From Airflow to Air Quality: Beyond the 0.05 Rule Through Digital Optimization of Underground Mine Ventilation Systems

Joshua Noonan[1],

Note: Presenting author's name should be underlined.

1. Graduate Mining Engineer, Alkane Resources, Tomingley NSW 2869, Australia.
   Email: Joshua.Noonan@alkres.com

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- Digital Ventilation Optimisation
- Diesel Particulate Matter (DPM)
- Respirable Crystalline Silica (RCS)
- Mine Health & Safety
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- Data-driven Mining

ABSTRACT

Underground mine ventilation remains one of the most critical controls for managing worker exposure to hazardous airborne contaminants, yet NSW industry practice continues to rely on simplified airflow demand factors such as 0.05 $m^3/s/kW$ of installed diesel power. This study critically evaluates whether this benchmark is sufficient to maintain safe and effective air quality in modern underground hard rock mining environments.

Conducted in collaboration with Tomingley Gold Mine, an operating underground mine in New South Wales, Australia, the research applies a data-driven and performance-based approach to assess ventilation effectiveness under real operating conditions. The study focuses on key airborne hazards including diesel particulate matter (DPM), respirable crystalline silica (RCS), and respirable undefined dust (RUD), which are strongly influenced by diesel fleet activity, drilling, blasting, and ore handling processes.

Air quality and airflow performance were assessed using in-situ monitoring with a TSI AM520i SidePak Aerosol Monitor alongside Kestrel and vane anemometer airflow measurements across multiple production levels. These field observations were integrated with historical datasets and Ventsim simulations to evaluate airflow distribution, contaminant dilution, and the impact of ventilation circuit configuration on exposure outcomes.

The results show that while total mine airflow capacity was substantial, distribution to active working areas was inconsistent, leading to periods where regulatory exposure limits for both RCS and DPM were exceeded. Importantly, findings demonstrate that airflow quantity alone does not determine air quality outcomes; instead, system design, regulator placement, and diesel activity scheduling play a dominant role in exposure control.

This research highlights the need to move beyond fixed ventilation demand factors toward intelligent, site-specific optimization strategies. By integrating monitoring data with ventilation modelling, the study demonstrates how digital approaches can enhance air quality management, improve worker health protection, and support more efficient underground mine ventilation design.

Note: Do not use extra returns between paragraphs, or double spaces between sentences.

Use of figures and tables is discouraged, unless absolutely vital to abstract submission.

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