CRWMS/M&O

Non-Q Design Analysis Cover Sheet

Complete only applicable items.

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*Complete only applicable items.***2. DESIGN ANALYSIS TITLE****CROSS DRIFT ALCOVE/NICHE UTILITIES ANALYSIS****3. DOCUMENT IDENTIFIER (Including Rev. No.)**

BABFA0000-01717-0200-00003, REV 01

4. Revision No.**5. Description of Revision**

01	Revised analysis to redesign alcove ventilation system from an exhausting system integral with the Cross Drift ventilation duct to an independent exhausting system that reuses air from the Cross Drift.
00	Initial issue

1. PURPOSE

The purpose of this analysis is to provide the design basis and general arrangement requirements of the non-potable water, waste water, compressed air and ventilation (post excavation) utilities required in support of the Cross Drift alcoves and niches.

This analysis does not support any level-3 deliverables, level-4 milestones, and supporting work products. It is not a part of or prepared in support of the Site Recommendation, Environmental Impact Statement (EIS), or Mined Geologic Repository (MGR) License Application or cited as a reference in the Site ecommendation, (EIS), or License Application.

2. QUALITY ASSURANCE (QA)

No QA controls are applicable to the designed system items addressed in this design analysis. Determination of Importance Evaluation (DIE) controls apply to items and activities concerning water use and other activities associated with construction in theEnhanced Characterization of the repository Block (ECRB) Cross Drift. These controls are addressed in the Cross Drift Subsurface General Construction Specification (Ref 5.17). The items addressed in this analysis are temporary and therefore have not been classified in accordance with QAP-2-3. There are no DIE controls associated with the actual utility design covered in this analysis (Determination of Importance Evaluation for the ESF Enhanced Characterization of the Repository Block Cross Drift) (Ref 5.4). A QAP-2-0 evaluation has also been completed (Ref 5.7) and also has determined that no controls are applicable to this analysis. Thus, this analysis is not subject to QA controls in accordance with NLP-3-18.

3. METHOD

The method used in this analysis to design the various utility items was to first determine the design requirements and criteria for each item. Water, compressed air and waste water bull hoses were sized based on the testing and construction equipment requirements in each alcove/niche.. The ventilation system design parameters were based on previously established system requirements and new considerations for the radon gas levels encountered in the Cross Drift. The velocity pressure method was used in determination of duct and fan size required for ventilation system of the alcoves and niches.

4. DESIGN INPUTS

4.1 DESIGN PARAMETERS

- 4.1.1** The roadheader Voist-Alpine AM 75 mechanical miner, Tamrock H205 DB drill jumbo, Atlas Copco H226 Drill Jumbo and Gardner-Denver hand drill use a 1-inch diameter water supply bull hose for dust suppression system (Ref 5.2)

- 4.1.2 100 psi @ 300 cfm drilling air requirement to be provided for flushing boreholes and operation of ancillary equipment (Ref 5.6, Ref 5.11)
- 4.1.3 Maximum excavation cross-section dimension will be $6\text{ m} \times 5\text{ m} = 30\text{ m}^2$, maximum alcove/niche length = 30 m (Ref 5.3)
- 4.1.4 Roadheader water use rate while excavating = 8 gpm (Ref 5.16, p. 7)
- 4.1.5 Water supply inlet pipe diameter for Alpine Miner = 1 inch (Ref 5.2, p. 7)
- 4.1.6 Water supply inlet pipe diameter for drill jumbo = 1 inch (Ref 5.2, p. 7)
- 4.1.7 Highest point in Cross Drift is located at Station 24+67 having a design water pressure of 50 psi at this point (Ref 5.5, p. 25)
- 4.1.8 Cross Over alcove located at approximately Station 7+72 (Ref 5.3, p. 2; Ref 5.21, Attach I, p. 8)
- 4.1.9 The horizontal distance between Station 24+67 and the approximate Cross Over Alcove location of 7+72 = 5561 ft (Ref 5.21, Attach I, p. 8)
- 4.1.10 Correction factor for temperature and elevation used for friction loss in duct $K_t = .96$ (Ref 5.15, Appendix 2) and $K_e = .89$ (Ref 5.15, Appendix 3)
- 4.1.11 Friction factor for new steel pipe = .18 (Ref 5.10, p.3)
- 4.1.12 Compressed air header designed to deliver 115 psig at terminal end of Cross Drift (Ref 5.5)
- 4.1.13 Maximum alcove/niche length = 98 ft (Ref 5.3)
- 4.1.14 Difference in elevation between Cross Drift Station 24+67 and terminal end of drift = 35 ft (Ref 5.21, Attach I, p. 8)
- 4.1.15 Minimum air velocity in underground drifts is 30 fpm (Ref 4.4.1)
- 4.1.16 Air velocity required in underground drifts for dusty conditions is 100 fpm (Ref 5.18, p. 5)
- 4.1.17 Approximate elevation above sea-level of ESF 3500 ft (Ref 5.5, p. 5)
- 4.1.18 Loss coefficient for abrupt pipe intake = 0.5 (Ref 5.15, page 36)
- 4.1.19 1 psi per 2.31 ft of water (Ref 5.20)

