 is pumped into mined-out areas (goaf/gob) where methane may accumulate. The vaporised nitrogen mixes with air, reducing oxygen concentration below the level needed for combustion.

In addition to oxygen displacement, LN_2 lowers temperatures, slowing or stopping spontaneous heating of coal or combustible materials.

Liquid Nitrogen

Liquid Nitrogen

Advantages:

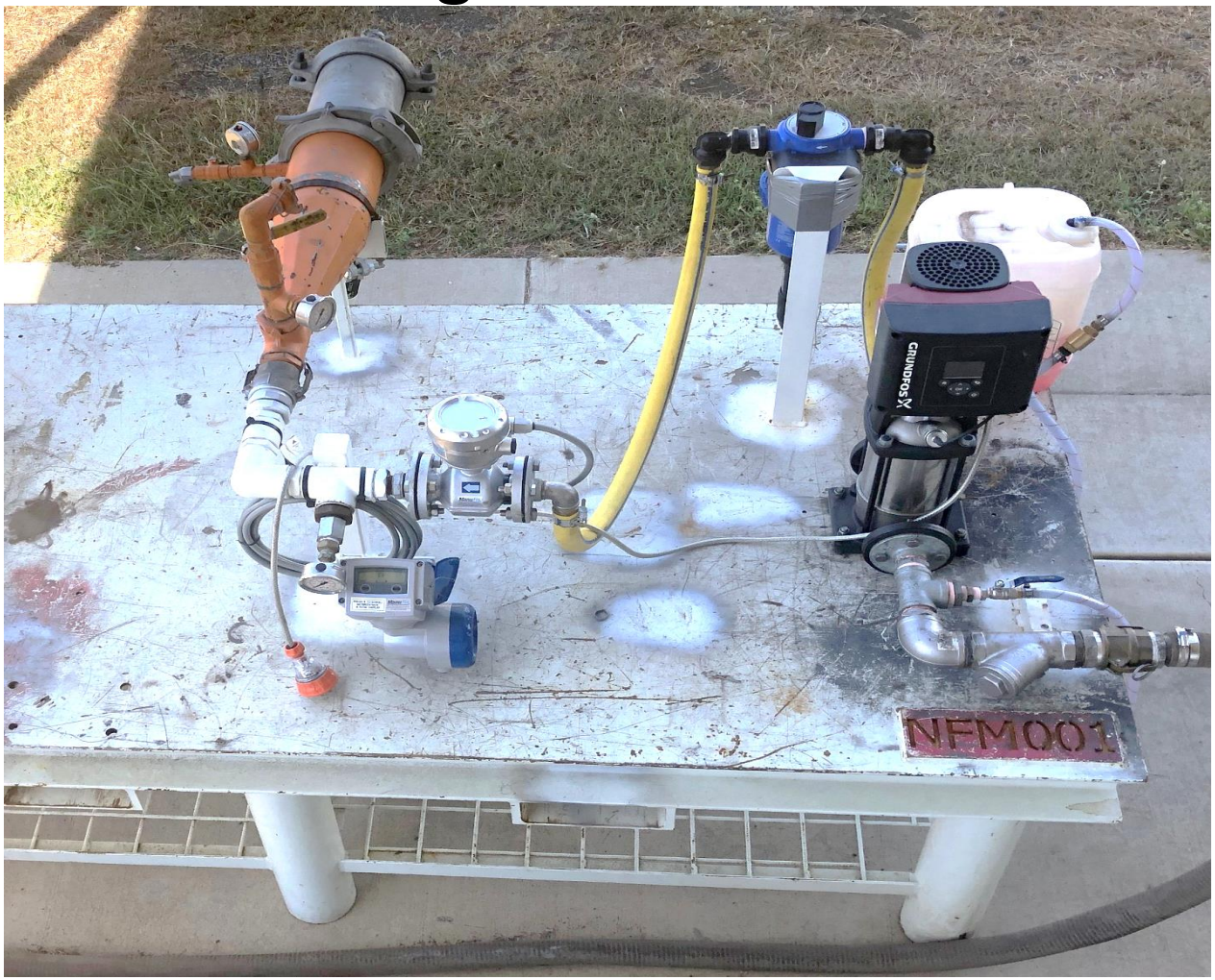
- Rapid creation of inert atmosphere.
- Non-toxic, leaves no chemical residue.
- Can be applied selectively to high-risk areas.

