

Case study – ventilation planning for Bog Zone, Lisheen Mine

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ABSTRACT: Ventilation planning in trackless metal mining is often taken for granted. This paper highlights the trials of planning and executing the ventilation design for Bog Zone at the Lisheen Mine. Ventilation planning for Bog Zone started at the feasibility study stage in 2003; subsequent design changes continued until 2006. In August 2006, the development of the Bog Zone ore body was accelerated through the use of contractors; in addition, the Lisheen equipment fleet was revised based on a larger load and haul fleet. As a result, the circuit was reviewed in terms of changes in design conditions and best practices. This review resulted in a 40% increase of total airflow required to mine Bog Zone. Resources utilized to design the circuit include: external review, computer modeling, and in-house Lisheen planning and operational staff review. The final ventilation design configuration was adopted in 2007, after modeling and evaluating 30 different scenarios, resulting in a better distribution of airflow, optimized secondary escape way, reduced contaminants, and a total power reduction. The value of investment in computer modeling of primary ventilation circuit and planning for staged implementation should never be underestimated.

1 Introduction

1.1 Lisheen Mine

Located in the rural heart of Ireland, the Lisheen Mine is sited near the village of Moyne in County Tipperary, Ireland.

The area is characterized by cool, wet climatic conditions. Mean temperatures vary from 4°C in winter to 15°C in summer, with an average humidity of 83%. Annual rainfall ranges between 700 to 1000 millimeters.

Since Lisheen is a limestone deposit and is adjacent to bog lands, water has been a significant challenge. The mine presently pumps 80 ML per day.

The current production rate is 1.611 million tonnes per year using three mining methods: room & pillar, drift & fill and blast hole stoping in thicker areas. Lisheen is a high grade zinc/lead deposit on average with 12% Zn and 2% Pb. The mine is expected to produce approximately 5 million dry metric tonnes of zinc and lead concentrates over the estimated 14 year life-span.

1.2 Primary Ventilation Circuit January 2007

Lisheen Mine is on average 170m below surface with no major geothermal gradient increases in temperature. The main ventilation circuit works via negative pressure with main fans at the exhaust shafts. As part of the mine's IPC (Integrated Pollution Control) License, all exhaust fans must be located underground. The decline is the main intake into the mine and is the main access for all personnel and equipment.

There are eight vertical shafts, the intakes for the mine are via the decline, 131 (shaft) and Fresh Air Shaft (FAS) which is also the second means of escape for the miners. Of the remaining six shafts, one is decommissioned and the

other five are used as exhaust shafts, with high flow, low pressure underground fans with surface evasee's.

The main fans currently exhaust around 500 m³/s in total, which is split into the four working areas, Main Zone, Main North, Derryville, and Bog Zone, see Figure 1.

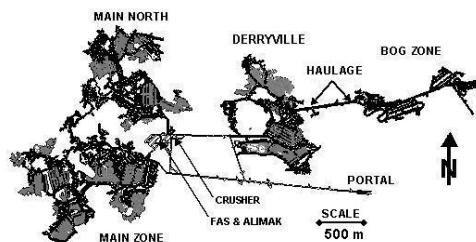


Figure 1. Lisheen Mine Layout

1.3 Bog Zone

The Bog Zone is a new addition to the Lisheen Mine which extends the underground footprint eastwards. The feasibility study for Bog Zone was completed in 2003 and planning permission was received from North Tipperary County Council a year later. This new zone is a valuable addition as it will provide 43% of total metal from Lisheen between 2007 and 2011. Ventilation planning for the new zone has been challenging as many conditions changed through the development stages from feasibility until final installation. The mine design changed, a new larger equipment fleet was purchased and mining development was accelerated. As a result the ventilation plan for Bog Zone evolved in order to mitigate and resolve all these issues and uphold best practices.

2 Mine and Ventilation Planning

2.1 Feasibility Stage

During the feasibility study of Bog Zone in 2003 a preliminary ventilation plan was developed. The majority of the fresh air entered the zone through Vent Raise 6 (VR6) along with fresh air from the portal via the Derryville haulage and exhausted through Vent Raise 7 (VR7) and Vent Raise 8 (VR8), see Figure 2. VR6 and VR7 were located due to their proximity to the ore body, but VR8's location was determined in order to coincide with Lisheen's property boundary. During this design stage, a parallel airway in Bog East was proposed, but due to the elevation characteristics of the ore body it was considered too difficult to implement.

