From compliance to risk management

Martin Olsen, Olsen Consulting Group, Australia, reviews the effectiveness of belt road segregation practices in preventing the migration of contaminants through the mine.

Maintaining separated intake escapeways is a legal requirement in Queensland and one that is often complied with by segregating the main belt road from the main travel road. Mine inspectors ensure compliance with the legislation by enforcing the segregation of the belt road at individual sites by issuing directives to bring the segregation into compliance.

For the mining operation the segregation of the belt road is often a nuisance, as it limits access to the belt road. It can also be a headache for the ventilation officer to control and maintain, as there are often operational requirements to breach the segregation stoppings for access purposes.

Mining operations invest considerable amounts of time and money in the installation and maintenance of these ventilation control devices. It is important that they are serving a purpose and reducing the risk to underground personnel. If they are not, then they are a waste of time and money and are providing a false sense of security to underground personnel and management at the mine.

This article reviews segregation practices through the application of ventilation engineering principles. Four different scenarios

Table 1. Contamination test: modelled segregation stopping effectiveness

	Modelled number of segregation stoppings	Modelled contaminant concentration (ppm)					
		Belt Portal	LW face	Mains	Dev1	Dev2	Primary escapeway (maximum)
Case 0	157	100	14	76	16	14	18 or 4*
	0	100	31	28	30	27	33 or 27*
Case 1	203	100	7	30	25	0	31
	0	100	17	22	21	1	22
Case 2	106	100	53	15	1	1	6
	0	100	53	1	7	0	31
Case 3	64	100	21	77	29	44	26
	0	100	22	26	24	25	29

* Depending on which heading is classified as the primary escapeway.

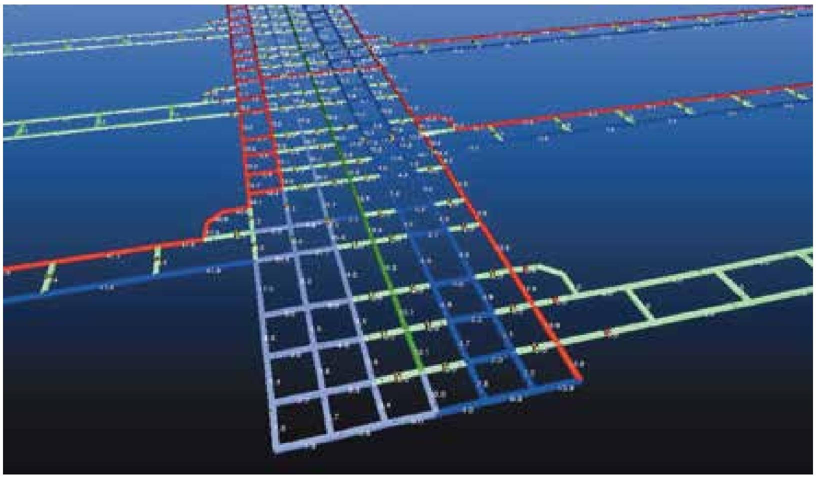

Figure 1. Case 0: ventilation layout.

were analysed with regard to the effectiveness of the segregation stoppings in preventing potential fire contaminants migrating to other parts of the mine. The results show that in some cases the benefits of segregation to a person evacuating a mine in the event of a fire range from beneficial to detrimental. This is influenced by many factors, including the location of that individual in that particular mine.

Mine scenarios

For the purpose of analysis of belt segregation, four different mine layouts were used to model the effectiveness of the segregation. The first scenario (Case 0) is a conceptual model and does not represent the workings of an actual mine. This was used so that any ventilation layouts and analysis results could be published without concern for confidentiality. The other three scenarios (Cases 1 – 3) are based on the ventilation models from actual longwall coal mines in Queensland, Australia. For the purposes of confidentiality only the analysis results are published.

Methodology

Pressures

Pressure gradient plots were generated for each scenario. These display the relative static pressure in the mine roadway from the surface intake to the longwall and along the return back to the main fans. The belt road pressure gradient was also plotted. The pressure gradients of any additional separated intake roadways were also plotted.

Contaminant test

A 100 ppm contamination was placed into the model inside the belt portal and then modelled to see where the contaminant would migrate throughout the mine. This test was applied to each of the scenarios and the results recorded. The models were then modified with all the segregation stoppings in the mine removed and the same 100 ppm contamination test reapplied. This allowed the two results for the same mine to be compared. This was used so the effectiveness of the segregation stoppings of the scenario could be measured.