Limitations:

- High cost and logistics of LN_2 supply.
- Requires careful planning to prevent condensation and frost damage.
- Usually used for emergency or pilot-scale applications rather than full-scale routine inertisation.

Nitrogen foam

Nitrogen Foam Table.

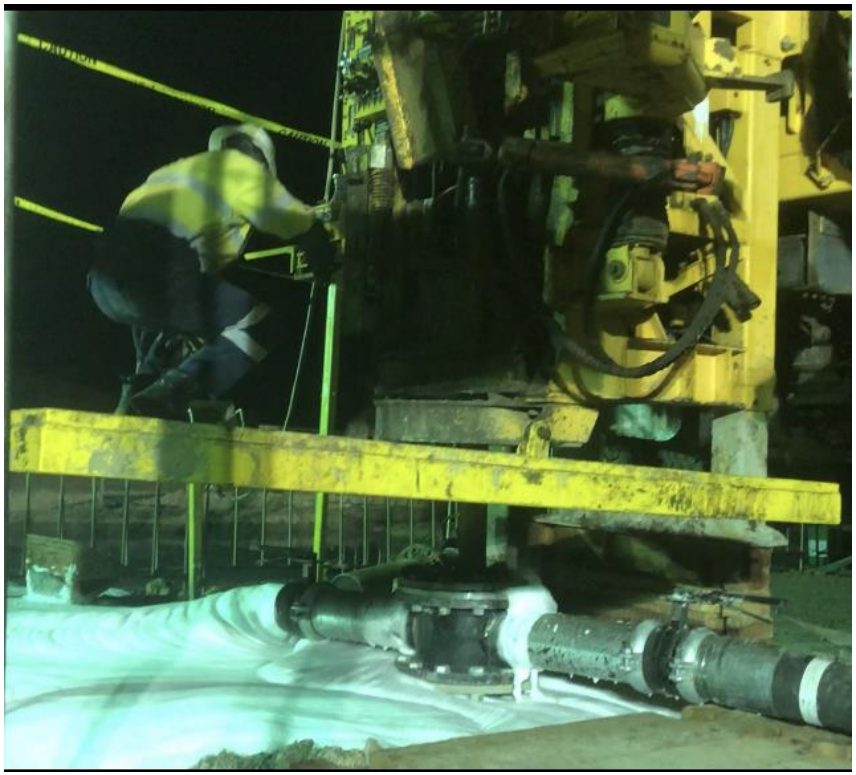


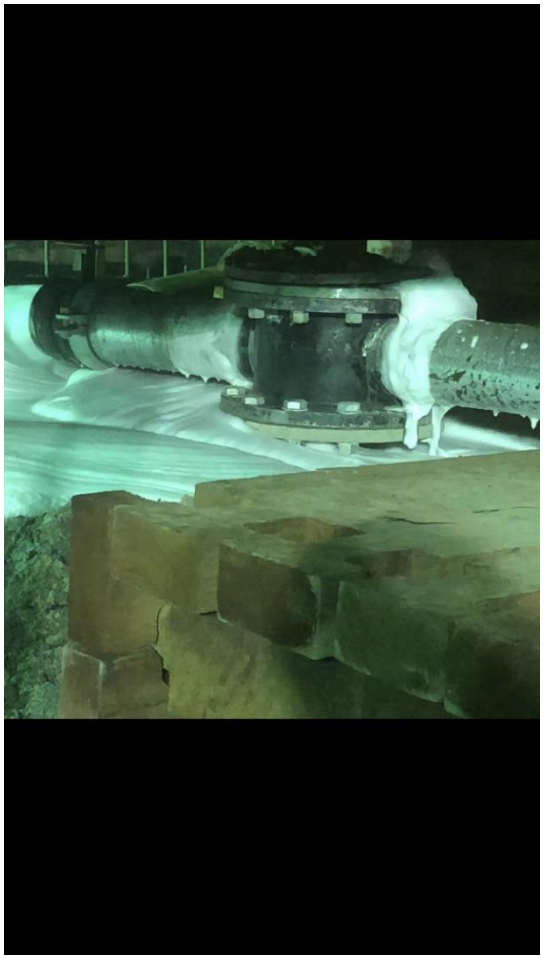