4.1.20 Elevation difference between highest and lowest point in Cross Drift = 20 m $\cong$ 65 ft (Ref 5.21, Attach I, p. 8)

4.1.21 Split set plate hanger rating = 1 ton = 2000 lbs (Ref 5.8)

4.2 CRITERIA

The following design criteria, which are applicable to this analysis, were developed in response to requirements from the Enhanced Characterization of the Repository Block Requirements Document (ECRB-RD) (Ref 5.1) and Test Coordination Office Criteria Letter (Ref 5.3)

4.2.1 ECRB-RD Requirements

4.2.1.1 The ECRB utilities hangers and supports will be selected to consider the seismic loading applicable to the ESF. That seismic criteria, after adjustment for underground dampening, is 0.30 g horizontal and vertical acceleration. This issue is addressed in Sections 7.4.1

4.2.1.2 The ECRB utility systems will be designed to suitably operate in a temperature range between 50° F (10 C) and 80° F (21 C), which bounds the ECRB-RD requirement. This issue is addressed in Section 7.4.2

4.2.1.3 The ECRB utilities will be insensitive to relative humidity within the range of 13% to 71%. This issue is addressed in Section 7.4.2

4.2.1.4 The ECRB utilities should have a maintainable life of 25 years. All utilities will be accessible for maintenance or replacement. This issue is addressed in Section 7.1, 7.2, 7.3 and 7.4.2

4.2.1.5 The ECRB wastewater system shall incorporate appropriate gravity/pumping systems for draining water away from testing and other work areas to suitable collection points. This issue is addressed in Sections 7.3

4.2.1.6 To the extent practical the ECRB utilities will be designed to be removable after completion of their intended use. This issue is addressed in Sections 7.1, 7.2, 7.3 and 7.4.2

4.2.1.7 The ECRB utility systems will support the testing utility requirements listed in Section B.2.3 of Appendix B of the ESFDR Document, YMP/CM-0019, Revision 2, ICN 01, (Ref 5.24) and construction utility requirements. This issue is addressed in Sections 7.1, 7.2, 7.3 and 7.4.2

4.2.2 TCO Criteria Letter

4.2.2.1 Minimum OSHA ventilation requirements, with ability to close ventilation behind alcove/niche bulkheads

4.2.2.2 One construction water tee outlet and three compressed air tee outlets near each alcove and niche

4.3 ASSUMPTIONS

4.3.1 The wastewater system flow will be equal to the non-potable water supply flow volume (at 0 psig residual pressure), (Ref 5.5). This is a conservative assumption because the ESF is dry, therefore waste water will handle all in-flows of water.

4.3.2 The difference in friction factor for bull hose vs. steel pipe is negligible for the length of bull hose used. This is conservative since bull hose section friction loss is a small or negligible amount due to the short length of hose.

4.3.3 Compressed air reaches an ambient temperature of 80° F prior to reaching alcove and niche locations. This is conservative because of the length of compressed air delivery pipe.

4.4 CODES AND STANDARDS

4.4.1 29 CFR, Part 1926.800, Safety and Health Regulations for Construction (OSHA)

5. REFERENCES

5.1 CRWMS M&O 1996. *Enhanced Characterization of the Repository Block Requirements Document (ECRB-RD)*. BAB000000-01717-5705-00013, REV 01. Las Vegas, Nevada: M&O. ACC: MOL.19980417.0713

5.2 CRWMS M&O 1999. Interoffice Correspondence, S.W. Goodin to File, LV.TFD.SWG.06/99-058, June 2, 1999, *E-Mails Used in the Utilities Analysis*. Attachment 1, ACC: MOL.19990602.0205.

