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COAL MINE INERTIZATION

WHAT ARE THE OPTIONS?

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ABSTRACT

Many techniques are available to inertize the atmosphere of an underground coal mine. Nitrogen, Carbon Dioxide, Exhaust Gases and the natural extinctive effect of some coal mine goaves are all possible. Different procedures are suitable for a variety of situations. No one system can be used in every instance. This paper examines the pros and cons of the commonly available systems.

INTRODUCTION

Inertization of a coal mine fire as a fighting techniques or mine recovery tool depends on the principle of reducing the oxygen content in the mine atmosphere to a point where even if there is a source of ignition present a flammable gas mixture will not ignite. Typically with methane as the predominant flammable mine gas the oxygen level should be below 10%. Concurrent to this elimination of explosion risk any open fires would also be eliminated. Coal would continue to smoulder at down to 2% oxygen but providing the oxygen level remains below 10% further ignitions are not possible in methane atmospheres.

The earliest recorded use of inert gas to control a mine fire was in 1885 when flue gas from an adjacent coke oven was allowed to flow into the downcast shaft of a colliery in Belgium. The point should be made that the introduction of this type of gas or any other inerting medium will render the mine unsuitable for human habitation. Carbon dioxide was used in the 1950's with some success and the first case of inertization using nitrogen was reported in 1974.

Carbon dioxide and nitrogen have been used in Australia with the most recent case in Queensland being the use of nitrogen at Moura in July 1986. In this case in excess of 500 tonnes of liquid nitrogen was vaporised using the NSW Mineshield Unit with a resulting oxygen content in the underground area of concern of less than 10%.

With methane as the predominant flammable gas this oxygen content precluded the possibility of an explosion even if a source of ignition was present.

PREDOMINANT INERTIZATION MEDIA

NITROGEN

CARBON DIOXIDE

PRODUCTS OF COMBUSTION

NITROGEN

Vaporised liquid nitrogen (LN2) has been used extensively internationally to inert coal mines on an on-going precautionary basis in longwall goaves for example or as a shock tactic where large volumes are pumped underground to extinguish a fire or advanced heating. In Europe and other parts of Australia large quantities of liquid nitrogen are available as a by-product of the steel industry.

SOURCES

(A) Atmospheric air can be purified and then refrigerated followed by the fractional distillation of the resultant liquid at cryogenic temperatures. This process can be conducted on a large scale industrially with liquid oxygen as the by-product or similarly on a smaller scale by a Linde type portable fractional distillation unit.

(B) Pressure Swing Absorption (PSA)