Trumpet Housing

Bio-Polymer Selection Matrix for Underground Inert Barriers

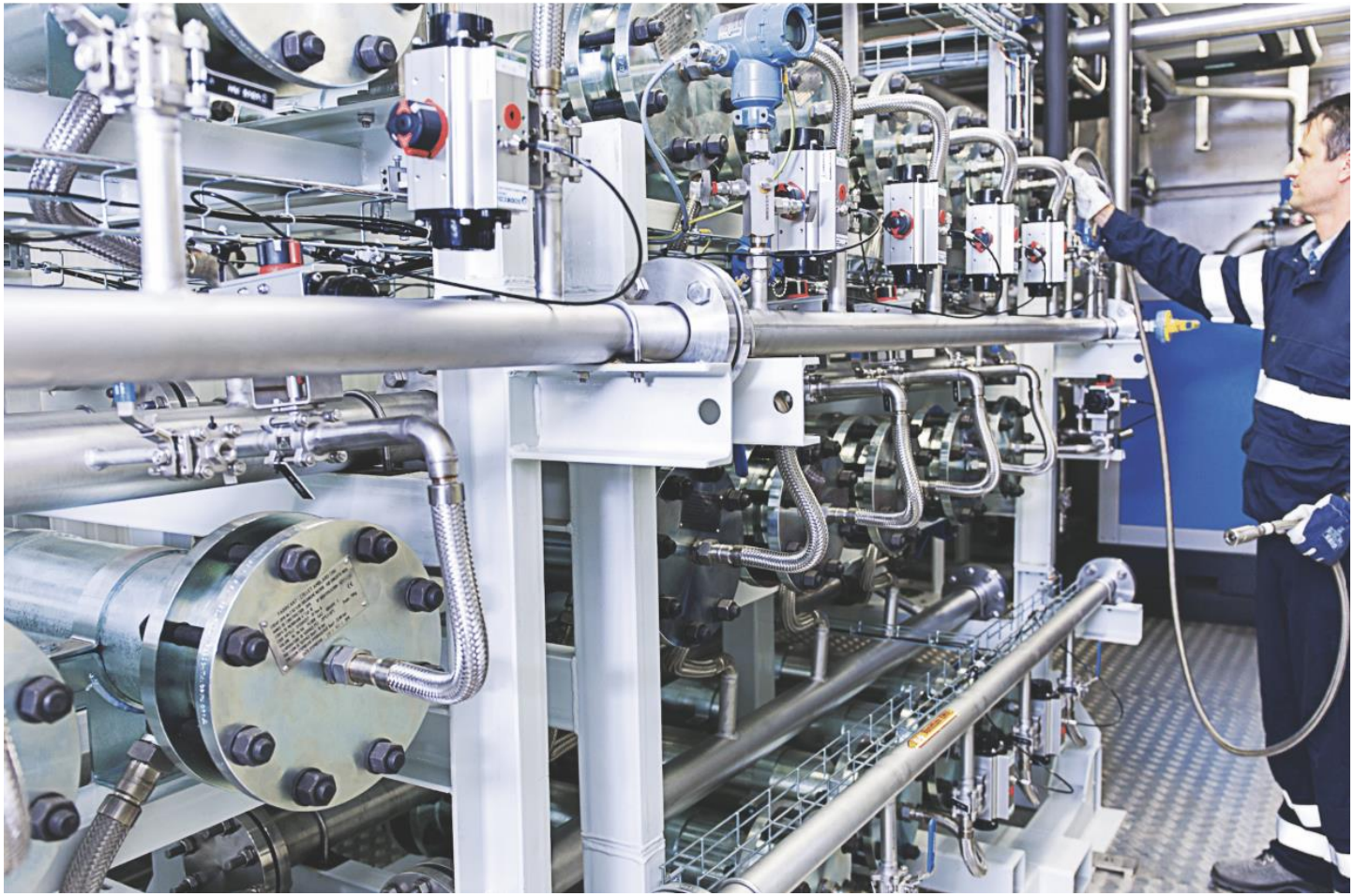
	Wet Conditions	Gassy Goaf	High Temp Area	Long-Term Stability	Eco - Friendly
Xanthan Gum	✓	✓	✓	✓	✓
Guar Gum	✓	△	✓	✓	✓
Chitosan	✓	✓	✓	✓	✓
Sodium Alginate	△	△	✓	✓	✓
Starch-Based	△	△	△	✓	✓
Cellulose (CMC)	✓	✓	✓	✓	✓