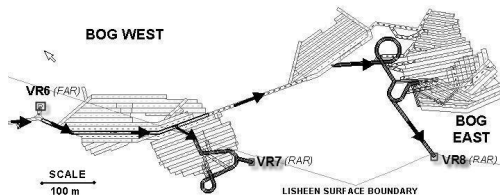


Figure 2. Bog Zone Main Ventilation Circuit in Feasibility Stage

As Bog Zone is on the periphery of the mine, therefore a secondary means of egress is required. In keeping with the mine's philosophy of secondary egresses, the plan was to install an Alimak in VR6.

2.2 Bog Zone Mine Design Change

After a redesign of the Bog Zone was performed changing the access in Bog West, a revised ventilation plan was required in 2006.

The first ventilation plan included an escapeway in VR6 via an Alimak. This option was reconsidered due to the cost of installing and maintaining the Alimak. An escapeway via a ladder was then considered. VR8 would be the ideal raise to use for a ladderway due to its short length, 85m (VR6 is 187m long). Therefore, the new ventilation plan had to incorporate VR8 as a fresh air raise (FAR). It was decided that the best configuration would be a return air raise (RAR) at VR7 with VR6 and VR8 as fresh airways, see Figure 3. The advantages of this arrangement include single exhaust fan set-up required, two clear paths for the air from VR6 and VR8 to VR7 with no series ventilation, also the two areas (Bog East and Bog West) can operate independently of each other. The risk of this method is ensuring that a flow of 25m³/s on the haulage road into Bog Zone, which is required as an optimum condition for haulage.

The volume flow for the Bog Zone main ventilation circuit was based on the mining method and the mining rate of 0.5 million tonnes per annum at the high point of the Bog Zone working life, see Table 1. The mining

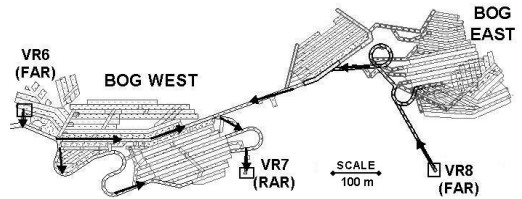


Figure 3. Revised Mine Design and Main Ventilation Plan for Bog Zone

method of most concern for ventilation will be in the areas using small stopes as the mining method.

Mining Method	Air quantity factor (m ³ /s/Mtpa)
Large open stopes >0.5 Mtpa	160
Small open stopes <0.5 Mtpa	240
Room and Pillar	200

Table 1. Design air quantity factors

The maximum air required was estimated to be 120 m³/s plus 25 m³/s for haulage drive (0.8 m/s) from the portal via Derryville, giving 145 m³/s as the total required air for Bog Zone.

2.3 New Auxiliary Fan Sizes

The ventilation design parameters were reviewed again in early 2007 due to new specifications for replacement scoops and trucks.

The standard minimum air quantity for the dilution of diesel fumes at Lisheen has been maintained at 0.04 m³/s per kW of rated engine power. Typically, this standard would yield target airflow in headings of 24 m³/s, based on a 250 kW loader and a 40 tonne (350 kW) truck working in one heading as the worst case scenario for auxiliary ventilation. The standard 42kW auxiliary fans employed at Lisheen meet this requirement.

The engine ratings of the equipment to be used in Bog Zone are substantially higher than the ratings used historically in the determination of airflow requirements. Loading 50 tonne (450 kW) trucks with 350 kW loaders within the same air stream increases the target delivery airflow to 34 m³/s. This increased requirement applies to all production areas where mucking and loading occurs in the same undiluted air stream, particularly in Bog Zone East where the long distances between the point of mucking and the haulage will force loading in the stope or crosscut. In either case there is no through ventilation available at the loading point as all headings in Bog East are single entry headings up to 150m long. Therefore, larger auxiliary fans are required.

