TENTATIVE PLAN
FOR VENTILATING THE HOMESTAKE SCIENCE LAB
PHASE I AND PHASE II
(DRAFT)

by
John R. Marks, P.E.
May 1, 2007

INTRODUCTION AND GENERAL VENTILATION DESIGN PRINCIPLES

Ventilation design for the Lab covers two phases; Phase I for the first five years, and then, depending on the NSF down-select, Phase II from five years to close-out.

General design principles were taken from standard deep metal mine ventilation practice. All work areas must conform with MSHA regulations involving toxic (CO, NO_x, SO_x, radon), dangerous (CH_4) and asphyxiating (CO_2, N_2) gases. Development headings must be cleared of blasting fumes within about an hour's time. Diesel equipment must be provided with enough airflow to conform to MSHA approval plates. If the vehicle does not have an approval plate, airflow should equal or surpass 125 cfm per rated brake horsepower. Dust from blasting, mucking or skipping operations should be handled in accordance with standard practices regarding wetting down, sprays at dump points, and placing dust-generating operations downstream of other operations whenever possible.

In addition to standard metal mine ventilation practices, particular care will be afforded to meet specifications provided by the scientists. Temperature and humidity will be controlled at chamber entrances. All chambers will be on their own parallel air split so that any troubles within the chamber (fire, release of gas) will be vented straight to exhaust. Monitoring will be provided as necessary.

PHASE I

Phase I covers the first five years. Mine entry will be achieved when the Ross hoists and shaft are refurbished, levels checked from the tramway to the 5000 level, and the pumping system re-commissioned. By the time these tasks are completed, the NSF should have decided which competitive site has been selected. If Homestake is selected, the Yates hoists and shaft will be refurbished to serve as secondary exit to the 4850 level, and ultimately as access for the scientists. Waste rock will be skipped at the Ross.

Ventilation of Phase I will be straightforward. The airflow selected is 120,000 cubic feet of air per minute (cfm). Intake air will flow down the Ross and Yates (the split depending on use), collect on 4850, and cross through the 8' x 9' drift to the Winze 4 station area. It will then flow down to the 5000 level where it will enter No. 5 Shaft. No. 5 Shaft is a 5000-ft deep, 17' circular concrete shaft with air, pipe, manway and cage compartments. Located on top of No. 5 Shaft will be two exhausting fans with the following specifications:

Spendrup Series 125-70-1760 Axial Fans (49.25" – 27.5" – 1760 rpm)
150/160 horsepower motor, 480V/60 Hz/3 Ph, 1.15 SF, 174/83 Amps
Weight 3800 lb; dimensions on Spendrup dwg. Data 125-70.

The fans have been used previously for about five months at Kennecott's Bingham pit for sinking shaft. They are in "like-new" condition. Expected fan duty (120,000 cfm total @ 12.5" total pressure) was outlined in a 01/06/07 memo, "Thoughts on Ventilation and Pumping Systems for the Science Lab". Circuit resistance was estimated at 8.28×10^{-10} in Atkinson's units, and the fan pressure required for 120,000 cfm was 11.9" static. The Spendrup fans together can achieve this operating point at a 4.5 blade setting. Power will be close to 150-hp each. The following equation was used as a quick check on the horsepower:

$$\text{Hp} = \frac{(\text{air quantity, cfm})(\text{total fan pressure, "WG})}{(33{,}000\ \text{ft-lb}_f/\text{min/hp}/5.2\ \text{psf/"WG})(0.80\ \text{effic.})}$$

$$= \frac{(120{,}000)(12.5)}{(6346)(0.80)} = 295\ \text{hp total.}\ \ (147\ \text{hp per fan})$$

After re-entry is achieved, the levels inspected and the pumps started, the Yates can then go through the same process as the Ross. This will probably occur two years after initial re-entry, depending on the NSF down-select. Thought can be given to developing science chambers between the Yates and Ross. The mining machinery needed has been considered but not yet confirmed. Tentatively, two diesel 3.5-yd LHDs with 200-hp engines, with 30-gage battery loco rail haulage of waste rock to the Ross, are envisioned. Other equipment will include a drill jumbo, bolter, shotcrete machine, and miscellaneous utility vehicles. Work headings will be cycled to fully utilize the equipment. After the first chamber nearest to the Yates is excavated, supported and equipped (concrete, electrics, etc.), the scientists can start moving in their experimental apparatus.

