P.T. FREEPORT DOZ MINE VENTILATION SYSTEM

Felipe Calizaya  Ketut Karmawan  Keith G. Wallace, Jr.
P.T. Freeport Indonesia  P.T. Freeport Indonesia  Mine Ventilation Services, Inc.
Tembagapura, Indonesia  Tembagapura, Indonesia  Fresno, California, USA

ABSTRACT

P.T. Freeport Indonesia’s Deep Ore Zone copper deposit is located in the province of West Papua, Indonesia. Currently, a block cave layout is being developed to mine this deposit. The ore production started in November 2000 at a rate of 2000 tpd. This rate is to increase to 25,000 tpd by year 2003. The total air quantity requirement for this mine is 780 m$^3$/s. To supply this quantity, the primary ventilation system will require three 5.5 x 5.5 m cross section intake drifts, two 6 m diameter exhaust shafts, five centrifugal fans (one 450 kW and four 750 kW) and numerous airlock doors and regulators. This paper summarizes the basic requirements to supply each working area with the required quantity of fresh air. It describes the ventilation system design and network modelling, the proposed airflow distribution in the panel and haulage drifts, and the key parameters used to determine the fan duties. Also discussed are the construction details of the main intake and exhaust airways, and the installation and commissioning of the main fans and other control devices. The paper also describes a fan monitoring system that was installed to continuously record and report the main fan duties.

KEYWORDS

VENTILATION, PLANNING, DESIGN, BLOCK CAVE, MAIN AND BOOSTER FANS

INTRODUCTION

The DOZ copper/gold mine is part of the large Ertsberg/Grasper Complex located in the province of West Papua, Indonesia. Figure 1 shows the location of the mine complex. The complex includes a mega-pit; Grasberg and two block cave operations, the IOZ (Intermediate Ore Zone) and the DOZ (Deep Ore Zone) mines. The IOZ mine was brought into production in 1994. The design capacity was 10,000 tpd. Currently, the mine produces 19,000 tpd. The deposit will be exhausted by 2006. The DOZ mine, located 350 m below IOZ, started production in November 2000 at a rate of 2,000 tpd. This rate is to increase to 25,000 tpd by year 2003. A study is underway to determine if an ultimate production of 35,000 tpd is feasible.

Over the past four years, P.T. Freeport, with its partner Rio Tinto, Ltd., have developed the DOZ block cave underground mine. Significant changes to the existing underground mine infrastructure were required for both production and ventilation purposes. The ore deposit is approximately 900 m long, 200 m wide with a maximum draw height of 350 m. On the production level, panel drifts are developed transverse to the ore-body on 30 m center and the draw points on 18 m center. Each panel drift is equipped with a central ore pass to deliver the ore to the truck haulage level and a ventilation raise to direct the return air to the exhaust galleries. On the undercut level, the drill drifts are developed to implement an advanced undercutting system. On the truck haulage level, a combination of chutes and trucks deliver the ore from the muck raises to a 1372 x 1956 mm gyratory cruiser. The discharge from the cruiser falls into an 1800 ton capacity ore bin. The bottom of this is equipped with an apron feeder, which discharges the ore into a 3500 tph conveyor system.

Figure 1. Location of mine in Indonesia

The DOZ ventilation system is designed such that all personnel working in the undercut, panel or truck haulage drifts are in fresh air. To provide sufficient
Airflow for the DOZ mine, new intake and exhaust airways were required. Furthermore, while the DOZ was developed, the IOZ mine was in full production, hence, airflow to this mine needed to be maintained in addition to airflow for the DOZ. Detailed ventilation modelling was performed to determine the optimal ventilation system for the DOZ mine.

In block cave mines control of air to the working areas can be challenging because of the multiple parallel drifts on the extraction (production) level. For the DOZ mine each extraction drift has an exhaust ventilation raise located near the center of the panel. The DOZ ore will be trammed by diesel loaders from the draw points to ore passes and dumped to a truck haulage level. Fifty-ton trucks on the haulage level will transport the ore to a primary underground crusher. After crushing, the ore is conveyed to surface for processing.

Because the orezone dips to the west, the mine is developed with the undercut and extraction levels lower on the western than on the eastern side of the DOZ block. This results in the ventilation system being split between the two sides since the undercut level on the west is nearly the same elevation as the extraction level on the east. Ramps and ventilation raises connect the levels.