5.3 CRWMS M&O 1999. *Revised Design Input transmittal of Design and Test- Related Information for Design and Construction of the Enhanced Characterization of the Repository Block Cross Over Alcove #8, and Niches #5 and #6*. TFDNEP-99157.T, Las Vegas, Nevada: M&O. ACC: MOL.19990330.0431

- 5.4 CRWMS M&O 1998. *Determination of Importance Evaluation for the ESF Enhanced Characterization of the Repository Block Cross Drift*, BABEAF000-01717-2200-00011, REV 03. pp. 102-111. Las Vegas, Nevada: CWRMS M&O. ACC: MOL. 19981016.0055
- 5.5 CRWMS M&O 1998. *Enhanced Characterization of the Repository Block, East-West Drift Utilities Design Analysis*, BABFA0000-01717-0200-00002 REV 00, Las Vegas, Nevada: CRWMS M&O. ACC: MOL. 19980325.0020
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- 5.7 CRWMS M&O 1997. Activity Evaluation, *12666055MC ECRB Cross Drift Design*. Las Vegas, Nevada: CRWMS M&O. ACC: MOL. 19990316.0181
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- 5.10 Flow of Fluids through Valves, Fittings, and Pipe, Technical Paper No. 410, 1982, Crane Company. TIC. # 237812
- 5.11 CRWMS M&O 1999. Interoffice Correspondence, S.W. Goodin to File, LV.TFD.SWG.06/99-059, June 2, 1999, *Clarification of Compressed Air Requirements for Drilling Equipment*. CRWMS-M&O. ACC: MOL. 19990603.0191
- 5.12 CRWMS M&O 1997. *Test, Inspection and Material Dedication Analysis: Shotcrete, Rockbolts and Accessories*, BABEE0000-01717-0200-00006 REV 01, p.34. Las Vegas, Nevada: CRWMS M&O. ACC: MOL. 19971006.0362
- 5.13 CRWMS M&O 1998. *ECRB Cross Drift Structural Design- Ventilation Duct Loads/ Lagging Material*, BABEE0000-01717-0210-00001 REV 00. p.3 of 6. Las Vegas, Nevada: CRWMS M&O. ACC: MOL. 19980410.0595
- 5.14 CRWMS M&O 1997. *Exploratory Studies Facility (ESF) Ventilation System Plan Including the Repository Block (ECRB) Cross Drift*, BABFAD000-01717-4600-00001 REV 00, ACC: MOL. 19980202.0299
- 5.15 United McGill Corporation, *Engineering Design Reference Manual for Supply Air Handling Systems*, 1993.

- 5.16 CRWMS M&O 1999. Interoffice Correspondence, S.W. Goodin to File, LV.TFD.SWG.06/99-058, June 2, 1999, *E-Mails Used in the Utilities Analysis*. Attachment 2, ACC: MOL.19990602.0205.
- 5.17 CRWMS M&O 1998. *Cross Drift Subsurface General Construction Specification*, BABEAF000-01717-6300-01502, REV 00, Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980409.0679
- 5.18 CRWMS M&O 1997. *ESF Flow-Through Ventilation Analysis*, BABFAD000-01717-0200-00006, REV 01, p. 9, Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19971208.0206
- 5.19 CRWMS M&O 1999. Interoffice Correspondence, S.W. Goodin to File, LV.TFD.SWG.04/99-044, April 22, 1999. ACC: MOL.19990415.0128 and ACC: MOL.19990429.0229
- 5.20 Heald, C.C. 1998. *Cameron Hydraulic Data a Handy Reference on the Subject of Hydraulics and Steam, 18th Edition*, Liberty Corner, NJ: Ingersoll-Dresser Pumps. TIC #242444
- 5.21 CRWMS M&O 1998. *East-West Cross Drift Starter Tunnel Layout Analysis*, BABEAF000-01717-0200-00008, REV 01, Attachment I, p. 8 of 8. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980216.0530
- 5.22 Schauenburg Corp, Inter-Office Correspondence, *Flexible Spiral Duct Weight*, dated 8/18/98. CRWMS M&O. ACC: MOL.19980928.0236
- 5.23 CRWMS M&O 1999. *Request for Radon information for ECRB Cross Drift*, Las Vegas, Nevada CRWMS M&O. ACC: MOL.19990526.0395
- 5.24 CRWMS M&O 1997. *Exploratory Studies Facility Design Requirements YMP/CM-0019*, Revision 2, ICN 01, Section B.2.3, Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19960926.0065 and ACC: MOL.19980107.0544

