Flammable Gas Emissions in South African Gold and Platinum Mines Review of Incidents and Accidents

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ABSTRACT

Flammable gas emissions are relatively common and widespread across the South African gold and platinum mines, but a general lack of awareness has lead to an increase in flammable gas related accidents and fatalities over the last ten years. The gas is usually a mixture of hydrocarbons C1 to C4 with hydrogen, each in varying quantities, with methane and hydrogen predominant.

The three most common causes leading to gas accidents are changes to the ventilation, lack of testing for gas, and contraband, with gas ignitions caused by contraband and illegal tampering with caplamps. Development work accounts for 70 percent of all accidents, with only 11 percent of all reported emissions in stopes.

KEYWORDS

Flammable Gas, Gold Mines, Platinum Mines, Accidents, Ignitions, and Contraband.

INTRODUCTION

Flammable gas is a common and expected hazard in coal mining, but not always associated with hard rock mining. South African gold and platinum mines report flammable gas emissions regularly, often resulting in ignitions, injuries and fatalities. Methane ignitions have long been acknowledged as a hazard in South African gold and platinum mines, b ut the origins and transport mechanisms of the gas have not been well understood. This lack of understanding has contributed to the hazard, making gas emissions difficult to predict and prepare for.

Furthermore, the name methane continues to be applied to the gases emitted, even though the presence of other gases has previously been acknowledged and documented.

The primary output of SIMRAC project GAP 504 is to improve the understanding of the gas emissions in general, particularly the factors contributing to gas emissions, and the measures that can be taken to reduce the risk of explosions and injuries. The gases encountered range from methane and other hydrocarbons, to hydrogen, and to inert nitrogen and helium, all in varying quantities.

The initial output of the project, as reported here, was to review the current situation and knowledge, particularly the reported methane accidents and incidents, and to evaluate the causes of accidents.

Research is still continuing into the present procedures for gas detection and combating, and gas origins and transport within the strata.

GASES PRESENT

Analysis of the gases emitted from strata and boreholes has shown a wide distribution of hydrocarbons C1 to C4 with hydrogen, and variable amounts of helium.

Table 1. Combustible gases in gold and platinum mines.

GAS	AVERAGE COMBUSTIBLES (%)	RANGE IN MIXTURE (%)
Methane CH_4	66	18 – 100
Ethane C_2H_6	8	0 – 28
Propane C_3H_8	1	0 – 17
Butane C_4H_{10}	2	0 – 17
Hydrogen H_2	26	0 - 80

Table 1 (Cook, 1998) shows the present average gas for all the gold and platinum mines, as well as the ranges of each individual gas. Methane is the predominant flammable gas followed by hydrogen.

Although not yet fully evaluated, and part of the continuing research, the gas mixtures have individual lower and upper explosive limits different from methane, and require correction factors when read on methanometers calibrated with standard methane.

The average explosive range for the mixtures is 4.2% to 17.4%, with a minimum LEL for an individual mixture of 3.3%.

DISTRIBUTION OF FLAMMABLE GAS

Flammable gas reports have been received from almost every gold and platinum mine, covering different regions, ore reefs and mining depths. Figure 1 shows the number of reports from individual mines, but this also illustrates a problem encountered with the reporting requirements. The number of reports per individual mine varied from less than 10 to almost 300.

Not every occurrence must be reported, and the requirements of South African regulations for reporting gas emissions are interpreted differently by different mines and regional DME offices. There is an apparently over-cautious approach from many, which report every occurrence. This in itself does no harm, and did seem to make these mines more aware of gas, but makes the number of incidents reported biased toward some mines.

Some mines report only what they consider to be consider to be an extreme case of gas. Some mines that indicated no gas problems do detect the methane inside drill holes but in very small quantities and do not report it. In most cases methane only detected in holes is not seen as a problem, because does not progress to the atmosphere in detectable concentrations due to the adequate ventilation.