When the 4850 level is reached, a crew should be sent to the Winze 4 station to open up the 5 Shaft connection. Then, if the rising water level reaches the 5000 level, exhaust air can still enter 5 Shaft on 4850.

The 120,000 cfm should suffice for ventilating the mining equipment mentioned above. A 3.5-yd diesel LHD requires up to 25,000 cfm. Auxiliary fans will be required to blow at least 25,000 cfm into each heading, assuming that three headings will be worked simultaneously. Probably 100,000 cfm will be directed down the Yates at this time, with 20,000 cfm flowing down the Ross to ventilate pumprooms and skip pockets.

There is a chance that Phase I may continue for much longer than five years even if Homestake does not receive the NSF down-select. With 84 letters of interest from the scientific community, there may be enough work to operate two science labs in the U.S. If that is the case, the 5 Shaft fans should adequately ventilate the 4850 level to the end.

The Spontaneous Combustion Problem

Spontaneous combustion fire potential is a potential problem with this plan. It is absolutely imperative that this potential not be allowed to put mine crews at risk. While the mine was in production, the Ellison Exhaust system protected the Yates and Ross intakes from receiving air from the No. 2 Airshaft area. This was intake air flowing in parallel with the Yates and Ross. Now, with the Kirk Fans idle, rouge intake air from the Open Cut and No. 2 Shaft areas would want to enter the Yates and Ross in order to get to the exhaust fans on top of No. 5 Shaft. It is imperative to prevent this. Air from the north end of the mine might conceivably become contaminated with spon-com fire by-products. All station doors at the Yates and Ross must be constructed as airtight as practically possible. This problem is especially relevant from the surface to the Ross pillar area.

Below the Ross pillar area, spontaneous combustion potential has been greatly reduced by back-filling Main ledge from the 2750 level to the 5000 level, where most all such fires have occurred. It is unclear what the spon-com potential remains in 7/9 Ledges. However, if a spon-com fire breaks out below the Pillar area, fire by-products should migrate toward Winze 4 through old workings and raises. The Ross and Yates must still be protected. After the 5 Shaft fans are operating and access has been gained to these levels, airflow directions will be noted and corrected if they pose a problem. It should prove relatively straight-forward to analyze airflow patterns during level inspections.

PHASE II

Ventilation

Phase II covers the Science Lab from the 5-year point to the end of the life of the Lab. The lower mine levels will be pumped out, and experiments placed on 7400 and elsewhere. During the first five years of Phase I, work steps must be completed in preparation for Phase II. The total airflow recommended by Dynatech is about 330,000 to 350,000 cfm. This amount is almost three times the Phase I airflow. I agree with this airflow quantity. The original 120,000 cfm will still be needed to ventilate the 4850 Lab. The remainder, 230,000 cfm, will be sent down 6 Winze. Historically, during mine production, about 190,000 to 220,000 cfm was sent down 6 Winze. So, 6 Winze will be near the maximum it can carry without excessive velocity and pressure drop.

The intake circuit will consist of both the Yates and Ross to the 4850/5000 levels. Below 5000, it is proposed to use both 6 Winze and a new parallel 8-ft diameter (?) borehole for intake to the 8000 level. The new borehole would be equipped for secondary escape. The two other alternatives for secondary escape, the ramp system and Winze 4, both have serious problems. Assuming that the ramp system covers about 1000 feet slope distance between levels, the boss buggy ride from 8000 to 4850 would be 21,000 feet. Refurbishment and maintenance would be a very costly headache. Getting to the ramp system on the deeper levels would require traversing half the level. The 7250, 7550, and 7850 levels do not connect directly with 6 Winze.

Maintaining Winze 4 for secondary escape has its own serious problems. Although access is good on the 6950 and 7400 levels, the distance is great (1½ miles?). Below 7400, the ramp system near 31 Exhaust would have to be used to get to 7400. Winze 4 hoist and shaft would have to be refurbished and maintained, and a hoistman ready for callout at all hours.

A new secondary escape borehole could be located at the optimum position for lab use. It could be equipped with either a small single-drum cage, or an Alimak raise climber. It would help 6 Winze handle the projected 230,000 cfm.