6.0 COMPUTER SOFTWARE

Not Used

7.0 DESIGN ANALYSIS

7.1 Non-potable water system

The non-potable water system will provide water for drilling activities and dust control during mining operations in each alcove and niche. The LongYear 38 drill rig which is planned to be used in the alcoves and niches for drilling of instrumentation holes requires a

water source to fill the reservoir tank. Water from the reservoir tank of the drill is recirculated in a closed loop during drilling activities for cooling of the drill motor.

Excavation of the niches and alcoves is required to be done using a mechanical Voist-Alpine roadheader type miner. During roadheader mining operations of the niche access drifts and alcoves a water mist spray is used on the cutter head of the roadheader to reduce airborne dust. This system uses a high pressure low volume water spray system made up of a series of spray nozzles located on the cutter head using approximately 8 gpm (Input 4.1.4) of water. The inlet water supply line for the Voist Alpine Miner is a 1-inch diameter line. (Input 4.1.5).

Rockbolt drilling will be done in the alcoves and niches using a Tamrock model H205 or Atlas Copco H226 drill jumbo. The jumbo uses water for flushing holes and cooling of the bit during drilling operations. The jumbo's are also manufactured with a 1-inch diameter inlet supply line for drilling water (Input 4.1.6).

Because of the fact that mining and drilling activities related to construction are temporary and since the LongYear drilling system requires only water for infrequent filling of the reservoir and not a continuous supply, there will not be a need for extension of non-potable water or wastewater hard line into the alcoves or niches. The water supply will be provided from a minimum 1-inch service outlet located on the main non-potable header in the Cross Drift and routed to machinery using a minimum 1-inch diameter bull hose routed along the invert. The bull hose rating is based on the following: The header pipe pressure in the Cross Drift at the highest point (Station 24+67) is designed to provide 50 psi in the header pipe (Input 4.1.7). The lowest alcove to be excavated is the Cross Over alcove located at approximately station 7+72 (Input 4.1.8). The elevation head gain is given by the difference in elevation between the two points is 20 m (65 ft) (Input 4.1.20) $\div$ 2.31 ft/psig = 28.4 psig. The friction head gain is determined as follows:

Total distance between Station 24+67 and the Cross Over Alcove is 5561 ft (Input 4.1.9) $\times$.154 psig/ 100 feet of pipe = 8.6 psig. The total gain in pressure at the lowest Cross Drift Alcove is then 50 psig + 28.4 psig + 8.6 psig = 87 psig. Considering allowance for water hammer pressure increase a bull hose for non-potable water with a minimum working pressure rating of 200 psi is adequate for all alcove and niche use.

The service outlet for non-potable water will use a 1-inch Inside Diameter (I.D.) shut-off type valve with a minimum 200 psi working pressure rating installed in the 6-inch schedule 40 header pipe located in the Cross Drift near the break out location of the alcove or niche.

This temporary water supply system using bull hoses to supply the necessary water to the alcoves/niches meets requirements of maintainability and of being removable. It also meets the requirements of the testing organizations since it has been designed using test criteria as input (Ref 5.3).

7.2 Compressed air

Compressed air will be required for test drilling activities. The testing boreholes will be drilled using a LongYear 38 drill rig that requires a nominal 100 psi at 300 cfm for cleaning/flushing bore holes and for running the Torit dry scrubber dust collector and ancillary equipment (Input 4.1.2). The compressed air header in the Cross Drift will supply air to the drill rig using a bull hose attached to a tee outlet in the header. The size of the required hose was determined as follows:

$$W = \text{rate of flow in lbs. per hour} = 300 \text{ cfm} \times 60 \text{ min/hr} \times .574 \text{ lbs/ft}^3 = 10,333 \approx 10,400 \text{ lbs/hr}$$

Assume friction factor for rubber bull hose is approximately the same as for steel pipe. This assumption is based on the fact that both surfaces are relatively smooth walled and that the difference in friction will be small based on the short lengths of hose required. (Assumption 4.3.2). Friction factor for steel pipe = 0.18 (Input 4.1.11).