Foaming drill rods





Floxal ASMA Unit



Mini GAG

- The Mini GAG or Steamexfire is a high-flow inert gas generator originally manufactured in the Netherlands.

- It operates using a two-stage jet engine combustion process:
  1. Air is first compressed and mixed with fuel for ignition.
  2. The exhaust (still containing oxygen) undergoes a second combustion stage that consumes all oxygen, resulting in inert gas output that includes nitrogen, CO_2, and steam.

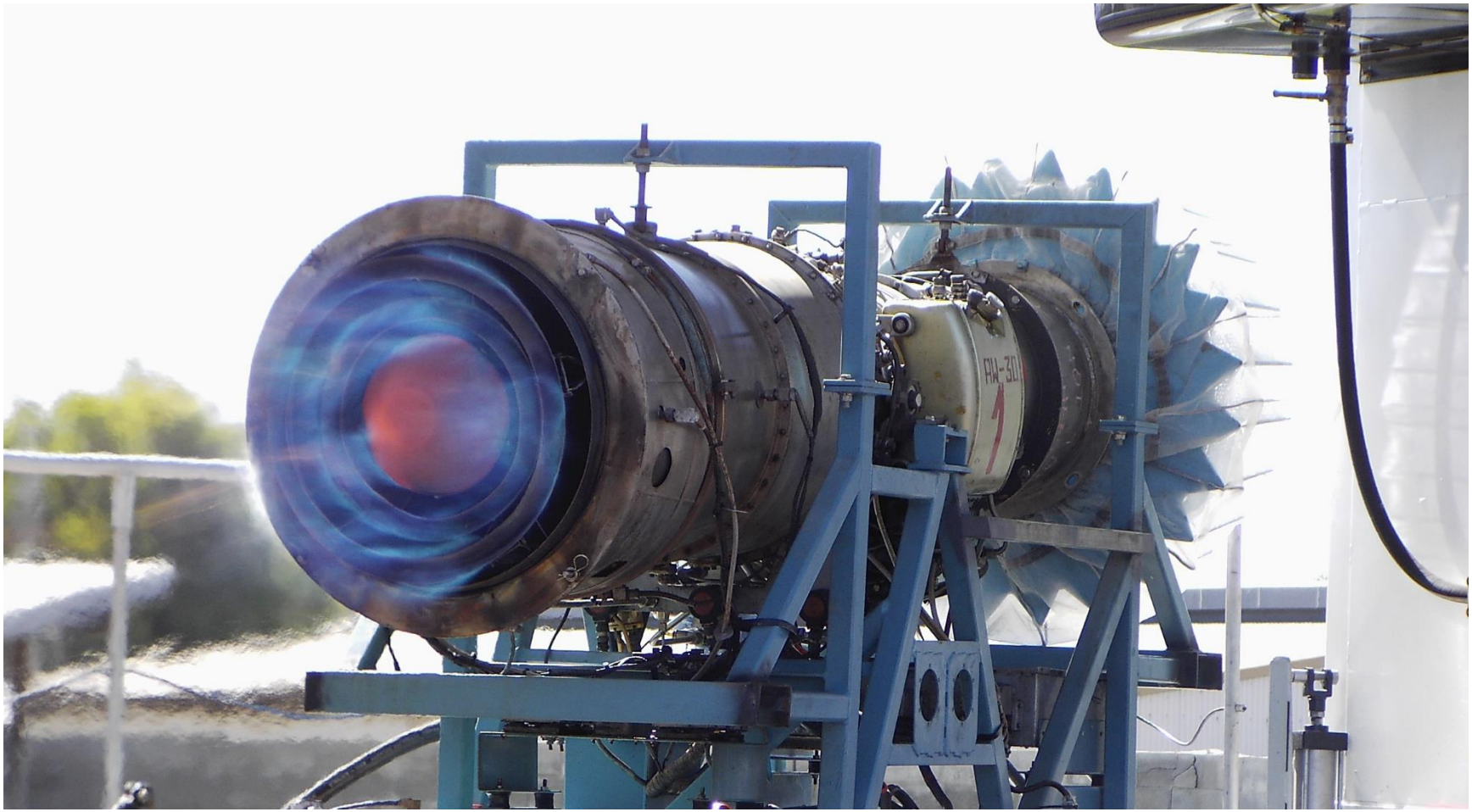
- The process involves water-cooling within a ~7-meter combustion tube to generate steam. The system can deliver up to 25 m^3 of inert gas and water vapor per second (for larger models).