Airflow requirements for the DOZ were based on dilution of diesel contamination and minimum velocity concerns in main travelways. To provide airflow to the DOZ mine, three main adits will be used for intake with an exhaust system consisting of a series of 5 to 6 m diameter raises in parallel from the DOZ ventilation level to surface. Five surface fans will be used to exhaust the total quantity of air from the mine. As of January 2001 two 750 kW and one 450 kW fans were operational. Two of the main intake adits have been constructed with development commencing on the third intake.

A total of up to 20 LHD’s could be in operation when the DOZ reaches full production. Three additional extraction drifts were modelled with 16.5 m³/s each to account for development mining (new extraction drifts, ore pass and draw point construction, etc.) and to have sufficient airflow for ancillary equipment such as service trucks, concrete trucks, graders, etc. that will be working on the level.

• Main shop on extraction level is ventilated with 47.2 m³/s.
• Undercut level is ventilated with approximately 70.8 m³/s cfm provided through separate intake and exhaust raises.
• Haulage level is expected to have eight 50 ton trucks in operation. Each truck will require about 23.6 m³/s. This results in an airflow of 189 m³/s with an additional 28.3 m³/s cfm exhausting above the crusher station.
• The primary conveyor drifts were ventilated from an existing portal and exhausted up an exhaust raise to provide a minimum of 35.4 m³/s along each belt way.
• The IOZ mine, which is expected to be in operation for the next six years, is ventilated with air from an internal ramp system and from surface above the orebody. Three 450 kW centrifugal fans are used to ventilate this mine.

Based on the above criteria the total mine airflow to support 25,000 tpd was predicted to be 780 m³/s. This is strictly fresh air and does not include the leakage flow quantity, which amounts to about 25 percent of this total. Figure 2 shows an approximate cross section of the DOZ mine ventilation system.

BASIS OF DESIGN

Airflow to each primary level, undercut, extraction, and haulage was based on providing 0.079 m³/s/kW over diesel equipment and a minimum air velocity of 0.76 m/s in areas where personnel and non-diesel equipment operate. Based on these requirements and the expected equipment fleet, the following airflow rates were computed for the mine:

• Each active extraction panel was ventilated with 16.5 m³/s (sufficient for one LHD in the drift). To accommodate two loaders in the same panel drift, intake air was provided from each end of the panel drift and exhausted through a central ventilation raise.
Figure 2. DOZ mine exhaust system

VENTILATION SYSTEM DETAILS

Raisers from the extraction level provide the intake air to the undercut level. Figure 3 shows the ventilation scheme for the undercut level. On the south side, the return air is directed through raises to the 3186 Level exhaust. On the north side, the return air flows around the perimeter drift to the 3107 ventilation galleries and three exhaust raises.

Figure 4 shows the ventilation system for the extraction level when production reaches 25,000 tpd. This system was designed to ensure that the fresh air is delivered to all areas where diesel equipment is operating. Intake air is provided to both ends of the extraction panel. A booster fan will be required when mining is concentrated on the northeast side of the orebody to deliver the required airflow to the backside (north) of each extraction drift. The return air is directed to ventilation raises located at the center of each panel drift. A regulator on the ventilation raises controls to each panel.

The ventilation level is located between the extraction and truck haulage levels. It consists of two main galleries that are interconnected by small cross cuts and raises that are used as pressure equalizers. The galleries are connected to the 3186 levels by two-6 m diameter ventilation raises. Air from panel and truck haulage drifts exhaust to these galleries. Figure 5 shows the main airways of this level.

The truck haulage level is provided intake air from the DOZ intake drifts and from the main ramps. Air exhausts this level through raises located on the north side of the truck ore pass loading points that will exhaust to the ventilation level. Mine planners have designed the truck haulage ventilation system to not have any ventilation controls where trucks will be operating. Therefore, to provide the airflow to specific loading pockets, small induction fans (small fans mounted on the back) in strategic locations will be necessary. Exhaust air from the truck haulage and extraction level is collected on the ventilation level. Figure 6 shows this level.

The ventilation software package, VnetPC 2000 was used to model the DOZ mine. Field measurements of airflow, differential pressure, and psychrometric conditions were conducted to compute typical friction factors for main airways (drifts, raises and shafts). This data was used to develop a ventilation model of the entire underground mine. Because of the mine elevation (over 3000 m above sea level), the measured friction factors are in the range of 0.005 to 0.0140 kg/m^3 depending on the size of airway and construction method. The model consisted of over 600 branches and provided the predictions necessary to determine the main fan duties of the DOZ mine. The predicted main fan duties when the DOZ mine at its design 25,000 tpd are shown on Table 1.
PRESENT MINE VENTILATION SYSTEM

As of January 2001, two of the three main fresh air adits are in service to the DOZ. The return system to the new fans consists of a series of single raises each of 6 m in diameter. These raises exhaust air from the ventilation level to the 3186 Level then to surface. Two 750 kW and one 450 kW fan are operational. The total airflow to the DOZ is approximately 530 m$^3$/s. This airflow is sufficient to support the caving operation that commenced in November 2000. The current problems with the ventilation system have to do with distribution of the airflow since some of the ventilation raises from the extraction drift and truck haulage drift have yet to be commissioned. Mine planners are also designing for a booster fan installation to be installed on a perimeter drift to provide air to the backside of the extraction level. This fan will ensure that airflow enters the panel drifts from both sides.