It is important to note that the numerical value of the contamination concentration in the results table is only relevant with respect to the 100 ppm contaminant that was used for the test. It is primarily for comparison between models and between segregation and no segregation. For example, a 20 ppm contamination in a primary escapeway may appear to be acceptable until you consider that if the contamination at the belt portal was 1000 ppm then the concentration in the escapeway would be 200 ppm. Table 1 displays the model results for each scenario with the segregation stoppings in place and also with the segregation stoppings removed.

The purpose of this test is to measure the effectiveness of segregation stoppings in reducing the spread of contaminants to other parts of the mine. No consideration has been given to the dynamic nature of a fire, the buoyancy and pressure differentials that are possible from an active fire.

Case 0

The ventilation layout for Case 0 is shown in Figure 1. This fictitious mine consists of seven heading mains, three headings with flanking returns and a segregated belt road in the middle heading. As the mine does not exist, there is not a designated primary escapeway.

There are two results for the contaminant test for the primary escapeway shown in Table 1, depending on which set of intake roadways is adopted as the primary escapeway. The results show that, with the 157 segregation stoppings in place, the contaminant is directed predominantly into the mains development area with a concentration of 76 ppm. The other three panels (including LW) modelled a contamination around 15 ppm. The greatest benefit modelled with this arrangement of segregation was the contaminant concentration of 4 ppm adjacent to the 76 ppm in the mains. The 4 ppm result came from the single intake airway to the left of the middle heading belt road in Figure 1.

The reason for the relatively low level of contamination can be seen in the pressure gradient plot for Case 0 in Figure 2. The heading that returned the result of 4 ppm is referred to in Figure 2 as primary. This heading for the most part sat at a higher static pressure than the surrounding roads, particularly the belt road where the contaminant was concentrated. This resulted in leakage paths flowing away from this primary heading. The instances where the static pressure in this roadway drops below the belt road is due to the placement of segregated belt underpasses that were put into the model to allow for transport movements (operational requirement) and balancing of the intake airway pressures. It is this balancing that has caused the drop in static pressure to below that of the belt road in some instances. This could be mitigated in practice by the installation of machine doors at the segregated underpasses.

The results in Table 1 also show that by removing all segregation from the model, all inbye areas of the mine received similar contaminant concentrations of around 30 ppm. This includes all working faces and escapeways.

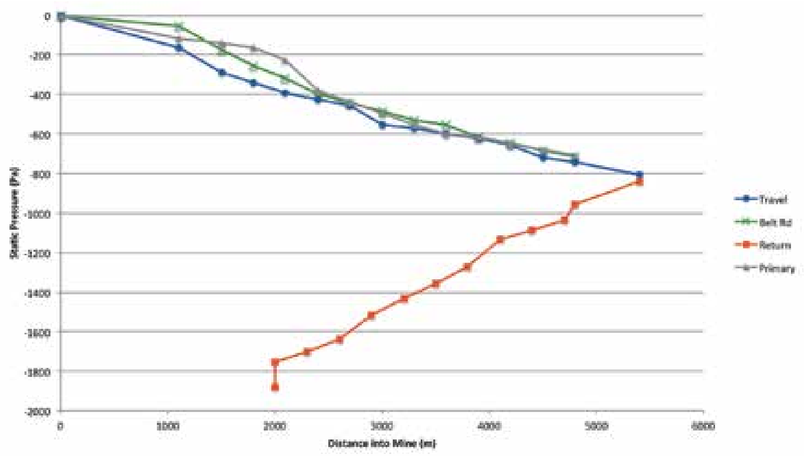

Figure 2. Case 0: pressure plot.

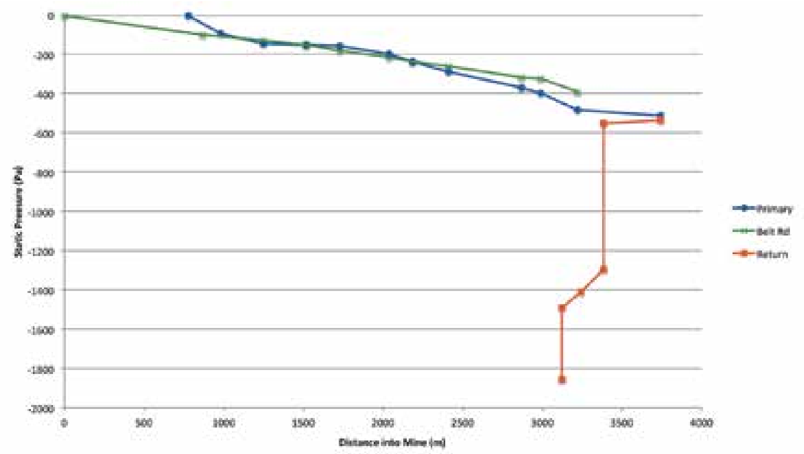

Figure 3. Case 1: pressure plot.

