

ist System Upgrade at

EIT.

Abstract: Highland Valley Copper is located about 90 km south of Kamloops, British Columbia, Canada. It is owned and operated by a Canadian mining company, Teck-Cominco Ltd. The company operates a large open pit mine and one of the world's largest copper concentrators. The operation mines and processes 130,000 mtpd of copper and molybdenum bearing ore and produces concentrates containing roughly a million pounds per day of copper and up to 27000 pounds of molybdenum per day.

The ore goes through several stages of crushing and grinding on its way to the flotation plant. Upgraded concentrate from the bulk flotation process feeds the copper-molybdenum separation flotation circuit.

Finely ground ore flows through a series of flotation equipment: first through two banks of molybdenum flotation cells, which separate it into a bulk molybdenum concentrate and a copper concentrate, also known as molybdenum plant tailings.. The molybdenum plant tailings is final copper concentrate that is dried and sold. The bulk molybdenum concentrate proceeds through three further stages of flotation to achieve the desired molybdenum concentrate grade.

The primary reagent (sodium hydrosulphide) used for copper-molybdenum mineral separation reacts with the concentrate to reduce the tendency of the copper minerals to float. Molybdenum minerals are not affected by the reagent and still float. Some of the reagent reacts with other molecules in the slurry, water containing solid particles, to generate hydrogen sulphide (H₂S) gas. In order to maintain a froth on the surface of the slurry so that minerals can be collected, a gas is forced into the slurry through the agitators in the flotation cells.

The molybdenum flotation cells were covered and connected to an exhaust system when two older mills were merged, in 1986. A wet scrubber and tall discharge stack disposed of the exhausted gases. In 2004 the plant operators became concerned about H₂S odour that occasionally escaped from the flotation cells and regularly escaped from the molybdenum tailings stream on its way from the cells to the dewatering circuit. Ore flowing through a regrind mill was also releasing H₂S into the plant. Measurement of the H₂S concentration in these areas confirmed that it would be prudent to upgrade the exhaust ventilation.

A new monitoring and maintenance strategy, a new enclosure and replacement of 3 ducts with larger diameter ducts have eliminated detectable releases of H₂S into the mill building.

This report describes the investigation and design process that lead to the changes, and the successful modifications to the system.

Introduction

Comment [KJ1]: It was actually the pipefitters (under maintenance crew) who were the primary complainants. I suppose for the purpose of this paper it does not make a significant difference. However, it may be important to know that the concentrations were not problematic in the areas where the actual operators frequented. (where the sensors are placed). The exception being opening the trash screen which released high concentrations of gases. The pipefitters often were working in areas that were remote and not all that close to the sensors. This is why it took us so long to realize the severity of the problem: our continuous monitoring was not picking up the pockets where the maintenance crew was working.

Significant volumes of solid material often settle in ducts. Significant volume may be accumulated in the cross section of a duct by 10%, change the air flow by 10% or more, or compromise another component of the system so as to reduce flow by 10% or more.

For a system to consistently meet its objectives for worker protection or process support, obstructions in ducts should be found and removed before they compromise health or production.

The nature and quantity of the solids will influence the frequency of cleaning required in a well designed system. Where the contaminant and air flowing through a system are always dry, and particle size does not exceed 5% of duct diameter, material may never accumulate in the ducts. If the solid contaminant is paint or glue spray - e.g. wet paint droplets accumulation of material is inevitable. A well designed system that conveys dust from woodworking machines will haul tons of solids to the waste bin without allowing material to obstruct ducts. That system will maintain an adequate transport velocity in every duct that is handling the solid material.

Comment [KJ2]: In the case of Highland Valley's process, the solids accumulating in the ductwork were from froth, very fine particles (<50 microns) with water, collected off the froth on top of the flotation cells.

A well designed paint booth and exhaust system will provide adequate air flow for several months before the fan and ducts need cleaning. The paint arresting filters may need to be replaced every day. The paint booth exhaust duct will be designed for a relatively low velocity so that a few millimeters of solids buildup in a duct will not compromise the air flow. The fan will be selected for its ability to operate with an accumulation of solids on the blades and housing, and being easy to clean.

Between these extremes are systems where the rates at which material will enter and accumulate are difficult to predict. Solids may stick to the duct walls, or flow through.

Ducts may also become obstructed because the nature or quantity of material being transported changed. One long stick in the exhaust duct for a table saw may lead to the duct becoming blocked at an elbow or junction.

