Conveyor Tunnel Airflow Requirement Update Based on Heat Exchange for the New Level Mine Project

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The New Mine Level Project (NMLP) is the future underground expansion of the El Teniente mine. This mine is near the city of Rancagua, Chile. The daily production rate is expected to be between 137 kt/d and a maximum of 180 kt/d, with production planned to start at the end of 2020 or early 2021. As part of the NMLP, two main tunnels are being constructed, one for personnel and supply transportation (TAP) and a second one for ore haulage by a belt conveyor system (TC) to bring the ore from the mine to surface. The airflow requirement of the two tunnels where estimated during the prefeasibility engineering phase and only the requirement of the TAP tunnel was updated in this phase of detail engineering according to the available information of diesel vehicle fleet and expected air velocities in the tunnel. This paper presents the findings of a recent study to update the airflow requirement of the TC tunnel based on the velocity range that minimizes dust pick up from the belt becoming airborne and to maintain the air temperature in a reasonable range according to Chilean law. The updated airflow requirement and power demand is compared to the results of the previous engineering phase in terms of magnitude and operational point of the main fans dedicated to the tunnels. A proposed design modification for the ventilation of the tunnel Conveyor N° 2 and 3, which are part of the ore haulage system, is also presented.

Keywords: Mine ventilation design, heat load calculations

1. Introduction

The New Mine Level Project consists of a new block cave mine being developed below the existing El Teniente mine. The mine is operated by the state run company CODELCO. The planned production rate may be as high as 180 kt/d over a ramp up period of about 10 years. The mine will use mechanized methods to move the ore from the draw points to the ore passes. The production level will be at the 1862 masl elevation. Ore passes, approximately 54 m in length, will send the ore to truck loading chutes on the haulage level located at an elevation of 1808 masl. The trucks will dump at one of three identical crushing plants located in the center of the ore body. The primary crushing plants will feed the ore to the 2m wide Conveyor N° 1 that is designed to operate at 6 m/sec and has a capacity of 12,280 t/h. Conveyor N° 1 runs in a nearly 9 km long tunnel which reaches the surface at the Coya river canyon on a specially excavated platform at elevation 1496 masl. At this location, a primary transfer station (Station N°1) is located. The conveyor has a horizontal length of 8,855 m, running down slope at 2%. The elevation difference over the tunnel length is 177.1 m. The conveyor will be driven by two 2.5 MW directly coupled synchronous motors.

At Station N° 1 the ore is transferred from Conveyor N° 1 to Conveyor N° 2 which has a horizontal length of 962.8 m and slopes upward 212.4 m with a maximum slope of 13.5 degrees. Conveyor N° 2 will be driven by four 2.5 MW directly coupled synchronous motors. This conveyor crosses the river and through a tunnel ending on a higher platform at an elevation of 1699.2 m. Transfer Station N° 2 is located at the end of Conveyor N° 2 and transfers the ore to Conveyor N° 3. This conveyor has a horizontal length of 1129.4 m and slopes upward a vertical distance of 213.5 m with a maximum slope of 12.5 degrees. The conveyor will be driven by four 2.5 MW directly coupled synchronous motors.

Conveyor N° 3 has a pant leg chute at his discharge where Transfer Station N° 3 is located. This chute allows for diverting the ore to a future stockpile or to the different processing plants of the concentrator.

Conveyor N° 1 of the project will be supplied with a Low Rolling Resistance (LRR) belt bottom cover and on all idlers of the system in order to reduce belt friction. The power demand estimated for Conveyor N° 1 is only 631 kW at full load since it will operate downhill and gravity will assist in moving the ore. The conveyor motors are primarily sized to be able to start the conveyor. Stopping the conveyor will be by an electro dynamic motor generation. The predicted heat dissipated by the conveyor is 6540 kW giving a per unit length rate of $q_1 = 0.74 \text{ kW/m}$. For Conveyors N° 2 and 3 the power demand is 8607 kW and 8766 kW giving a per unit length rate 1.44 & 1.35 kW/m, respectively.

The tunnel of Conveyor N° 1 has two ventilation adits one called P-500 and the other P-4600 which divide the tunnel into three separate ventilation sections. These adits were built for the construction of the conveyor tunnel and to divide the airflow in the tunnel in the event of a tunnel fire. P-500 has a length of 2.5km with P-
4600 having a length of 2 km. The P-500 will be used as air intake and P-4600 will be an exhaust. The sections from the tunnel of Conveyor N° 1 are described from surface portal to the inner mine as: Portal – P500, P500 – P4600, P4600 – Inner mine end. A scheme of the N°1 conveyor tunnel (TC), the personnel and supply transportation tunnel (TAP), and the two access ramps is shown in Figure 1.

