Carbon Dioxide v Nitrogen Inertisation in a Unique Situation

Abstract

Nitrogen inertisation has been the method of operation for intervention and treatment of underground heatings and fires in New South Wales since its introduction in 1985. A situation occurred in the Newcastle area in August 2001 that required a change in intervention methods due to a variety of influencing factors.

Background

Moonee and Wallarah Collieries operate in the Great Northern seam (part of the Sydney Coal Basin) in the Newcastle region of NSW. The collieries operate on either side of a major highway and were connected underground by at least one shared roadway.

The collieries operate at depths varying between 100m and 200m.

Both collieries are overlain by workings (Wallarah seam, some dating back 100years) that extend over and beyond the current workings of both collieries at a height above of approximately 40metres.

Operations are conducted in an area of pristine bushland regarded as being of national importance and are in close proximity to the ocean and surrounding townships – since closing, the area is being developed as a high priced residential housing development.

Moonee colliery was conducting longwall extraction at the time of this occurrence – Wallarah had been on "care and maintenance" for about six months.

Early Indications of a Heating

Low levels of Carbon Monoxide had been detected in return roadways in Moonee that were influenced by the previously mentioned ventilation connection between the two collieries.

No indication of Carbon Monoxide was detected at the corresponding area in the Wallarah mine. Tests could only be conducted along a seal line of an inaccessible goaf area adjacent to the shared ventilation roadway.
Due to the slowly increasing levels of Carbon Monoxide a decision was made to seal the connecting roadway from the surface using flyash and introduce a borehole to monitor conditions.
The Great Northern and Wallarah, seams had no previous history of a ready propensity to spontaneously combust.

What had changed?

While no two heating occurrences are exactly the same, history and past experience evidences that heatings often occur when influences are applied in the form of some change.

Investigation of the previous six months activities in the two collieries identified the following:-

Ventilation

Moonee colliery had instigated a regime of upgrading its outbye roadway seals with a view to increasing the amount of air available to its working faces.
The makeshift seal in the roadway joining the two collieries had been measured as leaking at the rate of $4m^3/s$. Increased ventilation pressure, from the above actions, in the adjacent return had caused this seal to fail resulting in a flow of $20m^3/s$.
This resultant increase in available ventilation across the goaf of Wallarah colliery was <u>not evident</u> in the general workings of that colliery.
The increased ventilation was identified as coming from the workings above and also being dragged through a geological fault on the lower dip side of the goaf area.

A previously dormant area of crushed coal now had positive ventilation flows across it.

Water

Several reasons were given for the existence of the interconnecting roadway between the two collieries although the exact reason seemed to be dimmed by time and interpretation.
The most recent use of the roadway had been to discharge all of the excess water from Moonee to Wallarah for that colliery to deal with in addition to their own.
This arrangement had been accepted by both collieries (same owner) as it reduced the need for doubling up of equipment and personnel, however, the arrangement was unworkable when Wallarah was placed on care and maintenance due to the absence of sufficient labour and equipment to maintain the pumping system.
A new pumping set up was introduced at Moonee to allow water to be pumped directly out of the mine.

A previously saturated/ flooded area was now dried out.

Actions

One borehole was in place to monitor the goaf conditions – it was decide to introduce three more boreholes to improve interpretation capabilities. One extra borehole was driven into the overlying Wallarah seam.
Flyash seal was completed to exclude/reduce ventilation flow.

Increasing levels of Carbon Monoxide and Hydrogen (in excess of 4000ppm and 5000ppm respectively) led to the introduction of Nitrogen gas from the Mines Rescue Mineshield plant.

Results

Initial dilution of the products was immediate and a subsequent reduction in the amount of Oxygen available was observed.
In excess of 200 tonnes of Nitrogen was pumped over a period of one week.

Concerns as to the long-term effectiveness arose due to the following:-

1. Nitrogen reported to the up-dip hole on first introduction and was most prominent at this point during injection – probably due to heat given off from the heating site.

2. Nitrogen was very evident in the upper seam – appeared to be influenced by barometric changes and surface temperature changes (1° to 25° C). Readings changed from the Wallarah borehole to the Great Northern borehole on a twelve hour basis, that is, due to the day to night temperature influence.