Case 1

Case 1 is based on a longwall mine in the Bowen Basin in Queensland, Australia. The trunk conveyor of the mine is segregated on both sides from the surrounding intakes with 203 segregation stoppings. The primary escapeway of the mine is the main travel road.

The contaminant test in Table 1 shows some very interesting and unexpected results. The highest contaminant results with the segregation stoppings in place were 31 ppm in the primary escapeway, 30 ppm in the mains development panel and 25 ppm in one of the gateroads. Without the segregation stoppings in place, the most significant result was the reduction of contaminant in the primary escapeway by 30% down to 22 ppm. The longwall result increased from 7 ppm to 17 ppm without the segregation stoppings in place, while the mains development and one of the gateroads both had reductions in the level of contaminant. As expected, the contaminant was more spread out and diluted without the segregation stoppings and more concentrated in particular areas.

The pressure gradient plot for Case 1 in Figure 3 shows the belt road at a higher pressure than the primary escapeway most of the time. The first 1000 m the primary escapeway and the belt are in separate drifts so the leakage would be almost non-existent. The time

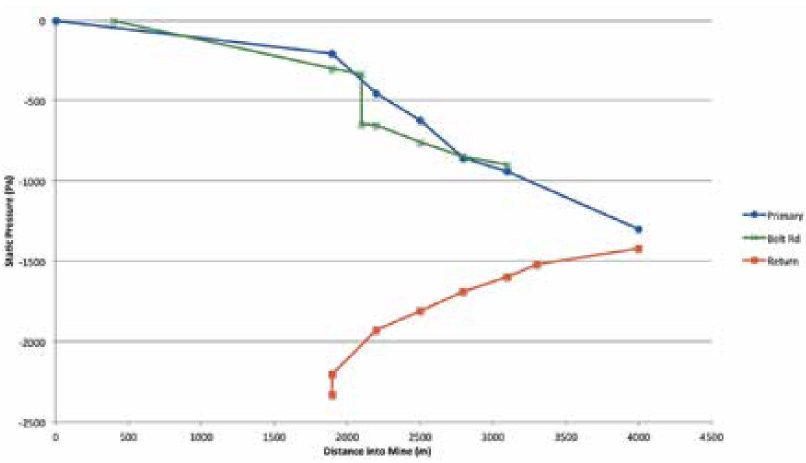

Figure 4. Case 2: pressure plot.

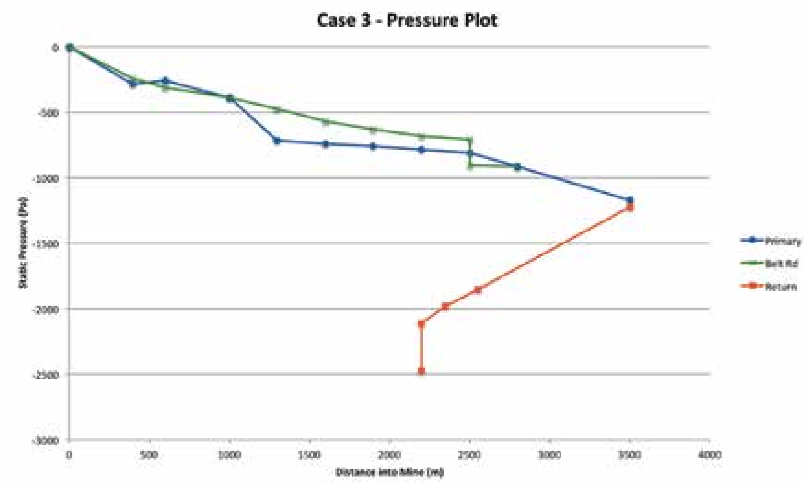

Figure 5. Case 3: pressure plot.

where the primary escapeway sits above the belt road in static pressure around the 2000 m mark is due to a significant reduction in the number of main headings, which causes the static pressure of primary escapeway to peak in this area. It is possible to see that the general pressure gradient trend of the segregated belt road is flatter than that of the primary escapeway, causing the belt road to be at a higher static pressure than the primary escapeway. This results in the leakage of contaminant into the primary escapeway in the event of a belt fire.

