Results of Depositional Tests for Combustible Dust

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Background

Production levels currently being realised from underground coal mines have increased significantly in the last 20 years, primarily due to significantly increased rates of longwall extraction.

An increase in methane drainage has occurred resulting in the dryer coal being mined due to the removal of water and seam gas. Safer production has resulted in an increased rate of winning coal, an increases in overall system availability, as well as increased time allocated to production. Which drives the overall pressure on current day coal mining.

The effect of increased production and gas drainage on the ability to maintain compliant levels of incombustible dust, particularly in district returns from longwall panels, has been the focus of the following two controls:

- achieving a sufficient and consistent rate of continuous application of stonedust at the return side of the longwall face whilst the ‘face is in production, and

- having the ability to apply sufficient stonedust on a ‘campaign’ basis in the district return in maintenance or other ‘downtime’ windows.

The primary effect of increased concentrations of coal dust deposition in the return airways is to increase the risk of propagating a coal dust explosion should an event be initiated.

The risk of a coal dust explosion in an underground coal mine has been recognised for more than a decade, and has been well addressed previously in Australia by Barker, B. and Humphries D. 1996 and Humphries D. 2003 in research work under the Australian Coal Association Research Program (ACARP), Of particular note in these reports is the reference to sampling problems associated with addressing the impact of “float dust” – fresh deposition of coal and stonedust. Both reports identified widely differing rates of coal dust fall-out (or deposition) from a variety of Australian longwall mines.

It is noted by Humphreys D 2003 that explosions typically lift the top 2 mm to 4 mm of material from peripheral surfaces as the explosion propagates through a mine workings.

There have been many notable explosions in underground coal mines, with the explosion at Benxihu Colliery disaster in China cost 1,549 lives caused by a mixture of gas and coal dust, Courrieres mine disaster in France, Soma Western Turkey 300 deceased coal miners, Upper Big Branch Mine in the United States 25 miners, being perhaps the most significant, recent explosion in a longwall mine. Page et al 2011

Legislative Context

This paper is presented considering the legislative regime in the Queensland Coal Mining Safety and Health Act 1999 (the Act), which requires that mining activities are conducted with an “acceptable level of risk”.

It is common practice in the aspect of explosion prevention to achieve an acceptable level of risk by following the prescribed methodology as provided under the Queensland Coal Mining Safety and Health Regulation 2001(the Regulations), That is the application of stonedust and the regular sampling and testing of dust accumulations from the mine workings.

Consistently meeting the defined incombustible dust content of sampling conducted in the mine roadways is taken to establish that stonedusting meets legislative requirements and provides for an acceptable level of risk.

The Regulation requires the mine to be zoned and the zones are sampled at a defined frequency to determine that the percentage of incombustible dust meets specified levels for the particular zone being sampled to validate compliance with the Regulation.

The Regulation further requires that sampling is conducted in a certain manner, this being “strip or spot sampling” for face zones, with a requirement that samples show an incombustible dust content of 85 % in order to demonstrate compliance with the provisions of the legislation.

Examination of the results of dust samples at a central Queensland mine at which the depositional tests were undertaken over the three month period show that the mine was consistently and reliably achieving “compliance” with the legislative requirements, and would be therefore considered to be conducting mining operations with an acceptable level of risk. Results from the period during which the depositional tests were conducted are provided in Appendix 3, and confirms a level of compliance with the required percentage content for incombustible dust.

The results noted are relative to a working longwall of some 5.2 metres of height, employing “trickle” dusting utilising a compressed air spear in suspended, 1 tonne bags of stonedust, and regular “campaign” stonedusting, providing surety of sampling compliance, or occasionally as a correctional application following an inadequate sample result.

“Campaign” stonedusting was generally undertaken utilising bulk pod applicators, quick detach system (QDS) ‘Quick Dusters’ and occasional ‘canton dusters’.

Finally in terms of legislative provisions, the Regulation requires that the application rate of stonedust is determined for sufficient stonedust to be applied to meet incombustible content percentages. Conducted by float tray analysis of combined coal/stonedust distributed.