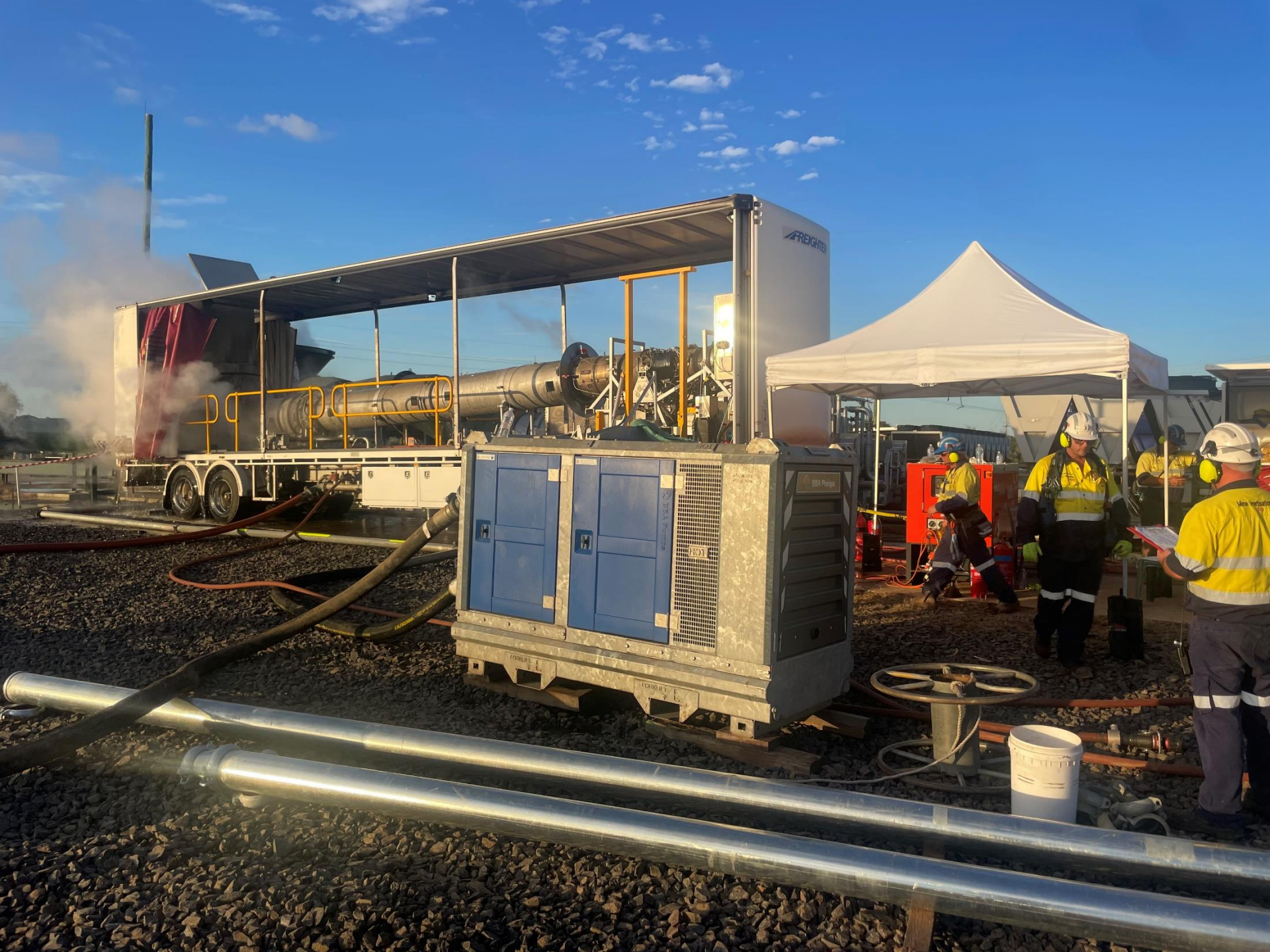
- Used for inerting underground mine fires, such as the Goedehoop mine fire in South Africa and the Svea Nord mine fire in Spitsbergen in 2005.