Presently, the Oro Hondo exhaust system is recommended for the Lab. The Oro Hondo shaft effectively connects the surface to the 3950 level. It is roughly 16' diameter. During mine operation, it handled 520,000 cfm at the top. Below 3950, the 31 Exhaust system would be used. The offset raises are for the most part 16' rough-blasted diameter. It has never given us much problem, except for the section that ran through the 19L mining area from 5900 to 6800. This was replaced by a 13' diameter borehole, which has performed admirably. The biggest potential problem for the exhaust system is the cave-in potential of the Oro Hondo shaft. Mucking fall rock takes place on the 4100 level. When the mine was active, fall rock was mucked about every other year and taken to some old stope for disposal. It the future, this rock will have to be hoisted at the Ross. Recent pressure measurements by Dan Regan indicate that the connection between the Oro Hondo Shaft and the 3950 level is plugged (no apparent flow, and zero pressure on the surface isolation doors). During Phase I, it may be worth considering rehabbing the Oro Hondo Shaft. It would be bolted and shotcreted for its entire length.

The Oro Hondo fan is an American-Davidson centrifugal fan, 12' diameter impeller, with backward-curved airfoil blades. The driver is a variable-speed-controlled 3000-hp synchronous motor. It has been an outstanding performer ever since its installation in 1986. It is backed up by a Jeffrey 8HU-84 2-stage axial fan with 1250-hp induction motor.

If the Oro Hondo Shaft is not judged reliable enough due to cave-in potential, thought should be given to moving the Oro Hondo fan to the top of 5 Shaft. In the meantime, the two Spendrup fans can serve as back-up in case something happens to the Oro Hondo system.

Air Conditioning and Refrigeration

Air conditioning is defined here as treating the air in the work environment (cooling and dust/contaminant removal) for the comfort, safety and health of the human occupants. Refrigeration, as used here, is an industrial process for cooling fluids or objects that are part of a scientific experiment.

Heat issues from wallrock, broken rock, hot fissure water, mining equipment, and scientific apparatus. This heat must be removed at a rate high enough so that the work environment temperature does not exceed design standards. The Homestake mine is very experienced in heat removal methods. Chilling service water, spot-coolers with DX coils, district chillers with closed loops of water coils, spray coolers with various capacities, and large bulk air coolers with heat rejection towers have all been employed. About the only mine cooling technique not used by Homestake is ice, either chunk or slurry. Heat can be removed via one of two methods: pump it out in the water, or draw it out in the exhaust air. In both cases, air and water are sent into the mine at a low enthalpy state and removed with a high one.

No air conditioning will be needed to develop Phase I. Intake air flowing from the bottom of the Yates typically has a wet-bulb temperature ranging in the low to mid 60's. As for refrigeration, it is not known at this time what scientific experiments may require cooler-than-ambient fluids or processes.

For Phase II development, a total of six 30-ton spot-coolers will be needed for 7400 level and deeper (three for 7400 development, one for 8000 drilling, and two in the maintenance cycle). For chamber air conditioning, air should be cooled at the chamber entrance to the specifications of the scientists. These units can be of various capacity with water-cooled condensers (heat rejection to the sump system), or air-cooled condensers, and be located on the exhaust side of the chamber. Cooled, filtered air from the evaporator would be ducted to where needed. If heat rejection is high enough, packaged cooling towers could be placed at the exhaust collection point downstream of the chambers on each level. A wide variety of commercial air-conditioning units are available to choose from.

Homestake's water system is designed to handle most any heat load. The 6 Winze and Ross pumps can discharge up to 1700 gpm. The surface water supply system in the past has provided up to 1100 gpm of fresh water, of which about 900 gpm were used solely for air conditioning.

For dust control, HEPA-style filters can be used in conjunction with the air conditioning. Steps will be taken at the Yates to ensure that low-radon air is drawn into the mine. Details will be worked out when requirements are more clearly defined.

Homestake's virgin rock temperature on the 7400 level (126°) might be higher than other sites, but the depth, 7400 feet below the surface, is unmatched. For the same rock shielding, other sites would be looking at similar depths. If some scientific experiment such as the mega-chamber requires more than, say 2000 tons of refrigeration, all sites would currently be hard-pressed to supply it. Homestake once had a 2300 ton plant on the 6950 level, but it is now under 1800 feet of water.

CONCLUSION

The Homestake site once operated a ventilation system which provided 860,000 cfm of fresh air. The air-conditioning system once had a nameplate capacity of over 4000 tons of refrigeration. From a ventilation standpoint, Homestake is well-positioned to become the nation’s underground science lab.