Measurements of airway resistances have been performed and used to update a ventilation model of the DOZ mine. Thus far the modelling exercises have been validated by actual field measurements. The DOZ mine is expected to be in full production in 2003. By this time the primary intake and return airways not installed as of January 2001 will be completed and the ventilation system in full operation.

CONSTRUCTION DETAILS AND MAIN FAN INSTALLATION

To supply 1040 m$^3$/s of air the DOZ mine will require five main fans. Figure 7 shows a plan view of the DOZ exhaust system on the 3971 level. It shows the general arrangement of the main fans and their location in relation to the main exhaust drifts and shafts. Each fan is of centrifugal type equipped with self-closing doors and a radial inlet vane controller operated by means of an AUMA actuator.

Fan 11 is a 2.9 m diameter fan that was refurbished and commissioned in 1997. It is used for both the IOZ and DOZ mines. A 450 kW Toshiba motor and a Hansen gearbox drive the fan. This gearbox is used to reduce the motor speed from 1750 to 550 rpm. Fans 12 to 15 are four 3.2 m diameter Howden Sirocco fans. A 750 kW induction motor drives each fan. These fans are installed in parallel arrangement at two exhaust portals. An attachment chamber is used to provide a smooth transition between the drift portal and the fan inlet ducts.

Each fan is equipped with a shaft bearing resistance temperature detectors (RTD’s) and a Schenek 920 fan vibration monitor. The fan duties are monitored by means of Rosemount pressure/quantity flow transducers. The transducer outputs are displayed at the starter cubicle and transmitted via a PLC system to the mine Ore Flow Control room. The data is then processed and displayed on remote screens. Table 2
shows a summary of present fan duties for the three fans presently in operation.

Table 1: Predicted main fan duties determined for the 25,000 tpd case

<table>
<thead>
<tr>
<th>Model</th>
<th>Fan Location with Airway Dimensions and Fan Description</th>
<th>Airflow (m$^3$/s)</th>
<th>Fan Pressure (kPa)</th>
<th>Annual Cost ($/yr)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>(25,000 tpd)</td>
<td>Surface Exhaust Drift 2 - 5.5m x 5.5m portal with two 750 kW fans – each at 217 m$^3$/s (fans 13&amp;15)</td>
<td>435.0</td>
<td>2.64</td>
<td>1,007,500</td>
</tr>
<tr>
<td></td>
<td>Surface Exhaust Drift 1 - 5.5m x 5.5m portal with two 750 kW fans – each at 217 m$^3$/s (fans 12&amp;14)</td>
<td>435.0</td>
<td>2.64</td>
<td>1,007,500</td>
</tr>
<tr>
<td></td>
<td>Surface DOM Exhaust - 4.2m x 3.8 m portal with one 450 kW fan (fan 11)</td>
<td>170.0</td>
<td>1.95</td>
<td>292,800</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>1,040.0</td>
<td></td>
<td>2,307,800</td>
</tr>
</tbody>
</table>

* Assuming a power cost of $0.065/kW hr and a fan/motor efficiency of 70%.

SUMMARY

The DOZ block cave mine at Freeport’s Ertsberg/Grasper Complex is designed for 25,000 tpd. The ventilation system has been developed with the concept of providing fresh air to each main level of the mine. The extraction level is designed to have fresh air enter both sides of the panel. This concept will ensure fresh air to diesel-powered units operating on this level. Single pass ventilation is designed into the system as much as practical. The total mine airflow is predicted to be 1040 m$^3$/s. Five main exhaust fans will deliver this airflow.

The primary infrastructure required to maintain reasonable velocities and fan pressures were three main intake drifts, each over 5.5 m x 5.5 m in cross sections. The returns from the DOZ consist of 5 to 6 m diameter raises from the exhaust level to the surface fans. At present two of the intake adits are installed and one set of the exhaust raises. Three main fans are currently in operation and delivering a total flow quantity of 632.9 m$^3$/s to the mine.

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REFERENCES