The System Described

The system to be described in this report exhausts nitrogen and hydrogen sulphide gases from mineral processing flotation cells. A flotation cell is a reactor in which the three phases: solid, liquid, and gas, interact to separate valuable minerals that contain saleable metals, and waste minerals called gangue. In the case of mineral flotation, the solid is the ground rock particles, the liquid is water, and the gas is usually air. A small amount of a chemical, called a collector, is added to the slurry mixture of solids and water to alter the surface chemistry of the metal bearing minerals such that the valuable minerals are more hydrophobic, "water-fearing", which means they like to escape the water and float to the surface. One end of the reagent molecule chain attaches to the surface of valuable mineral particles, and the other end will attach to a bubble and the particle will float to the surface with the bubble and be collected in the froth that forms on top of the flotation cell. An agitator in the flotation cell is used to force the air into the slurry creating the bubbles and mixing the three phases. The froth that collects on the surface of the slurry flows over the side of the flotation cell and gets collected in a launder. This froth contains a much higher

feed stream to the flotation cells so is called a
float are called tailings.
flotation cells have produced a flotation
molybdenum minerals. If this concentrate were
sold to a smelter, the mine would not be paid for the molybdenum in the concentrate and
may actually be fined because it is much more difficult to separate the copper and
molybdenum metals than it is to separate the minerals. For this reason the bulk flotation
concentrate is further treated in the Copper-Molybdenum separation stage which also
uses flotation.

In the Copper-Molybdenum separation circuit, known as the Moly plant for short,
another chemical is added to the slurry, now a water and concentrate mixture, that
selectively modifies the surface chemistry of the copper minerals so they are now
hydrophilic, water-loving, and will not float as easily. The molybdenum minerals are
naturally more hydrophobic than the copper minerals and remain hydrophobic. In this
way, the molybdenum minerals float while the copper minerals do not.

Nitrogen is forced into the flotation cells to recover the moly minerals into the
froth where they can be collected. When bubbles in the froth burst, droplets of water
containing solid particles can become airborne. Those droplets enter the exhaust system,
and stick to the duct walls. The water mostly evaporates, leaving behind a hard coating
of solids. The solids accumulate in the ducts and restrict the flow of the exhaust gas,
thereby reducing the efficiency of exhaust collection.

Comment [KJ3]: Air is used in
flotation cells other than in the copper-
molybdenum separation stage because it
is cheaper, but can not be used in copper-
molybdenum separation because oxygen
consumes the primary, and most
expensive, reagent used for the
separation.

Hydrogen Sulphide is formed as a result of a byproduct reaction between the
reagent used to modify the surface chemistry of copper minerals and a pH modifying
agent added during flotation. The Hydrogen Sulphide can exist in aqueous form within
the slurry, or can take a gaseous form and be released into the surrounding air.

The exhaust system was originally designed to exhaust Hydrogen Sulphide gas from the
three conventional flotation banks. The system has since been modified to exhaust gases
from other equipment in the Moly plant. These secondary sources included the other
stages of flotation and some slurry storage areas.

The owners of the mine ran a regular monitoring program that often detected hydrogen
sulphide gas around the flotation cells and other equipment. Ducts serving the flotation
cells were inspected or cleaned when H₂S was detected around the cells. The causes of
emissions from the other equipment were less clear, and the ducts were not cleaned
regularly.

The objective of the initial investigation was to understand the system operation and
recommend changes that would reduce concentrations of H₂S in the plant, ideally to the
point where the odour was not detectable, generally considered below 0.1 ppm.

Comment [KJ4]: Check sources for
this one.

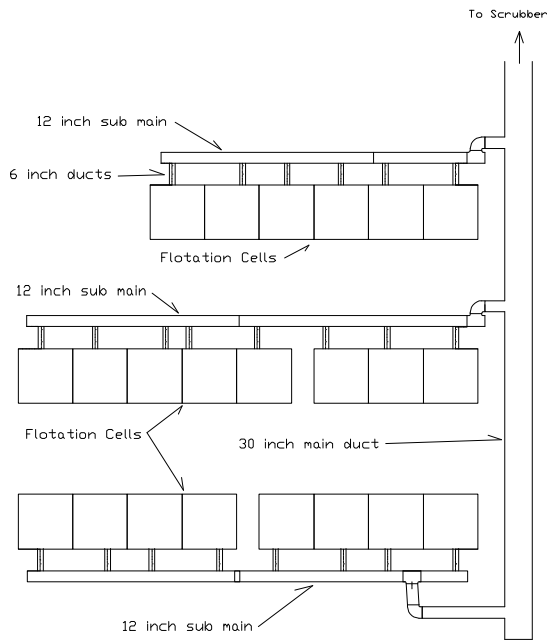
Background

The mill was expanded in 1989 when the site and connected to the original.