The primary fan designated for mining in this area will also have to change as this impacts the required duty at VR7 and will have to be incorporated into the modeling.

2.4 Reevaluate Total Volume Flow

Once the new standard for the auxiliary fans was agreed, the total number of working headings in Bog Zone needed to be revisited in order to determine the overall amount of air needed based on the size of the fleet and crew, and the overall mining schedule.

The planned ventilation requirements for Bog Zone used the following assumptions:

1. A truck/ loader pair will use $40\text{m}^3/\text{s}$ ($35\text{m}^3/\text{s} + 5\text{m}^3/\text{s}$ of leakage).
2. Recommend only 2 truck/loader pairs at any one time in Bog East.
3. All other working headings will use $10\text{m}^3/\text{s}$.
4. Use 90kW fans capable of $40\text{m}^3/\text{s}$. Will be up to individuals in non load-haul working headings to tie back vent bag in order to reduce flow required.
5. Flow on the DV-BZ haulage will be $35\text{m}^3/\text{s}$.

Maximum demand on the system can be:

1. In Bog East/Central: 2 truck/loader pairs and 2 working headings. Total of $100\text{m}^3/\text{s}$.
2. In Bog West: 1 truck/loader pair and 2 working headings. Total of $65\text{m}^3/\text{s}$.

Therefore, the amount of air needed is $200\text{m}^3/\text{s}$, a 40% increase of total airflow required to mine Bog Zone. With this increase, a new fan specification was required as well as modeling to understand the impact this would have on the remainder of the mine.

3 External Review and Modeling

Once the total volume of air required for Bog Zone was decided, a model was needed to examine the effect the new ventilation shafts would have on the rest of the mine. As the Lisheen ventilation model was not up to date, a ventilation consultant was hired to build a new working model of the mine and over thirty simulations were performed. In the course of this analysis several areas of concern were highlighted.

VR8 was planned to be raise-bored at a diameter of three meters. This dimension was based on a previous audit report using old design criteria and ventilation plan. However, VR8 was now to include an escape way via ladder which would take up a large volume of the ventilation raise. VR8 would have to be larger to accommodate the escape way and the amount of air required for Bog East. It was recommended to enlarge VR8 from three meters to four meters in diameter.

The preferred direction of flow on the haulage from the mine is towards Bog Zone. This was the preferential direction to accommodate trucks traveling through clean air and to mitigate the smoke plume from potential truck fire in the haulage way. But with the ideal ventilation plan still VR6 and VR8 in taking and VR7 exhausting, the air's natural tendency is to flow opposite of the direction desired on the haulage. In order to combat this, a jet thrust fan will have to be located in the haulage along with other ventilation controls to maintain the direction of flow as preferred.

The total volume of air to be exhausted through VR7, $200\text{m}^3/\text{s}$, would require an exhaust fan drawing power of over 800kW because of the size of the already raise-bored ventilation shaft, three meters in diameter. This amount of power was unacceptable as the current system was already nearing the maximum power output available. In order to reduce the pressure and the power consumption, a larger raise would be required. As VR7 was already drilled, there were two options available, enlarge the current raise or drill a second parallel raise for dual exhaust. The second option would be more practical as a contractor would already be onsite to complete VR8 and the costs were estimated to be similar to the first option. After the geotechnical risks of the parallel raise were reviewed, a second parallel raise, VR7A was approved and drilled successfully, see Figure 4.

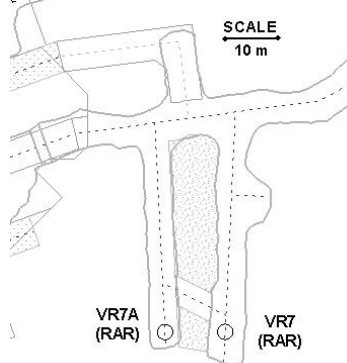


Figure 4. VR7 and VR7A Layout

With all these issues resolved a final simulation was performed to give an exhaust fan motor size of 200 kW. The power savings of the fan size difference justified the additional raise, VR7A, with a payback in 18 months.

4 Staged Implementation

4.1 Accelerated Development

In house waste development of Bog Zone began in November 2004 at a rate of 50m per month. In April 2005 during the annual life of mine resource estimation it was identified that if Lisheen wanted to maximize its production over the remaining life of mine, Bog Zone needed to be in full production by September 2007.