Application rates are commonly based on or verifiable by observation or experience rather than theory or pure logic. This is sometimes based on the history of pass/ fail of incombustible dust sampling at the mine.

Current Practice

An appreciation of the effectiveness of stonedusting application techniques in thick seam mining environments provides the realisation that a great deal of the stonedust applied lands mainly on the lower rib section and the floor, be that as a result of "trickle dusting" or from a "campaign" application.

Furthermore, as noted by Humphreys D 2003, the stonedust commonly used in the Industry and applied from trickle dusters falls out of the airstream in approximately 150 metres from the point of application.

It is noteworthy that trickle dusters in general, largely provide an inconsistent rate of application and require significant oversight in establishment and operation in order to obtain reasonable application rates with some semblance of consistency.

Given the requirement in Queensland that face zone incombustible samples are taken using the strip or spot sampling methodology, it is considered commonplace that most strip samples would only include the floor and ribs to a height of approximately 2 metres.

It should also be noted that strip sampling techniques specify a sample depth of up to 5 mm, although the accuracy with which this can be achieved using the usual tools of a dustpan and paint brush is likely to be problematical.

It is highly probable that strip or spot samples invariably collect all dust accumulated in the sample position, this is inclusive of initial (post drive-age) stonedust applications and later "campaign" applications, as well as 'continuous' trickle dusting application.

Appendix 3

It refers to the weekly analysis result from campaign application of stonedust relating to the work frame window: ie compliance dusting

Appendix 4

Is the compliance timeline. When samples are taken set against the maintenance window then the re-commencement of coal mining operations.

Review Determination

Regular inspection of the workings prompts recognition of a gradual deterioration of the effectiveness of the stonedusting, as indicated by the increasingly dark surfaces in the returns as dust from the coal winning operation is deposited in the return airway.

With high production rates, it is likely that the 'float'dust accumulations will result in a significant depth of dust cover in the return roadway.

It is also apparent that trickle dusting does not always provide a consistent throughput of stonedust, or that the stonedust that is being utilised is being adequately dispersed.

Consideration of a combustible dust sampling regime in thick seam workings provides further doubt as to the ability to effectively assess the overall stonedust application in achieving 85 % incombustibles over all areas of a roadway periphery.

It is therefore usual practice to conduct ‘campaign’ stonedusting during the week, with sampling undertaken shortly after a ‘campaign’ application of stonedust.

Given the impact of freshly deposited ‘float’ dust and the periodicity of sampling, satisfactory ongoing weekly sampling results are likely to merely indicate compliance in achieving the requirements of the explosion prevention aspects of the legislation.

Compliance in achieving the specific requirements of the legislation may not necessarily indicate that the percentage of incombustible dust in the upper 2 mm to 4 mm between the weekly sampling is at the level indicated by that periodic sampling.

In order to establish the effectiveness of the stonedusting provisions and confirm an acceptable level of risk, an understanding of the depositional characteristics of the dust produced under the specific operating environment is required.

As noted by Humphreys D 2003 the dispersal of coal dust emanating from coal winning varies widely between different longwall operations, therefore prompting specific testing and investigation on a site specific basis.

The test programme that was undertaken followed previously established practice of measuring the dust deposited on collection trays placed at pre-determined spacing in the return gateroad on the outbye side of the longwall.

Depositional Dust Measurement Programme

The programme of depositional dust collections instigated at the central Queensland mine, targeted the longwall and development panels of the mine.

A series of samples were collected from selected points in the longwall return over a number of days in order to provide representative results, intended to reduce the effect of unforeseen operational variations unduly skewing the results.

A similar set of samples was taken from a development panel.

The samples were taken by placement of a set of stainless steel collection plates on the floor of the return roadway, at set distances from the then current face position.