Technical details:

Engine:	Rolls Royce
Total weight:	650 kg
Total length:	6 metre
Output:	max 12 m3/second
Fuel consumption:	max 1.200 litre/hour
Water consumption:	max 10 m3 litre/hour
Electric power:	400V, 10Kw (required)

GAG - Gorniczy Agregat Gasniczy




FREIGHTER
BBA Pumps

D. S. Gillies and H. W. Wu

Table 1 Characteristics of the outlet flow of the GAG, Mine Shield, Tomlinson and Floxal inertisation units.

	Flue Gas[1] Generator (Tomlinson Boiler)	Mineshield[2] Liquid Nitrogen System	GAG unit[3]	Membrane[4] System (AMSA Floxal Unit)
Inert Output Range, m^3/s	0.5	0.2 – 4.0	14 – 25	0.12 – 0.7
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	

Future Developments

Utilising nitrogen or carbon dioxide foam in a proactive manner.

i.e. Using the foams as the longwall is retreating. Some mines are trying this with limited success by pumping between the shields.

Why can't we modify the pontoons on longwall shields to discharge the foams during the retreat cycle – the industry did it with silica suppression by introducing water sprays through the canopies during shield advance – South Bulga mine in NSW – anything is possible.

Using foams in the exhaust of Tomlinson boilers / mini – gag / GAG engines – research & experimentation is required.

Conclusions

1. Turn what you don't know into what you do know. – Good gas monitoring systems with redundancy – real time or tube bundle and ventilation modelling. Understand the issue before adopting the selected tool/s.

2. With jurisdictions reluctant to send rescue teams into hostile environments the use of "disposable" robotics to ascertain the environment using lidar radar, temperature sensors, gas monitoring sensors etc so that minesite Incident Management Teams can make better informed decisions. More Research & Development in this area is required in some juristications.

3. Trained & competent personnel who understand the selected tool to be used & why.

4. Practice, Practice, Practice – Both desk top simulations, along with periodic & annual practical exercises to validate that your inertisation systems at your minesite is working.

Thank You & Questions from the floor?