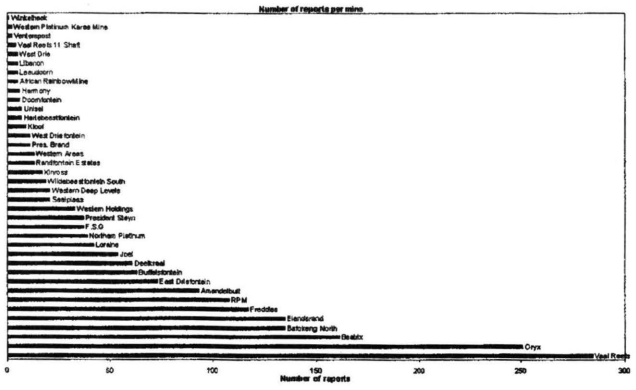

Figure 1. Flammable gas reports from individual mines.

REPORTS OF FLAMMABLE GAS EMISSIONS

The review covered all reported incidents and accidents for the ten year period from 1987 to 1997.The total number of gas reports is given in Figure 2, showing a general increasing trend for both gold and platinum, but with annual variations.

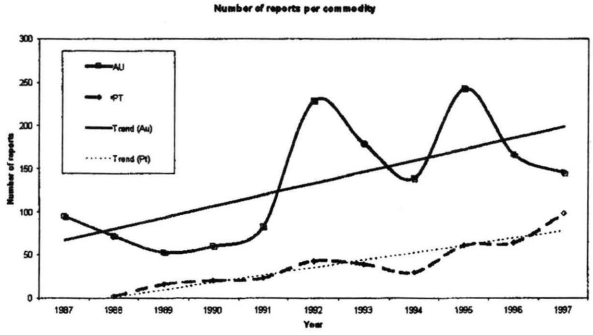

Figure 2. Flammable gas reports, gold and platinum mines, 1987 to 1997.

There has been a decrease in the number of gas reports, over the last two years, and by comparing this to Figures 3 and 4, for the number of accidents, it is seen that such a decrease in reporting has previously been followed by an increase in accidents.

This appears to indicate a lack of awareness of the hazards associated with gas emissions.

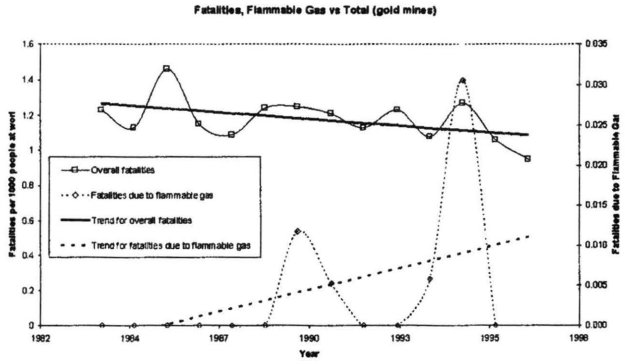

Figure 3. Fatalities associated with flammable gas, and all fatalities, gold mines.

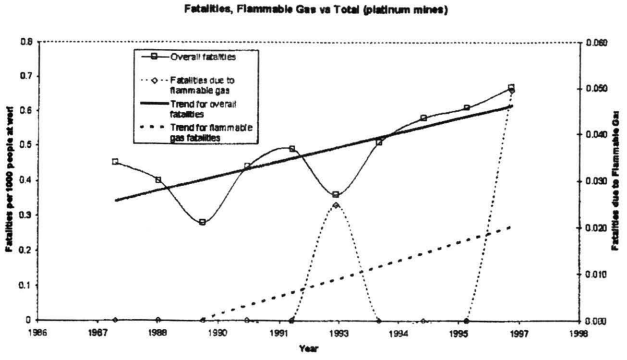

Figure 4. Fatalities associated with flammable gas, and all fatalities, platinum mines.

Both gold and platinum mines show an increasing trend in fatalities due to flammable gas. Although the platinum mines show a similar increase for all fatalities, the trend for gases is in contrast to a general downward trend for the industry as a whole.

LOCATION AND CAUSES OF ACCIDENTS

Location

The vast majority of incidents are reported from development, and most of these are from cover, or exploration drilling. This does however indicate a variation in reporting, as not all mines or personnel consider this to be a reportable emission.

Figure 5 shows the working place distribution of reports, with stopes accounting for only 11 percent.