The placement / spacing of the trays was arranged on the basis of avoiding a wet zone in the immediate cutting area of the tailgate, and monitoring sufficiently in the zone in which the trickle dusting was considered to be discernible, as well as monitoring the area at which the trickle dusting effect was likely to have ceased.

The plates were placed slightly offset to centre in the roadway to enable reasonable clearance for foot traffic, clear of obstructions that would influence the airflow, and sufficiently outbye as to avoid interference with trickle dusting operations and immediate gate-end inspections.

Following a significant production run, the plates were promptly collected, sealed in collection bags and sent to Safety In Mines Testing And Research Station (SIMTARS) for analysis.

Data regarding the extent of production achieved during the sampling period and the mine environment at that time (airflow, roadway dimensions, trickle dusting, etc) was obtained from the Mine Deputy reports (statutory and production) for the section being sampled, together with ventilation reports and stonedust sampling results where applicable.

Discussion

Evaluation of the data contained in the various reports indicates that whilst the mine was achieving high compliance rates with the sample requirements taken for the weekly sampling regime, the comparable depositional dust results from the tray samples were significantly lower in incombustible dust content than the regime samples.

This implies that the extent to which the incombustible dust content met legislative requirements was primarily only at the time of sampling, with gradual deterioration over time (with correlation to the rate of production) and decreasing "compliance" until the next campaign treatment.

There is also likely to be a result-skewing effect from the dust sampling methodology, in that the legislative requirements for taking sample limit the depth of the sample taken to 5 mm, which with the commonly used method of paint brush and dust pan is highly unlikely to be achievable.

The effect of the method of sampling is to cause the samples to be inclusive of recent float dust (including trickle duster stonedust content), prior campaign dust applications as well as the initial application of stonedust following primary drivage of the workings.

Conclusions

The current sampling practices as required by legislation have a gross lack of understanding of the intent and requirements. This likely to promote an environment in which stonedusting practices at the mine effectively establish compliance with the periodic sample targets, but do not reflect the true nature of the dust content on the surfaces of roadways.

An understanding of the relationship between acceptable risk and apparent compliance is necessary, if consistent explosion prevention and mitigation is to be achieved.

In order to provide for an acceptable level of risk that addresses the incombustible dust content on a continuous basis (as opposed to a periodic, (weekly) sample), continuous application of sufficient and appropriately sized stonedust appears to be necessary.

If such a continuous trickle dusting provision is not feasible, an alternative means of suppressing a coal dust explosion should be adopted, for example distributed barriers at the gateroad entry, or by the application of suitably heavy stonedusting at a point close to the longwall tailgate, moved on a regular basis (such as 24 hour intervals) such that the effect of a "moving distributed barrier" that retreats with the longwall is created.

A review of the legislated sampling requirements would enable the vagaries of sampling due to height of the workings, depth of sampling, and the effectiveness of trickle dusting relative to the float dust deposition rate, to be reviewed.

Such a review of the sampling methodologies available to Industry, including colorimetric sampling, could provide for a more suitable system of sampling that more accurately reflects the true status of the key control for explosion prevention and mitigation.

Acknowledgement

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References

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7. DNRM 2001, Mines Safety Bulletin No 134, 16 August 2013 - Review of Queensland underground coal mines stone dust application, sampling and analysis of roadway dust concentrations.

APPENDICES

Appendix 1

Relevant Legislative extracts;

Coal Mining Safety & Health Act of 1999 - section 29;

(1) For risk to a person from coal mining operations to be at an acceptable level, the operations must be carried out so that the level of risk from the operation is –
   - *a. Within acceptable limits; and*
   - *b. As low as reasonably achievable*

(2) To decide whether risk is within acceptable limits and as low as reasonably achievable regard must be had to –
   - *a. The likelihood of injury or illness to a person arising out of the risk; and*
   - *b. The severity of the injury or illness.*

Coal Mining Safety & Health Act of 1999 - section 30;

(3) Also, the way an acceptable level of risk of injury or illness may be achieved may be prescribed under a regulation.