The purpose of the ventilation study described in this paper is to define the minimum air requirements of the three tunnel segments of the Conveyor N° 1 to keep acceptable environmental conditions considering the high energy dissipation of the conveyors. In addition, the natural ventilation effects to ventilate Conveyors N° 2 are described.

2. Results of the previous engineering phase and TAP airflow update

The airflow requirements of the two main tunnels TAP and TC were initially estimated during a prefeasibility engineering phase. Detail engineering studies resulted in the airflow requirement of the TAP tunnel being updated according to new information on the diesel vehicles fleet and expected air velocities in the tunnel to maintain a flow to assist in dust control. Figure 1 represents the prefeasibility engineering phase and Figure 2 presents the results considering TAP updated requirements.

Table 1 presents the expected airflow velocities in each of the three sections of the conveyor tunnel (TC) as a result of the updated requirements of the TAP tunnel study. As can be observed in Table 1, the three sections have almost the same air velocity, slightly over 1 m/s.

A result of the TAP detailed engineering update was the power increase required to move the airflow through both TAP and TC tunnels went from 1,075 kW to 1,970 kW. One of the main concerns of this study for the TC tunnel was to hopefully validate that the current airflow velocities in the tunnel while maintaining acceptable environmental conditions through each tunnel segment.
The temperature and the absolute humidity distribution were obtained from measurements made during one year at the Sewell meteorological station located at the 1980 masl elevation. The daily temperature distribution considered corresponds to the average of the hottest summer days. The parameters for Conveyors N° 1 were estimated by correcting the temperature by the altitude temperature gradient of the atmosphere. The relative humidity is considered equal to the values of the station. The absolute humidity was obtained with the atmospheric pressure, relative humidity and air temperature. Figure 3 shows the temperature and humidity curves for a typical summer day.

The absolute humidity was considered for the air temperature calculation in the tunnel since it is constant while travelling along the tunnel. The primary heat source is the sensible heat added by the conveyors. Applying absolute constant humidity assumes the tunnels are dry and no major water infiltrations to the tunnel will occur. For this study, the mean rock temperature was assumed to be equal to the mean air temperature $T_{am} = 19.15 \degree C$ in ET 1, and $T_{am} = 17.85 \degree C$ at the tunnel portal as measured in the summer. This data has an air temperature amplitude of $\Delta T_a = 7.5 \degree C$, a mean humidity of $X_m = 5.068 \text{ gm/kg}$, an amplitude of $\Delta X_a = 5.068 \text{ gm/kg}$ and a time lag of the maximum temperature and humidity of $\tau_m = -3 \text{ hr}$.

The temperature inside the El Teniente mine is comfortable and very stable all year long. The depth temperature gradient of the rock is lower than in other continental plates ($-15 \degree C$/km) due to the mountainous terrain. This makes the above assumptions reasonable for this study. Furthermore, the heating and cooling of the rock during a year cycle is very slow so that the heat flow due for this analysis was neglected. The behavior of the air heating during winter has not been modeled in this analysis since the existing mine shows no problems with excessive air temperature.

To model the heat flow in the rock on the tunnel wall the one dimensional partial differential equation for the
heat conduction in a plane solid is used. This assumes the heat penetration is about 1 m deep as compared to the tunnel width of 6 m. This allowed for a plane surface to be assumed, hence we have the following with a thermal diffusivity assumed to be \(a_t = 1.111 \text{ mm}^2/\text{sec}\).

\[
\frac{\partial}{\partial t} T(x, t) = \frac{\partial^2}{\partial x^2} T(x, t) \tag{2}
\]

To determine the temperature distribution in the rock close to the tunnel wall it was assumed that it follows a sinusoidal fluctuation of the day cycle of the outside air temperature. This allows modeling as a quasi-steady heat flow with an alternating expression for the time dependence with \(w=2\pi/\tau_a\) being the frequency and function \(F(x)\) will only depend on the distance \(x\). Equation 3 shows this function.

\[
T(x, t) = e^{i\omega t} F_a(x) \tag{3}
\]