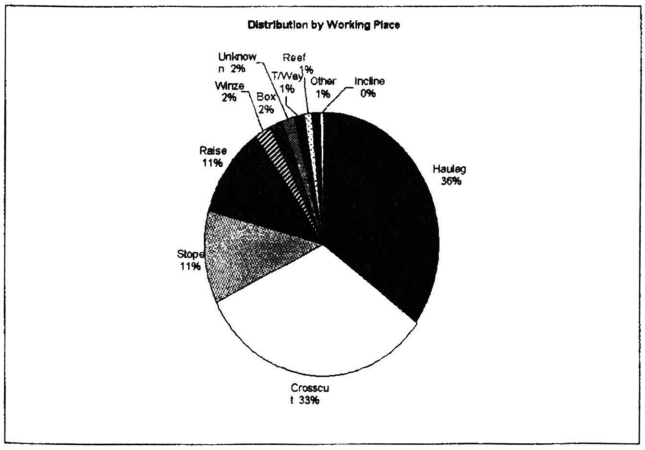

Figure 5. Flammable gas reports, per working place.

Accidents are split between development and stoping, as shown in Figure 6, with 72 percent reported from development. The high ratio is similar to that of the reports of gas, although the ratio of accidents in stopes is higher, so a gas emission in a stope is more likely to result in an accident.

Ignitions

The reported sources of ignition are shown in Figure 7.

Contraband is the single biggest known cause of ignition at 22 percent, followed by tampered cap lamps to make ignitors at 14 percent.

No ignitions took place in 23 percent of the accidents, which are those on the platinum mines consisting of blow-outs or breaks from the face. These blow-outs are attributed to methane, however, the gas is always quick to disperse, and not measured, so it is not definite that the gas is in fact flammable.

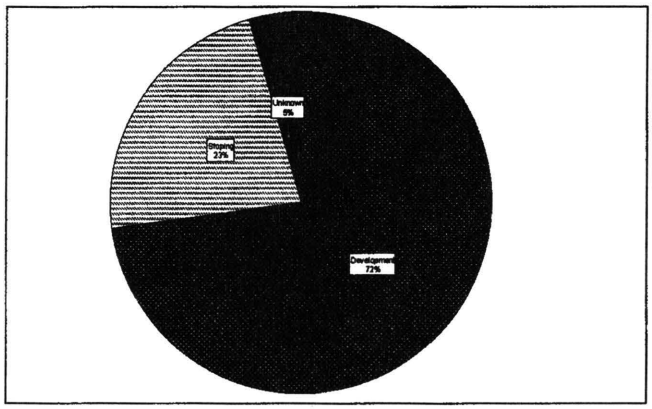

Figure 6. Locations of accidents.

Mining activities

Three main mining activities associated with gas ignitions are handling of explosives, drilling and construction, in almost equal proportions of one quarter each, although an equal number are also "unknown". These are shown in Figure 8.

Causes

There are three main causes leading to methane accidents, shown in Figure 9. These are changes to ventilation, not testing for gas, and contraband including tampering with caplamps to make ignitors. Changes to ventilation, and a

lack of gas testing both contributed to more than 60 percent of all accidents.

The ventilation conditions leading to accidents are not necessarily non-standard or poor ventilation, but are also cases where, for example, the ventilation had recently been changed, or a fan had not been operating. This has allowed a build up of gas, which is then moved by the ventilation being restored.

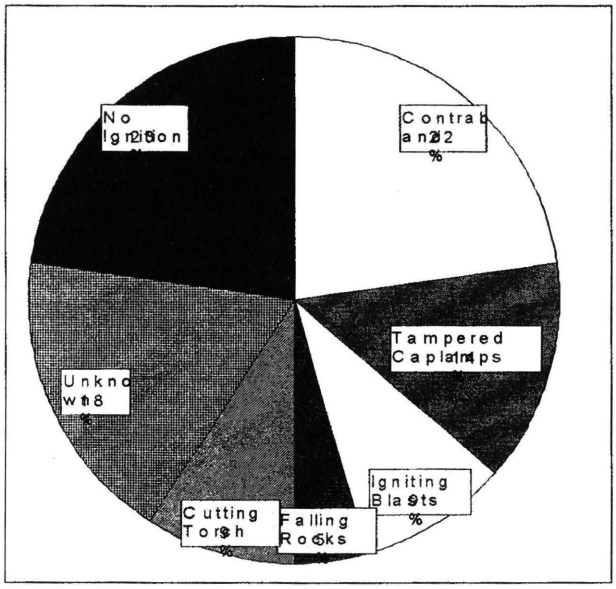

Figure 7. Sources of ignitions.