Coal Mining Safety & Health Regulation of 2001 – section 300 General;

(1) *An underground mine's safety and health management system must provide for the following –*
    a. *Minimising the risk of coal dust explosion;*
    b. *Suppressing coal dust explosion and limiting its propagation to other parts of the mine;*

(2) *The system must include provision for the following –*
    a. *Limiting cola dust generation, including its generation by mining machines, coal crushers and coal conveyors and at conveyor transfer points;*
    b. *Suppressing, collecting and removing airborne coal dust*
    c. *Limiting coal dust accumulation on roadway and other surfaces in mine roadways;*
    d. *Removing excessive coal dust accumulations on roadway and other surfaces in mine roadways;*
    e. *Deciding the stonedust or other explosion inhibitor application rate necessary to minimise the risk of a coal dust explosion.*

(3) *The mine must have a standard operating procedure for the following –*
    a. *Regularly inspecting, sampling and analysing roadway dust layers, including laboratory analysis for incombustible material content;*
    b. *Applying stonedust or another explosion inhibitor for suppressing coal dust explosion.*

(4) *The procedure must provide for the dust sampling and analysis mentioned in subsection (3)(a) to be carried out at least at the following intervals –*
    a. *For a strip or spot sample of dust mentioned in section 301 (1)(a) or (b) – weekly;*
    b. *For a strip sample of dust mentioned in section 301 (1)(a), (b), (c), or (d) – monthly;*
    c. *For a strip sample of dust mentioned in section 301 (e) – every third month.*

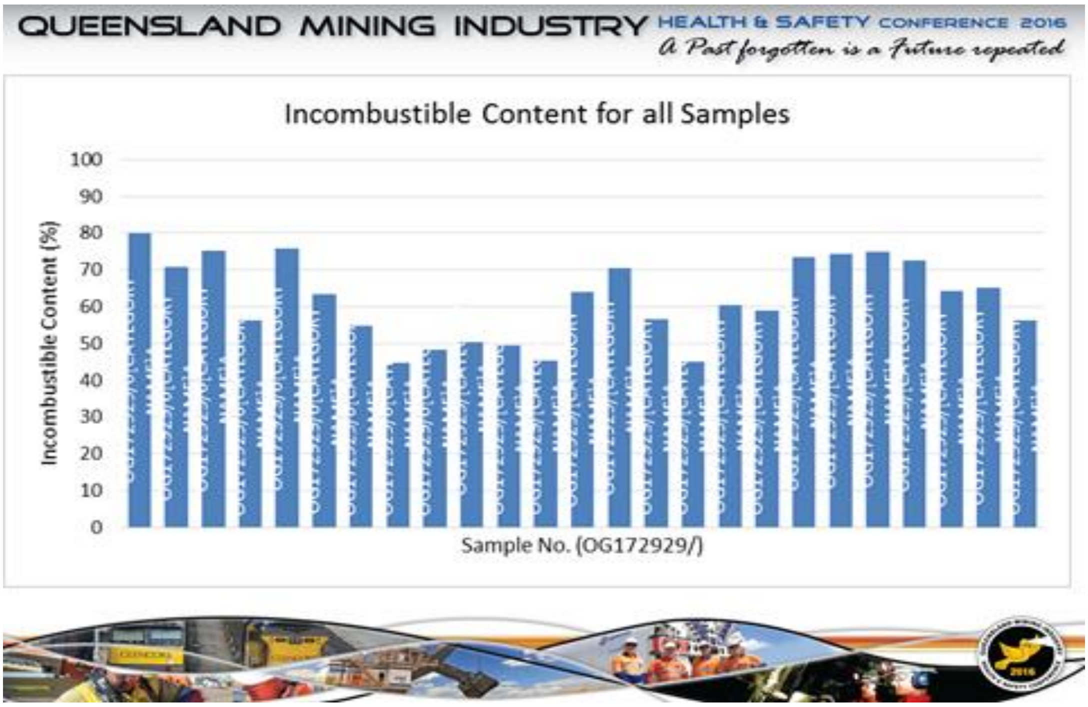
(5) *The procedure must also provide for the analysis of each sample mentioned in subsection (4)(b) or (c) to be carried out in a laboratory*.