Nitrogen pumping was ceased for a two day period with a resultant rapid return to the pre pumping status, High Carbon Monoxide and Hydrogen readings.

Review

It was decided that unless the Nitrogen was to be delivered for a protracted period of time the intervention would be ineffective.

The Wallarah colliery was in the process of being prepared for closure and the expenditure of funds to prolong its life was not considered to be worthwhile.

The position of the colliery and the large amount of entries (some unmapped in the upper seam) meant that sealing was virtually impossible.

The introduction of water to flood the area was impractical due to the very porous nature of the floor – all water rapidly traveled through the floor strata to the lower points of the colliery.

Carbon Dioxide Infusion

It was decided to infuse Carbon Dioxide for the following reasons:-

1. Heavier density should ensure it settled in the suspect area.
2. It should follow old water paths through the area
3. Similar cost to Nitrogen.
4. Used effectively in other parts of the world.
5. Increased properties as an extinguishing gas compared to Nitrogen
6. Resistance to ventilation flow patterns
7. Resistance to thermal effect of the heating

Four hundred tonnes of liquid Carbon Dioxide was pumped into the void in gaseous form using the Mineshield plant over a period of four days, initially at 20 tonnes per hour and then at the rate of 5 tonnes per hour.

Oxygen content was reduced to just over 10% for ten days after injection and remained below 12% for about thirty days. No further heating activity was detected from the site.

Conclusion

Various forms of intervention techniques are available to industry.

The Mineshield plant has been used to great effect in several instances in both NSW and Queensland when using Nitrogen.

The GAG engine has had great success when required for high flow intevention.

All intervention techniques should be considered as different types of "fire extinguishers" and applied for their relevance for the particular operation.

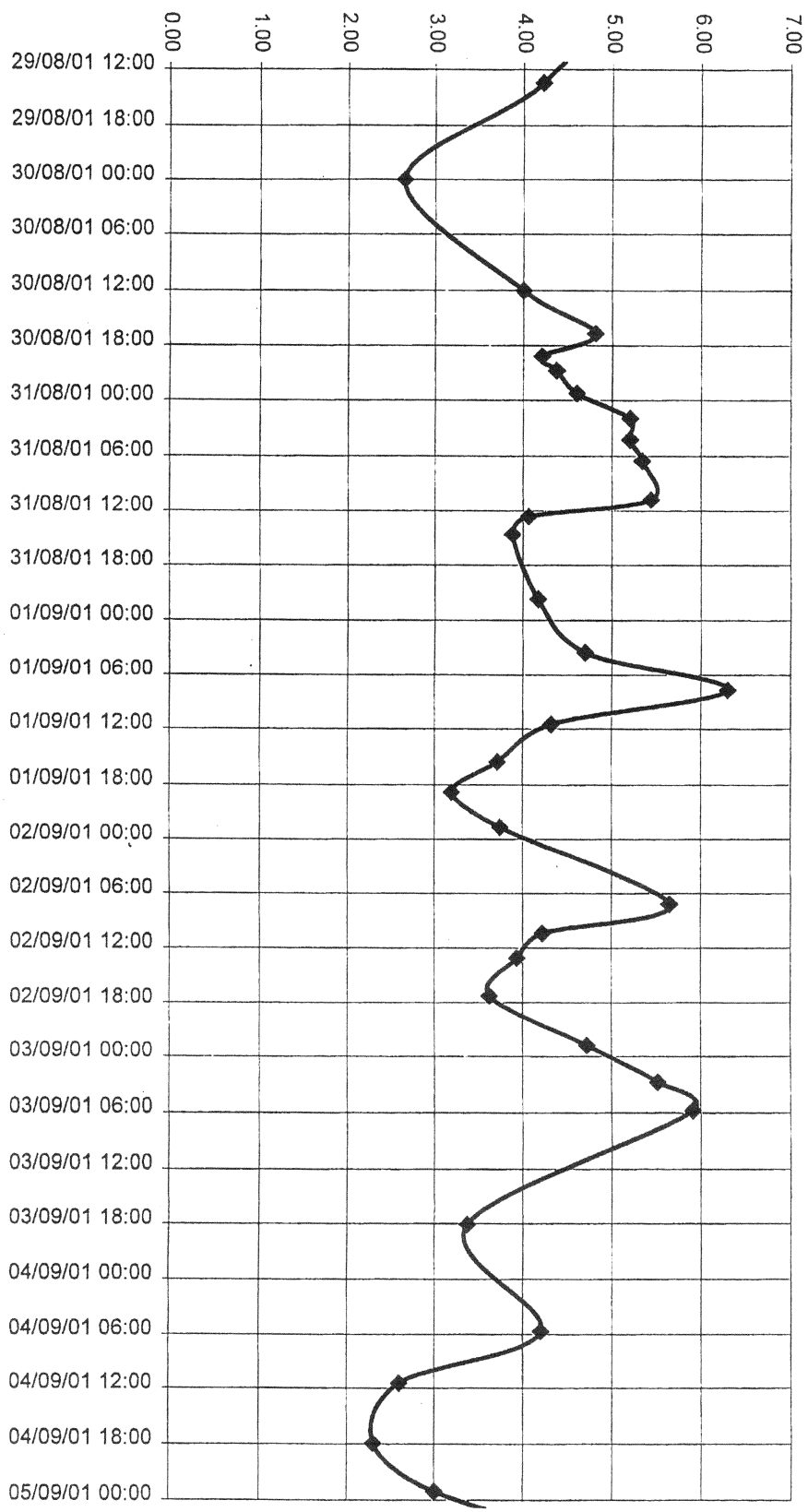
Some areas of caution were identified pre the use of Carbon Dioxide:-