Replacing this expression in the heat conduction equation gives a differential equation for \(F(x)\) which depends on \(x\) only (whose solution is of the sinusoidal form):

\[
\frac{d^2}{dx^2} F_a(x) = \frac{i \omega}{a_t} F_a(x) \tag{4}
\]

The solution of this differential equation is as follows:

\[
F_a(x) = A e^{-\frac{x}{a_t}} - i B e^{\frac{x}{a_t}} \tag{5}
\]

The boundary conditions require that the function \(F(x)\) decreases with increasing depth into the rock so that the coefficient \(A = 0\).

\[
\lim_{x \to \infty} T(x, t) = T_{am} \quad A = 0 \tag{6}
\]

On the wall surface, the heat flow by convection of the air inside the tunnel must be equal to the heat conduction in the rock. Here \(h\), is the convective heat transfer coefficient, \(\lambda_a = 1.9 \text{ W/m}^2\text{K}\) is the heat conduction of the rock, and the air temperature in the tunnel is expressed as a complex function with the same frequency as in the rock:

\[
\tau_a = \tau_{a0} - \tau_{am} e^{i\omega t} = \lambda_a \frac{T_{am} - T_{a0} e^{i\omega t}}{h} \tag{7}
\]

Replacing \(T_a(t)\) from (7) and \(T(x, t)\) from (3) at \(x=0\) gives the value of the coefficient \(B\) of (5).

\[
B = \frac{\Delta T_a}{1 + \frac{\lambda_a}{h_t} \frac{\tau_{a0}}{a_t}} \tag{8}
\]

Inserting \(B\) into equation (5) and with the function \(F_a(x)\) from equation (3) it is possible to simplify the expression to get the solution of temperature distribution inside the rock. Replacing \(w=2\pi/\tau_a\) gives \(\lambda_a\) the wave length. \(K_p\) is a parameter that depend on \(\lambda_a\) the conduction coefficients of the rock and \(h_t\) is the heat convection coefficient inside the tunnel on the wall surface. Considering that the expression has complex numbers to match the phase of the alternating air temperature the imaginary part of the equation is used. With \(x\) the distance from the wall into the rock and \(t\) the time elapsed during the cycle the temperature distribution inside the rock is computed as follows:

\[
\lambda_o := 2\sqrt{\pi a_t \tau d} = 1.098 m \quad K_p = \frac{2\pi \lambda_t}{h_e \lambda_0} \tag{9}
\]

The heat flow into the rock wall has the following expression:

\[
q(x, \tau_a \tau_d) = \frac{\Delta T_a \lambda_a}{\lambda_0} \frac{2\pi ((1 + i) \tau_a \tau_d)}{1 + K_a ((1 + i) \tau_a \tau_d)} \exp(i 2\pi \frac{\tau_a \tau_d}{\tau_d}) \tag{10}
\]

Balancing the heat in a section of tunnel (dy) was done using: \(\Gamma\) as the air mass flow, the function \(v_a\) for air velocity, \(C_a\) for air heat capacity, \(T\) the air temperature (which is a function of \(y\)), for the tunnel wall temperature, \(q\), the heat dissipated by the conveyor per unit length (= 1.568 kW/m for Conveyor No 2), \(S_a\) the perimeter of the tunnel section, and \(\tau_a\) the time elapsed of the day cycle temperature, the following equation is obtained:

\[
G_a C_a \left( \frac{d}{dy} T \right) = q_a - h_a S_a (T - \theta(0, \tau_d)) \tag{11}
\]

Ordering the terms the following first order differential equation is obtained

\[
\Lambda \left( \frac{d}{dy} T \right) + \tau_a \cdot T_a \cdot \frac{\theta(0, \tau_d)}{h_a S_a} \cdot \Lambda(v_a) = \frac{G_a}{h_a} \frac{v_a}{S_a} C_a \tag{12}
\]

Integrating with respect to \(y\) considering the boundary condition \(T = T_a\) at \(y = 0\) the equation reduces to \(T(\tau, y)\) for the air heating along the tunnel with \(f_e\) the load factor of the conveyor.

\[
T_a(\tau, y) = T_a(\tau) + \frac{\frac{E_v q_c}{h_a} - (T_a(\tau_a) - \theta(0, \tau_a))}{1 - \exp(-\frac{y}{\Lambda \tau_a})} \tag{13}
\]