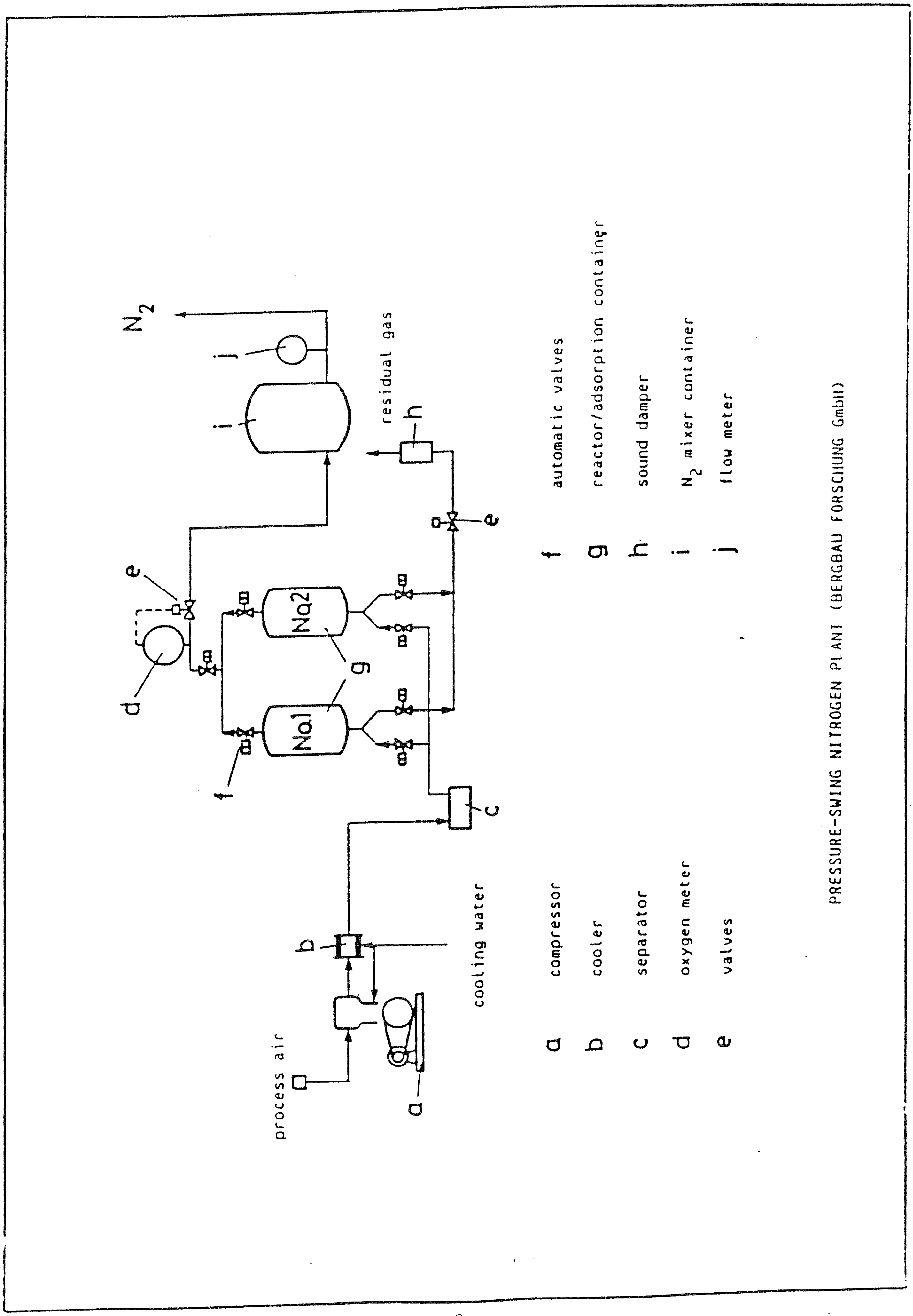
This system relies on a physical process which separates air into nitrogen and an oxygen rich component. The basic mechanism of separation relies on the property of carbon molecular sieve, by virtue of their internal pore system, to differentiate between molecules of disparate size. This size selective property facilitates the separation of oxygen and nitrogen. A diagram of the PSA system is included as figure 1.

USAGE OF LIQUID NITROGEN

The lack of significant liquid nitrogen production facilities in Queensland has meant that severe logistical difficulties exist with respect to the provision of sufficient liquid nitrogen to inert a significant mine fire. This was evident at Moura where problems were experienced with respect to continued timely supply where the LN2 production facilities were at least 500km away.

The use of the portable PSA system answers the problem of on-site delivery in a reasonable time but suffers from the fact that low delivery rates (30m^3/min) means that PSA cannot be used as a swamping measure for open fires or serious heatings. PSA is admirably suited for control situations before a heating has a chance to take hold and this tends to be the methodology practiced in Europe.