1. Introduced gas is toxic – this also meant mine tracing had to have 'Area Inerted with CO_2 ' added to it as a safety precaution.
2. Introduced a 'new' gas into the mine that workers are not familiar with, this also would require CO_2 gas monitors to be introduced.
3. A risk of it flowing to other down dip areas – especially pump stations
4. Not an easy gas to remove (if required) even with good ventilation

GN2
RESULTS

No.	DATE / TIME	H2	O2	N2	CH4	CO2	CO	HHC	Bar Press
1	20/08/2001 03:40	0.0524	13.16	83.02	0.19	3.55	0.0271	0.0003	1004.0
2	20/08/2001 12:37	0.0544	12.53	83.46	0.19	3.74	0.0289	0.0004	1002.0
3	21/08/2001 03:30	0.0587	12.76	83.30	0.19	3.65	0.0430	0.0004	1003.0
4	21/08/2001 12:15	0.0610	12.09	83.79	0.21	3.82	0.0309	0.0005	1005.0
5	22/08/2001 04:00	0.0600	12.22	83.49	0.23	3.97	0.0301	0.0004	1002.0
6	22/08/2001 12:10	0.0562	12.02	83.65	0.22	4.02	0.0317	0.0004	1002.0
7	23/08/2001 03:15	0.0360	15.33	82.23	0.09	2.30	0.0130	0.0000	1009.0
8	24/08/2001 03:00	0.0008	8.03	89.53	0.10	2.34	0.0000	0.0000	1019.0
9	24/08/2001 12:20	0.0007	6.30	90.90	0.10	2.70	0.0000	0.0000	1019.0
10	25/08/2001 03:40	0.0023	6.36	90.61	0.13	2.90	0.0022	0.0000	1015.0
11	25/08/2001 12:05	0.0135	6.40	90.31	0.18	3.09	0.0081	0.0000	1014.0
12	26/08/2001 04:25	0.0118	6.20	90.22	0.22	3.34	0.0065	0.0000	1005.0
13	26/08/2001 12:06	0.0301	6.70	89.53	0.25	3.47	0.0194	0.0000	1003.0
14	27/08/2001 04:25	0.0325	6.40	89.55	0.30	3.70	0.0168	0.0000	996.0
15	27/08/2001 12:08	0.1007	7.31	88.37	0.33	3.83	0.0555	0.0005	992.0
16	28/08/2001 03:45	0.0929	8.92	87.32	0.21	3.41	0.0477	0.0005	995.0
17	28/08/2001 13:05	0.0037	6.43	89.77	0.15	3.64	0.0065	0.0000	1000.0
18	29/08/2001 04:00	0.0177	10.59	86.51	0.18	2.70	0.0024	0.0000	1001.0
19	29/08/2001 13:15	0.0075	6.07	90.05	0.17	3.70	0.0009	0.0000	1003.0
20	30/08/2001 16:40	0.0000	7.20	89.12	0.00	3.68	0.0000	0.0000	1013.0
21	30/08/2001 19:05	0.0000	7.00	89.28	0.00	3.72	0.0000	0.0000	1014.0