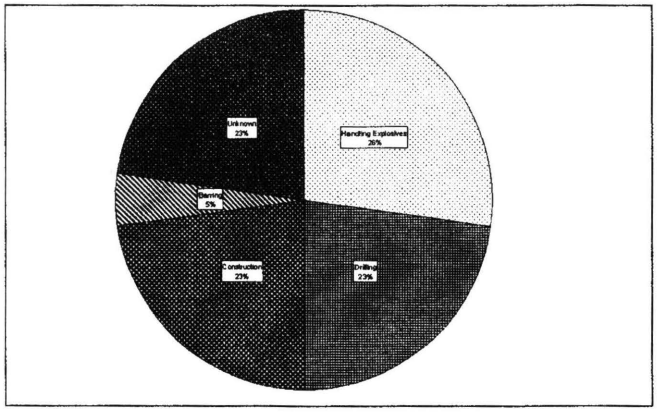

Figure 8. Mining activities associated with accidents.

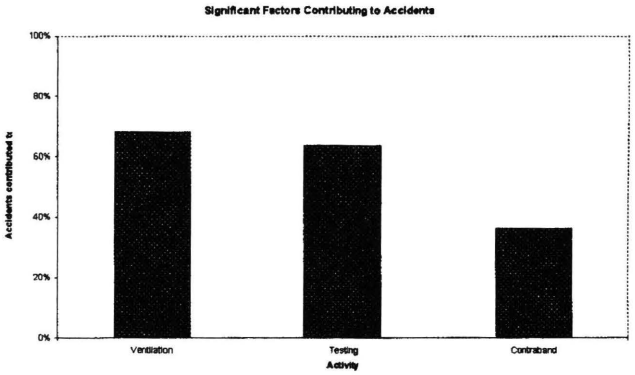

Figure 9. Main causes leading to accidents.

Lack of gas testing in some respects is associated with the ventilation problem, but is also a problem on its own. Inadequate gas testing shows a general lack of awareness of the hazards and occurrences of combustible gas.

CONCLUSIONS

Flammable gas is widely reported from both gold and platinum mines, and has resulted in a total of 25 fatalities and 36 injuries in the last 10 years. An increasing trend in reported incidents of flammable gas is reflected in increasing fatality and injury rates, in contrast to a generally reducing trend in other fatalities and injuries.

Flammable gases are usually a combination of hydrocarbons and hydrogen, altering the lower and upper explosive limits for the mixtures from those of methane. Methane is the predominant gas in most cases, but hydrogen can be as high as 80 percent of the combustibles. The average gas across all the mines is 66% methane and 26% hydrogen.

The present number of gas incident reports is in decline, the same situation that has preceded the last two multiple fatality accidents.

Most of the gas reports are from development, with only 11 percent from stopes, and an accident is three times more likely to occur in development than in stoping.

Three main factors contribute to the accidents: adjustments to ventilation arrangements, inadequate testing for gas, and contraband. Changes to the ventilation and inadequate or no gas testing are both reported in over 60 percent of all accidents, with contraband in more than 40 percent.

The two main identified causes of gas ignitions are contraband and tampering with caplamps to make ignitors, although the second biggest cause of all ignitions is "unknown". The mining activities when most ignitions occur are handling explosives, drilling and construction.

Platinum mines have a high proportion of non-ignition accidents, when blowouts occur during drilling. These normally involve face and head injuries caused by either the drill, or rock and gas, being ejected form the drillhole. The

gas quickly disperses, and is not measurable, but it is assumed to be methane.

ACKNOWLEDGEMENT

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REFERENCES

Cook, A.P., 1998, "SIMRAC Project GAP504. Interim report," Johannesburg.