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The ventilation system serving the flotation cells in was installed in 1986. Some changes were made in the following years. The system in place in January 2005, (and for some years before) is shown in Figure 1. The duct sizing and fittings selections are quite different from the recommended practice set out in the ACGIH Ventilation Manual. Conventional duct sizing would result in small changes in velocity as air flows through branch and main ducts. Velocities in this system will decrease by 75% as the air moves from branch to main duct in some places, and may increase by 75% where other branches enter a main duct. Given that this system consistently meets the objective of controlling the gas emissions from the flotation cells and is easier to clean than a conventional system, it is a very satisfactory design. If it were intended to transport solids it would be unlikely to succeed.

Figure 1, Exhaust Ducts for Flotation Cells



Plant maintenance personnel had learned that solids from the cells often plugged the 12 inch header duct that serves each bank of cells. The duct system from the cells to the main duct was fabricated from mechanical joint pipe, each fitting or length of pipe connected to its neighbours with a bolted clamp enclosing a rubber gasket. These ducts have the distinct advantage of being easier than most ducts to take apart, clean and re-assemble. Portable H₂S monitors were used to measure the gas concentration in all areas

from the monitors and odour complaints
ducts serving a bank of floatation cells.
eight inch diameter ducts serving the other H₂S
found in the regrind area, two levels below the
floatation cells.

The Investigation

The ventilation system drawings were reviewed by a specialist engineer, who then toured the process with the process metallurgist. The metallurgist pointed out a large open box, called the 125 foot thickener feed box, which collected slurry from several sources. It was in a busy area, and a source of H₂S emissions. At the Regrind Mill and Trash Screen a lack of face velocity at enclosure openings indicated very low flow through the ducts. The next step was to measure pressure and air velocity at all key points in the exhaust system. Those measurements demonstrated that several ducts to secondary sources were completely blocked. One of the floatation cell headers had no significant flow obstruction, one was partially obstructed about half way long its length, with no serious impact on its total flow, the third had about 60% lower air flow than the first two. There was a major obstruction in the third 12 inch header, near the main header.

The main duct, wet scrubber and fan were found to have adequate capacity to handle all the identified sources of H₂S and nitrogen.

Recommendations

The specialist engineer suggested that several steps be taken:

1. Cover the 125 box as much as process needs would allow
2. Assess the air flow required to control emissions from the covered 125 foot thickener feed box by connecting two 600 cfm portable fans in parallel, with ducts discharging out the wall of the building.
3. Design a new duct to connect the 125 foot thickener feed box to the main header of the scrubber system
4. Design and install larger diameter ducts to connect the other secondary sources
5. Institute a routine program of pressure and velocity monitoring for the exhaust ducts, and a cleaning program guided by the monitoring results.

Implementation

The design and installation of the 125 foot thickener feed box cover and portable fans was completed in a few weeks. Checks for H₂S emissions around the 125 foot thickener feed box found none, and tracer smoke evaluation confirmed an obvious inflow at openings to the 125 foot thickener feed box. Measurements of flow through the portable fans led to a prescription for an exhaust air flow of 900 cfm with clean ducts, and cleaning of the duct when flow drops to 650 cfm. Within a few weeks of the temporary system evaluation an eight inch diameter duct was installed from the 125 foot thickener feed box to the header, and the portable fans were removed.

connected boxes were packed out of the flotation cell headers with process water, restoring full flows.

Results

Velocity and static pressure measurements were taken in the ducts near each source e.g. in the 12 inch header for each bank of flotation cells, near the 125 foot thickener feed box, near the Moly Regind mills, at the Trash Screen and Moly Tails Collection Box. Measurements taken just after the system was modified indicated some ducts were clean and providing the expected air flows while others were partly obstructed. H₂S concentrations were all less than 1 ppm.

Eight months later measurements indicated the flow in 12 inch ducts from the flotation cells had dropped relative to the flow measured in a clean duct and that cleaning was required. The rate of change in flows over the eight months was very different from one cell bank to another.

Flows in several of the new ducts were also found to have decreased substantially over a period of 8 months. It appears that certain portions of many of the ducts in this system will need cleaning at least yearly or when required based upon the air flow data. Static pressure readings will pinpoint the lengths of duct that need to be cleaned.

After eight months, monthly H₂S surveys were finding concentrations were still below 1 ppm in all areas, indicating the system has considerable reserve capacity. H₂S odour was detected when process upsets resulted in spills of slurry.

Conclusions:

The system that was installed in 1986 to control gas emissions from the flotation cells was, despite its unconventional appearance, efficient to operate and maintain. The cell covers are a key component. The scrubber and fan had valuable reserve capacity. Subsequent additions to the system suffered from use of undersized (4 inch) ducts and a lack of enclosure at the 125 foot thickener feed box. These problems were quickly and efficiently rectified.

Routine measurement of velocities in the cell line headers had guided maintenance for some time. Adding static pressure measurements provides additional information that should reduce cleaning costs.