To calculate the convection heat transfer coefficient \(h\), the following relation is used which corresponds to the forced heat transfer along a prismatic conductor since the air movement is created by the air draft due to the heat
released by the conveyor or the ventilation fan and not by natural convection from the wall. Here Nu_u and Re are the Nusselt and Reynolds numbers of the air and are functions mainly of the air velocity v_a. Pr = 0.712 is the Prandtl number of the air; D_b = 6.22 m the hydraulic diameter of the conductor (i.e. the tunnel of Conveyor N° 2), \( \lambda_a = 0.0263 \) W/m°K the heat conduction coefficient of the air, \( v_a = 0.176 \) cm/s the cinematic viscosity of the air.

\[
Nu_u(v_a) = 0.024Re_e(v_a)^{0.8}Pr_a^{0.333}
\]

\[
Re_e(v_a) = \frac{v_aD_b}{\nu_d}
\]

\[
h_f(v_a) = \frac{Nu_u(v_a)\lambda_a}{D_b}
\]

The airflow in the tunnels of conveyors 2 and 3 is obtained from the balance of the hot air draft with the pressure drop of the air movement. The air draft corresponds to the buoyancy of the warmer air inside the tunnel with respect to the outside colder air.

The pressure drop of the air flowing in the tunnel is obtained with the Darcy relation in which \( \lambda_{ad} \) is the friction factor of the tunnel wall and \( K_{sec} = 3.126 \) the sum of the loss factors (entrance loss, curves, contractions, lovers and roof ventilators in the Transfer Stations, etc. in the tunnel of Conveyor N° 2). The friction factor is obtained with the Colebrook relation in this case for the wholly rough zone (\( Re \sim 6 \times 10^4 \)) with the absolute roughness \( e_a = 360 \) mm of the tunnel wall.

\[
\lambda_{ad} := \left(2 - \log \left(3.7 \frac{D_b}{e_a}\right)\right)^{-2} = 0.089
\]

The air draft is calculated with \( L_z \) the tunnel length, the height difference \( H_z \) between the inlet at the lower end of the conveyor tunnel and exit at the upper end of it, \( H_1 \) the height difference in the Transfer Station from the tunnel entrance to it and the air outlet in the static roof ventilator, \( \Delta T_e \) the temperature rise of the air heated in the building and \( \beta_a \) the thermal expansion coefficient of the air at the mean temperature. As the temperature of the air varies while moving along the tunnel, the draft increases and therefore the buoyancy force is the integral over the tunnel length.

The air drag of the belt movement generates a pressure raise \( \Delta h_b \) in the same direction as the air draft and is obtained using the resistance to the air movement over a flat rough surface. The resistance factor \( C_D \) is obtained with the roughness of the surface and in this case corresponds to the rocks lying on the belt which have a size of \( e_m = 350 \) mm, \( L_z \) is the belt length, \( D_b \) the belt width and \( A_z \) the tunnel section. The total resistance force \( F_{ar} \) which is the action of the movement of the belt on the air is obtained with the expression of relation (16) obtained from reference [2]. So the pressure raise over the whole length of the conveyor can be calculated as follows:

\[
F_{ar} := L_z C_D D_b \frac{\rho_a(T_{am})v_a^2}{2} - 186.6N \quad \Delta h_c := \frac{F_{ar}}{\rho_a(T_{am})v_a} = 6.38 \frac{m^2}{s^2}
\]

With this the final expression to calculate the air velocity \( v_a \) is:

\[
\left(\frac{K_{sec} + \lambda_{ad}L_z}{D_b}\right)\frac{v_a^2}{2} + \Delta h_c + \phi_h \Delta T_e = \frac{\int_{T_{am}}^{T_{am}} h_a(t_c, t_a)}{\int_{T_{am}}^{t_c} h_a(t,c)dt} - \frac{\int_{T_{am}}^{T_{am}} h_a(t_c, t_a)}{\int_{T_{am}}^{t_c} h_a(t,c)dt}
\]

(18)

To get the velocity and outlet temperature of the air in the tunnels of Conveyors N° 2 and 3 an iterative procedure has to be used to solve simultaneously the equations (9), (14), (15) and (18).