22	30/08/2001 20:45	0.0005	7.60	88.71	0.00	3.69	0.0012	0.0000	1015.0
23	30/08/2001 23:15	0.0000	12.30	84.99	0.00	2.71	0.0000	0.0000	1015.0
24	31/08/2001 02:15	0.0000	6.49	89.25	0.00	4.26	0.0000	0.0000	1009.0
25	31/08/2001 04:20	0.0000	6.85	89.20	0.00	3.95	0.0000	0.0000	1013.0
26	31/08/2001 06:05	0.0000	6.34	89.67	0.00	3.99	0.0000	0.0000	1008.0
27	31/08/2001 10:15	0.0000	6.68	89.63	0.00	3.69	0.0000	0.0000	1008.9
28	31/08/2001 12:10	0.0000	9.88	87.39	0.00	2.73	0.0000	0.0000	1007.5
29	31/08/2001 14:15	0.0000	7.00	89.47	0.00	3.53	0.0000	0.0000	1005.9
30	31/08/2001 21:10	0.0000	7.08	88.90	0.00	4.02	0.0000	0.0000	1006.0
31	01/09/2001 03:00	0.0002	7.47	88.76	0.00	3.77	0.0002	0.0000	1006.0
32	01/09/2001 07:15	0.0002	6.95	89.16	0.00	3.89	0.0001	0.0000	1004.0
33	01/09/2001 11:10	0.0000	8.21	88.02	0.00	3.77	0.0000	0.0001	1003.0
34	01/09/2001 15:10	0.0000	8.33	87.60	0.00	4.07	0.0000	0.0000	1000.0
35	01/09/2001 18:30	0.0001	7.50	88.35	0.00	4.15	0.0000	0.0000	999.0
36	01/09/2001 22:20	0.0000	7.91	87.84	0.00	4.25	0.0000	0.0000	998.0
37	02/09/2001 06:45	0.0003	9.11	86.67	0.00	4.22	0.0001	0.0000	1003.0
38	02/09/2001 10:00	0.0004	8.90	87.07	0.00	4.03	0.0000	0.0000	1002.0
39	02/09/2001 13:20	0.0011	9.52	86.34	0.00	4.14	0.0000	0.0000	1001.0
40	02/09/2001 17:00	0.0009	9.58	86.33	0.00	4.09	0.0000	0.0000	1001.0
41	02/09/2001 23:15	0.0000	12.03	84.47	0.00	3.50	0.0000	0.0000	1002.0
42	03/09/2001 02:15	0.0000	12.66	83.56	0.00	3.78	0.0000	0.0000	1001.0
43	03/09/2001 05:19	0.0000	13.15	83.25	0.00	3.60	0.0000	0.0000	1003.0
44	03/09/2001 17:35	0.0000	15.11	82.20	0.00	2.69	0.0000	0.0000	
45	04/09/2001 05:15	0.0000	16.24	81.46	0.00	2.30	0.0000	0.0000	1008.0
46	04/09/2001 11:11	0.0000	16.14	81.54	0.00	2.32	0.0000	0.0000	
47	04/09/2001 17:33	0.0000	15.69	81.76	0.00	2.55	0.0000	0.0000	
48	04/09/2001 22:39	0.0000	15.81	81.65	0.00	2.54	0.0000	0.0000	


NORTH WEST 1 ROAD
NORTH EAST 2 ROAD
NORTH EAST 3 ROAD
SOUTH EAST 3 ROAD



WALLARAH HOLE
CO2 VS TIME 29/08/01 - 04/09/01