While revisions of the main ventilation circuit were on going, the development of the Bog Zone ore body was accelerated through the use of contractors. Starting in August of 2006, a development contractor was on site for one year and mined approximately 2.5km of development. The milestones for the contract development schedule were closely tied to the ventilation circuit implementation plan. The first of which was reaching the underground access for VR6. After the raise was complete in November 2006 a

temporary fan installation was located at VR6. This greatly reduced the forcing distance for the auxiliary fans as it allowed for a dedicated return airway for advance on the priority haulage and also enabled the contractors to work more faces as the total volume flow for the zone doubled. Once the underground access for VR7 was complete and raise boring finished in April 2007, the temporary fan installation was moved to VR7 and realized the same auxiliary fan forcing benefit on the primary haulage as well as increased volume flow with the addition of one fan in the exhaust raise. The final milestone reached by the contractors was completing the long run to VR8 in July 2007.

4.2 Secondary Egress

A cost benefit analysis of the ladder escape way and a refurbished Alimak at VR8 was also performed. Due to the current steel prices, the projected installation costs, and the potential resale values (scrap metal value in the case of the ladder way), it was found to be more cost effective to install a refurbished Alimak than a ladder way. In December 2007 a contractor was onsite to support/shotcrete VR8. The support work was completed in 4 weeks while the chosen Alimak was refurbished by the supplier. Installation of the Alimak and all associated electrics was completed by March of 2008.

4.3 Bog Zone Main Exhaust Fan

The specification for the Bog Zone main fan was sent out to suppliers for quotation. The majority of quotes that came back involve a parallel fan installation. While this would be ideal in terms of availability, the power implications were beyond Lisheen's capabilities. The fan that was chosen is a single axial fan 4.5m in diameter, see Figure 5.

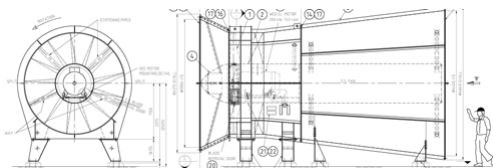


Figure 5. Bog Zone Main Exhaust Fan

While the fan was being fabricated, other installation issues were being sorted: brattice walls for auxiliary fan installations, ventilation flyovers, and main fan electrics.

Given the size of the fan and the logistical complications of placing the fan underground, the fan was shipped piecemeal and assembled underground on site. In order to complete all the installations required, the temporary fan installation had to be again moved to VR6 while work commenced at VR7 and VR7A.

5 Conclusions

Ventilation planning is often over looked during the chase for grade and tonnes. From feasibility stage until

implementation, the ventilation plan must be reevaluated and changed as conditions evolve. The ventilation design for the Bog Zone at the Lisheen Mine was modified several times in order to realize a better distribution of airflow, optimized secondary escape way, reduced contaminants, and reduced total power requirements. All of these changing conditions impact ventilation and can be managed through the tools of computerized ventilation modeling. The value of investment in computer modeling for primary ventilation circuit and planning for staged implementation should never be underestimated.

References

- Anglo American, 2004. *Environmental Impact Statement Extension to Existing Underground Mine Development Bog Zone*, pp 3.2 (Anglo American Lisheen Mining Ltd: Moyne).
- Anglo American, 2005. *Lisheen Mine Sustainability Report 2005*, pp 12 (Anglo American Lisheen Mining Ltd: Moyne).
- Anglo American, 2006. *Lisheen Mine Sustainability Report 2006*, pp 22 (Anglo American Lisheen Mining Ltd: Moyne).
- Barret, Padraig, 2007. *Bog Zone Development Contract - Project Completion Audit*, Internal Audit Lisheen Mine Report.
- Howes, M J, 2000. *Ventilation Planning, Pressure Survey and Network Simulations*, External Audit Lisheen Project Report.
- The Lisheen Mine, 2007. <http://www.lisheenmine.ie> Background, Mining, and Ventilation, December.
- Unstead, A D, 2007. *Report on Visit to Lisheen April, 2007*, External Audit Lisheen Mine Report.