As the ventilation of the tunnel of Conveyor N° 1 is with fans, equation (18) has to be replaced by the constant air velocity considered, to get the air temperature at the outlet of the tunnel. Conversely, in this case the air flows through the adits to reach the conveyor tunnel itself, and the ventilation fan power will add heat to the intake air. The heat generated by the fan power was distributed along the length of the tunnel with \( q_e = 0.402 \) kW/m and the result was a sinusoidal air temperature with a lower amplitude \( \Delta T_e = 4.25 \) °C and a mean air temperature \( T_{am} = 20.25 \) °C (a bit higher then the outside air temperature of relation (1) at the inlet of the conveyor tunnel). This stabilization effect of the air temperature happens due to the heat exchange with the tunnel wall.

4. Results of the model

To assess whether the heat stress in the tunnels are suitable for people working in this environmental condition, the Wet Bulb Globe Temperature (WBGT) according to the Chilean code DS 594 was estimated. As the radiant heat load within these tunnels is negligible the WBGT temperature is calculated considering the dry bulb \( T_c \) and the wet bulb temperature \( T_{wb} \) of the air. This is a simplification, but it is based on the absolute humidity, and both \( T_c \) and \( T_{wb} \) are functions of the distance \( y \) in the tunnel and \( \tau_c \) the hour of the day under analysis. The instant and shift mean WBGT temperature are calculated with the following relations with the second equation giving the mean value of the hottest shift.

\[
T_{WBGT} := 0.3T_c + 0.7T_{wb} = \frac{1}{15 hr} \int_{15 hr}^{23 hr} T_{WBGT} d\tau_c
\]

(19)

The permissible limit for heat stress according to the code is WBGT = 25 °C for heavy and continuous work within the tunnels. Applying the model to the main tunnel adit of P500 it can be seen that a stabilizing effect
on the temperature is noted as shown in Figure 4 with Figure 5 showing the air cooling effect along the adit.

The modeling results for the different variables for Conveyor Tunnel N° 2 are shown on Figures 6 through 9. Figure 6 shows the heat exchanged between the air and the rock while Figure 7 illustrates the variation of the different temperatures during the day cycle time.

Figure 8 gives the predicted temperature distributions of the rock wall, dry and wet bulb of the air, and mean day cycle of the air along the tunnel. Figure 9 shows the temperature distribution inside the rock at different times of day. It is noted that the heat penetration is relatively small, around 1 m into the rock.

From the graphs the stabilizing effect the rock has on the temperature inside the tunnel is observed. This is because the rock will absorb heat when the air has a higher temperature and, conversely will release the heat when the air is cooler (at night).

An analysis based on the utilization of the conveyors was done, and the WBGT temperature was predicted based on a daily average utilization factor of 75% and 100%. The last case was considered in order to assess the heat conditions when the conveyors have been operating for several hours at maximum conditions.

Table 2 summarizes the predicted temperatures for the different conditions studied. Relatively small length differences of the main tunnel sections of Conveyor N° 1 shown in Table 2 can be observed if they are compared to the length given in the previous study performed in reference [1].

These differences can be attributed to changes during the detail design of the tunnel mainly due to layout requirements and geomechanical constraints observed during the current construction phase. As noted in Table 2, the most demanding section of Conveyor N° 1 tunnel is the one from the injection adit P500 to the extraction adit P4600.
Table 2. Summary of air velocities and temperatures in conveyor tunnels.

<table>
<thead>
<tr>
<th>16 hrs</th>
<th>75 % conveyor heat dissipation</th>
<th>100 % conveyor heat dissipation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air velocity m/s</td>
<td>Air T&lt;sub&gt;db&lt;/sub&gt; Tunnel exit °C</td>
<td>Amb heat stress T&lt;sub&gt;gbh&lt;/sub&gt; instantan °C</td>
</tr>
<tr>
<td>Conveyors 1: Section Portal - P 500 = 3105 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.8</td>
<td>29.90</td>
<td>23.80</td>
</tr>
<tr>
<td>1.0</td>
<td>28.48</td>
<td>23.12</td>
</tr>
<tr>
<td>1.2</td>
<td>27.52</td>
<td>22.65</td>
</tr>
<tr>
<td>1.4</td>
<td>26.22</td>
<td>22.03</td>
</tr>
<tr>
<td>Conveyors 1: Section P500 - P 4600 = 4312 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.8</td>
<td>29.98</td>
<td>23.84</td>
</tr>
<tr>
<td>1.0</td>
<td>28.55</td>
<td>23.15</td>
</tr>
<tr>
<td>1.2</td>
<td>27.57</td>
<td>22.68</td>
</tr>
<tr>
<td>1.4</td>
<td>26.87</td>
<td>22.34</td>
</tr>
<tr>
<td>Conveyors 1: Section P 4600 - Mine inner end = 1431 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.8</td>
<td>29.18</td>
<td>23.40</td>
</tr>
<tr>
<td>1.0</td>
<td>27.91</td>
<td>22.78</td>
</tr>
<tr>
<td>1.2</td>
<td>27.06</td>
<td>22.36</td>
</tr>
<tr>
<td>1.4</td>
<td>26.45</td>
<td>22.06</td>
</tr>
</tbody>
</table>