FIGURE 1



PRESSURE-SWING NITROGEN PLANT (BERGBAU FORSCHUNG GmbH)

LN2/PSA ADVANTAGE

- Stable, inert and non-reactive
- High purity product which can be pumped significant distances (up to 5km)
- Will not affect mine gas analyses (meaningful monitoring can continue)
- Low flow rates can be produced on-site economically by the PSA system
- Higher flow rates can be produced by vaporising liquid nitrogen utilising a NSW Mine-Shield type system.
- Can be delivered at low temperatures to promote the cooling of the fire zone.
- Nitrogen systems are easy and safe to operate.
- Density close to air (0.97)

LN2/PSA DISADVANTAGES

- Lack of bulk LN2 supply in Queensland (This may be about to change)
- PSA Systems are expensive to source and low flow rates can be a disadvantage.
- Both PSA and LN2 systems have to date been used on the surface only, therefore section inertization can be difficult.
- The density of nitrogen being similar to air can be a disadvantage at times.

CARBON DIOXIDE (CO_2)

PRODUCTION

Carbon dioxide is produced by the action of acid on calcium carbonate.

USAGE

Carbon dioxide can be delivered on-site in a liquid form and the vaporised gas has been used in Queensland but without tangible success. There are documented cases in the UK where CO_2 has been successfully utilised.

CARBON DIOXIDE ADVANTAGES

- Available in commercial quantities (can be difficult in Queensland)
- Can be delivered at low temperatures to promote fire zone cooling.
- CO_2 has a density higher than air and is therefore useful for fires located in depressions and sinking workings.

CARBON DIOXIDE DISADVANTAGES

- Expensive
- Highly reactive (CO_2 can be reduced to CO)
- Interferes with fire gas interpretation
- Because of its high density (1.53) it may not follow the ventilation paths
- Makes explosibility prediction difficult

GASEOUS COMBUSTION PRODUCTS

Inertization by this method typically involves the utilisation of a small aeroplane jet engine to produce exhaust gases which are then cooled and channelled into the mine. The jet flame is quenched using water. A diagram of the device is included as Figure 2.

The exhaust gases produced by these devices contain:-

80-85% N_2
13-16% CO_2
2% O_2
0.5% CO
Water Vapour

Jet based inerting devices have been produced by the Poles (GAG) and the Russians (GIG) with the Polish unit tending to have the highest level of acceptance (Czechoslovakia, South Africa). A Polish unit was recently used successfully to control a deep seated heating in a South African Gold Mine. The unit and a team of operators was flown from Poland and managed to control the fire in a comparatively short period of time.

GASEOUS COMBUSTION PRODUCTS ADVANTAGES

- Inerting medium can be generated on-site without any reliance on commercial suppliers.
- Reasonable cost compared to nitrogen or carbon dioxide.
- High production rates - up to 1800 m^3/min compared with 30 m^3/min for the PSA type system.
- Jet units can be operational within two hours of arrival on site and can be operated by small crews.
- The inerting product contains large volumes of water vapour which aids in the cooling of the fire zone.
- Ventilation can be maintained to the fire zone due to the high production rates.