Coal Mining Safety & Health Regulation of 2001 – section 301, Incombustible material content for mine roadway dust

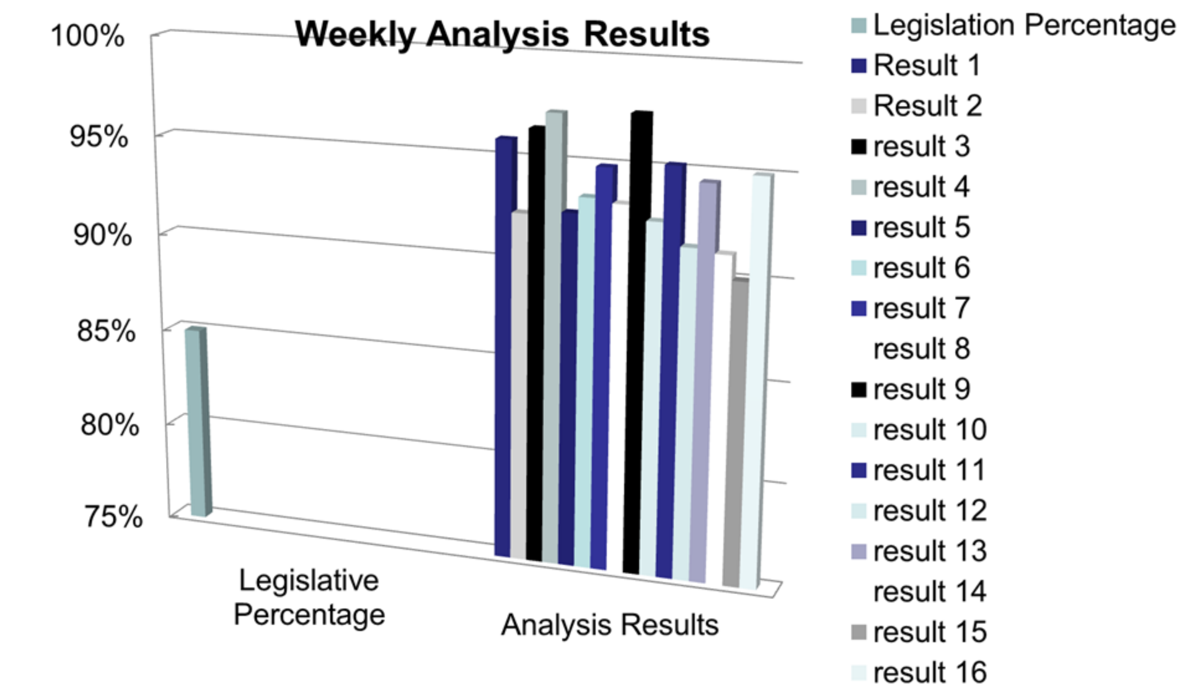
(1) *The underground mine manager must ensure the content of incombustible material in roadway dust at the mine is kept at or above the following concentration level –*
    a. *For dust in a panel roadway within 200 m outbye the last completed line of cut-throughs in the panel – 85 %*
    b. *For dust in a 200 m section of panel roadway within 400 m of a longwall face – 85 %*
    c. *For dust in a panel roadway within 200 m from the main roadway, if paragraphs (a) and (b) do not apply to the 200 m of roadway– 80 %*
    d. *For dust in a return roadway not mentioned in paragraphs (a) to (c) – 80 %;*
    e. *For dust in an intake roadway not mentioned in (a) to (d) – 70 %.*

Recognised Standard 05, Coal Mining Safety & Health Act of 1999 - Quality of incombustible dust, sampling and analysis of roadway dust in underground coal mines.

Appendix 2



Appendix 3



Appendix 4

Compliance reference percentage average weekly, compared to the actual percentage results of samples taken over sample time period set against the weekly samples