However, even in the case of full load (100%) a velocity of ~ 1 m/sec in the tunnels is sufficient to keep the WBGT temperature within the legislated limit of 25 °C.

5. Summary

The results indicate that for all the considered scenarios, including the updated ventilation design of the tunnels, modification to the current ventilation system design is not required due to heat. The fan operational point will not change and the power...
consumption determined for the fans will not increase further as it did with the last study.

The previous results also open an additional avenue for study which is the possibility of applying ventilation on demand (VOD) strategy for each tunnel section to minimize the use of energy, while maintaining the permissible limits for temperature and other contaminants. The conveyor tunnel (TC) VOD strategy could be based on temperature, dust control and diesel fleet. On the other hand, the personnel and supply tunnel (TAP) should be based on diesel fleet and mitigating any potential fire risk.

The tunnel ventilation of Conveyor N° 1 is a forced ventilation system with constant flow rate and for the purposes of defining the air velocity the 3 sections, between the Portal and the junction with the P 500 adit, between junctions of adits P 500 and 4600 to end of the tunnel inside the mine were modeled. The air velocity was varied over the range of 0.8 to 1.4 m/sec and the dry bulb temperature and the maximum instantaneous heat stress and average shift WBGT for these air flows were calculated.

According to the results, an air flow of 47.5 m$^3$/s with a speed of 0.9 m/sec is recommended in order to cover the scenarios investigated. Under this condition the heat stress limit WBGT is not met even during maximum conveyor heat dissipation (i.e. 100% of the heat generated by the friction of the idler and belt heating by hysteresis in the indentation of the rollers). This situation should not occur very often since the maximum outside air temperature combined with the belts operating at full load only occur a few times a year. Hence, a WBGT exceeding 25 °C for heavy duty and continuous work would rarely occur.

For the natural draft ventilation of the tunnels of Conveyors N° 2 and 3 the model shows that the concept works well with the resulting air velocity sufficient in magnitude to assure good ventilation inside the tunnel. Only during the 15 to 17 hour during the summer will the WBGT temperature possibly exceed the 25 °C at the exit of the tunnel.

Tunnel ventilation of Conveyors N° 2 and 3 can be ventilated naturally due to their respective inclined design and from the heat generated by the conveyor system. At the transfer stations air louvers in the lower part of the building need to be considered in addition to Robertson type static roof ventilators to allow air to enter the stations and to release heat from the tunnels and transfer station.

The air intake louvers and roof ventilators were sized to keep the temperature under the values defined by these calculations. The intake louvers must have an area of at least 60 m$^2$ and the roof ventilators must be 800 mm wide with an area of 40 m$^2$ (50 m long).

During summer the outlet air temperature of the tunnels is not predicted to exceed 34 °C and at the roof ventilator discharge a temperature of 40 °C may be possible. The air flow in the tunnel of Conveyors N° 2 and 3 is in the range of 50 - 70 m$^3$/sec with a speed between 1.8 to 2.1 m/sec which adjusts itself by the heat released by the belts.

This paper presents an approach to predict the heat transfer in a long conveyor tunnel being constructed for the New Level Mine. WBGT was calculated to determine if acceptable environmental conditions could be maintained in the conveyor tunnels. The study was used to verify previous studies on the airflow required for the Conveyor N° 1 tunnel and the proposed natural ventilation of Conveyors N° 2 and 3 tunnels. The results of this study indicate that heat does not appear to be an issue in the conveyor tunnel based on the original design airflows. Furthermore, the predicted maximum WBGT criterion is not expected to be met. This result may give an opportunity to explore the benefit of reduced airflow quantities to save operating power costs. However, such a reduction would also need to consider dust dilution and mitigating any potential fire event.

References