GASEOUS COMBUSTION PRODUCTS DISADVANTAGES

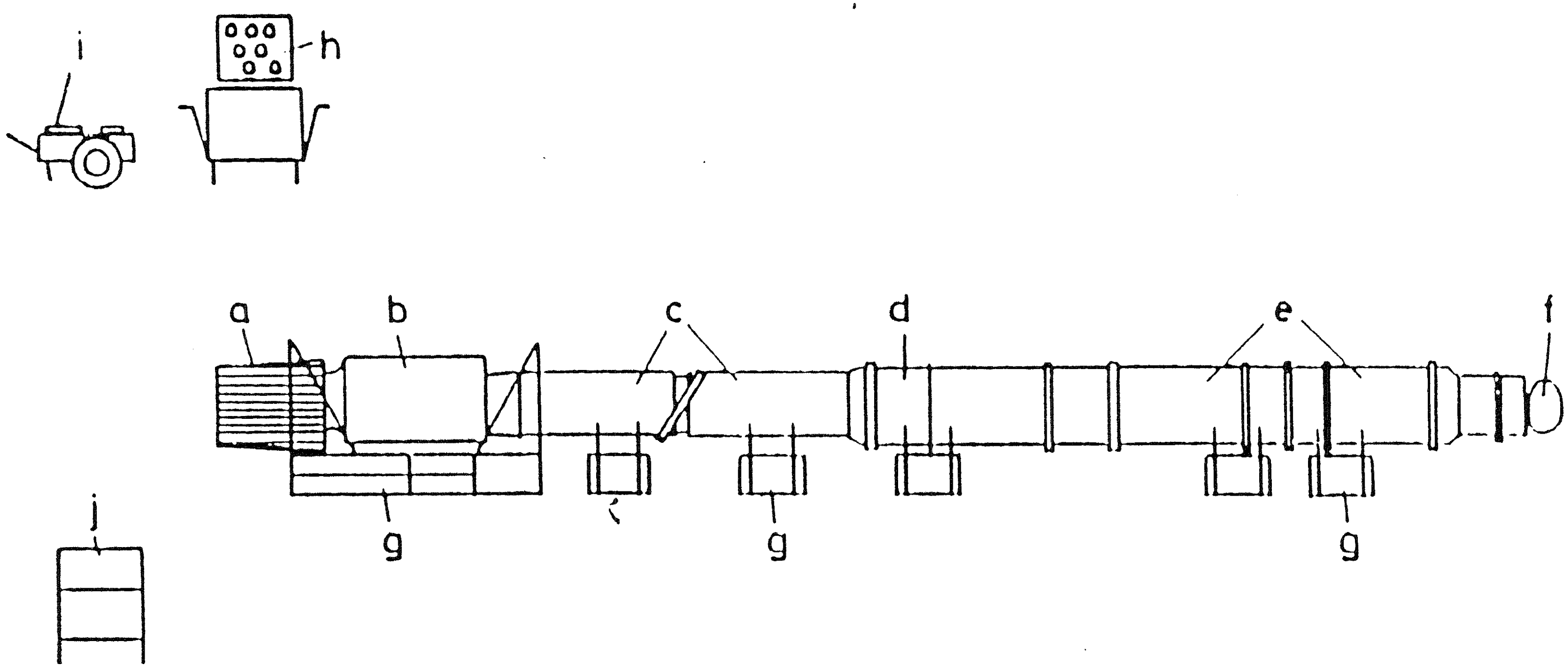
- The jet unit uses large quantities of fuel, air and water. (up to 1 tonne per hour of jet fuel).
- The inerting gas can contain up to 3% oxygen (This was observed in Poland and during the South African fire control episode).
- The inerting gas, even after cooling still maintains a temperature of up to 90°C.
- Inerting gas cannot be pumped long distances without the assistance of a secondary blower. (The PSA type system can pump up to 5km).
- The high water content can lead to the production of hydrogen gas if incandescent coal is present.
- Not flame-proof. Units have been used underground successfully in Czechoslovakia to inert sections of large coal mines with complicated ventilation systems.
- The units are extremely noisy (in excess of 135dBA).
- Normal gas analysis procedures with respect to trending of fire gases are of little use. The Poles tend to monitor the carbon monoxide levels.
- The mine atmosphere becomes totally unsuitable for human habitation (even in breathing apparatus).

CONCLUSIONS

Inertization systems have been used worldwide for many years with a high level of success. Two main types, nitrogen and gaseous combustion products, have been used successfully but with the caveat that sealing procedures used in conjunction with the inertization must be of a very high standard.

Different fire situations can be handled using different inerting mechanisms but as an overriding principle coal mine inertisation recovers mines rather than rescuing trapped miners.

FIGURE 2



a	air filter	f	fire damper flap (open)
b	aircraft engine	g	support
c	after-burner	h	control desk
d	cooling chamber	i	battery wagon
e	pipe duct	j	fuel tank and pump

POLISH GAG INERT GAS GENERATOR