This scenario had 17 vehicle doors positioned along the trunk belt system. This highlights the need for vehicle and personnel access to the belt road and subsequent issues with quality of stoppings and leakage.

Case 2

Case 2 is based on a longwall mine in the Bowen Basin in Queensland, Australia. The trunk conveyor of the mine is generally segregated on both sides from the surrounding intakes with 106 segregation stoppings. The primary escapeway of the mine is the main travel road.

This scenario involved the most elaborate layout for segregation of the belt road of all the scenarios analysed. Table 1 shows that the contaminant result for the longwall face is 53 ppm regardless of whether the segregation stoppings are in place or not. The mains development panel showed a reduction of 15 ppm to 1 ppm with the removal of the segregation stoppings and another development panel showed a rise from 1 ppm to 7 ppm. The primary escapeway, however, showed a significant increase from 6 ppm to 31 ppm with the removal of the segregation stoppings. The pressure gradient plot for Case 2 shown in Figure 4 shows the extent that this particular operation has gone to get the pressure in the belt road to below the pressure in the primary escapeway (travel road).

The step in the pressure gradient for the belt road at the 2000 m mark is due to the placement of a regulator and an air dump in the belt road. This does a good job to reduce the pressure of the belt road and largely prevents leakage of the contaminant into the primary escapeway. The infrequent instances when the belt road has a higher static pressure than the adjacent primary escapeway results in the low result of 6 ppm. The air dump directs air out of the belt road into adjacent intake roadways. It is this air that is directed to the longwall – and this is the reason for the 53 ppm result for the longwall face.

Case 3

Case 3 is based on a longwall mine in the Bowen Basin in Queensland, Australia. The trunk conveyor of the mine is generally segregated on both sides from the surrounding intakes with 64 segregation stoppings. The primary escapeway of the mine is a roadway separate from the main travel road and on the other side of the trunk conveyor.

This scenario initially showed the most promise for having a simple design and maintaining a primary escapeway at a pressure above the adjacent belt road. However, the pressure gradient plot in Figure 5 shows that this is not the case. The belt road is generally at a greater static pressure than the adjacent primary escapeway. This is reflected in the results in Table 1, with arguably better results achieved with the segregation stoppings removed from the model. The primary escapeway showed an increase in contaminant concentration from 26 ppm to 29 ppm with the segregation stoppings removed.

There are two ways this scenario could be dramatically improved. The primary escapeway loses significant pressure early in the mains due to a segregated belt underpass. This allows air to travel from the primary escapeway to the travel road. This could be easily corrected with the installation of a vehicle door. Additionally there is a 200 Pa pressure drop in the belt road around the 2500 m mark. This is due to a high resistance ventilation control device (VCD) located in the belt road. This VCD would have very likely been installed to achieve compliance with belt segregation. The result is an increase in the static pressure of the belt road and the increased level of contamination of the primary escapeway in the event of a belt fire. In fact ,the primary escapeway suffers less contamination if this VCD is removed from the model. This is a good example of where compliance does not necessarily result in lower risk.

Conclusion

A line of stoppings will not prevent contaminants from a belt fire entering a primary escapeway, if the belt road is at a higher static pressure than the primary escapeway. For the examples analysed, segregation of the belt road from all other roadways usually resulted in the belt road being at a higher pressure than surrounding intake airways.

Consideration needs to be given to the static pressure differential between separated escapeways. The only way to ensure that a contaminant does not enter the primary escapeway is to ventilate the mine such that the primary escapeway is generally at a higher pressure than the surround roadways. Ideally the primary escapeway should have the highest static pressure of any adjacent roadways.

Consideration should be given to establishing primary escapeways that are not the main travel road in the mine. This will allow for the following:

- Provide a primary escapeway for the full length of the main headings free from contaminants in the event of a fire in the belt road or travel road.
- Ease of access to the belt road and less issues with damaged stoppings or leaking vehicle doors.
- Improve early detection of heatings and small fires (i.e. via smell).

Consideration should be given to putting more focus on reducing the level of risk to personnel than just being compliant. There are several examples from the modelling conducted where compliance is achieved but a more hazardous result is also achieved. WC

Note

This article is based on a presentation given at the Coal Operators' Conference 2014, 12 – 14 February 2014, Wollongong, Australia.