Assume that the temperature of the compressed air at each alcove location has reached an ambient temperature of approximately 80° F. This assumption is based on the conductive heat flow from the compressed air to the steel header pipe and then to the surrounding air. The length of pipe from the North Portal is great enough that the air that leaves the compressor at 125 psi and 180° F should reach ambient temperature prior to entering the alcoves (Assumption 4.3.3).

Since the header pipe is designed to deliver 115 psig at the terminal end of the Cross Drift (Input 4.1.12), 115 psig will be used as a conservative value of available pressure at each alcove/niche location. Selecting an initial bull hose diameter of 3-inches and use of the nomograph (Ref 5.10, page 3-21) yields a pressure drop of approximately 5 psi per 100 ft of hose. Since, the maximum alcove length is 98 ft (Input 4.1.13) the pressure drop for a 3-inch bull hose used for compressed air will provide $115 - 5 = 110$ psi at the drill rig which meets the nominal 100 psi requirement (Input 4.1.2).

The 3-inch bull hose rated at a minimum 200 psig working pressure can be connected to a 3-inch service outlet on the compressed air header located in the Cross Drift. The service outlet for compressed air will use a 3-inch inside diameter (I.D.) shut-off type valve with a minimum 200 psi working pressure rating installed in the 6-inch schedule 40 header pipe located in the Cross Drift near the break out location of the alcove or niche. A compressed air manifold header connected to the terminal end of the bull hose routed along the invert in the alcove should be used to provide three outlets, one for the LongYear Drill Rig and an additional two outlets for dust scrubber operation and ancillary compressed air requirements (Test Criteria 4.2.2.2).

This temporary system using bull hoses to supply the necessary compressed air to the alcoves/niches meets requirements of maintainability and of being removable. It also meets

the requirements of the testing organizations since it has been designed using test criteria as input (Ref 5.3).

7.3 Wastewater system

The size of the wastewater bull hose will be based on the size of the non-potable water bull hoses since any wastewater will be pumped off of the invert using a small portable submersible pump. The rate of pumping will not be required to exceed the rate at which water is supplied (Assumption 4.3.1).

No significant wastewater is expected to be discharged from the alcoves or niches since test drilling operation will be dry drilled. Minimum wastewater may be generated during rockbolt hole drilling and other construction activities that will be captured and removed with small portable pumps placed on the invert.

The service outlet for wastewater will use a 1-inch I.D. shut-off type valve with a minimum 200 psi pressure rating installed in the 6-inch schedule 40 header wastewater pipe located in the Cross Drift near the break out location of the alcove or niche.

A 1-inch flow check valve rated at 200 psi working pressure will be installed between the shut-off valve and header pipe to prevent back flow of wastewater from the header pipe into the alcove/niche when the sump pump is not in operation. The Cross Drift waste-water header is a gravity drain system from Station 24+67 to a collection sump located at the intersection of the Cross Drift and North Ramp. Thus, only minimal pressure will be required by the alcove sump pumps and bull hose to overcome the elevation head between the pump and the inlet on the header pipe. For alcoves located beyond station 24+67 the maximum elevation head that the pump would be required to overcome would be 10.7 m (35 ft) (Input 4.1.14) that is equivalent to $35 \text{ ft} \times (1 \text{ psi} / 2.31 \text{ ft of water, Input 4.1.19}) = 15.2 \text{ psi at } 65^\circ \text{ F}$. Thus, the same type bull hose used for potable water rated at 200 psi or above and routed along the drift invert to the pump will be adequate for wastewater pumping in any alcove or niche.

This temporary system using pumps and bull hoses to remove wastewater from the alcoves/niches meets requirements of maintainability and being removable. It also meets the requirement that wastewater shall be removed from testing areas.

7.4 Ventilation

7.4.1 General

The Exploratory Studies Facility (ESF) has three A/E designed ventilation systems providing required fresh air to the TS Loop, Cross Drift, and Thermal Testing Facility (TTF). The TS loop is a flow-through system that intakes air at the North Portal transporting the air through the tunnel opening along the TS Loop and exhausting it at the South Portal. The ventilation system in the Cross Drift is currently designed as an exhausting system in which air enters into the ventilation duct at terminal end of the

drift and is exhausted using a series of vane-axial fans at the North Portal. The TTF is a reuse blowing system that intakes the air in the Main Drift and blows this air using a duct system and vane-axial fans to various areas of the TTF.

Recently, radon has been detected in the ESF subsurface excavations and has become an additional concern in maintaining air quality in the A/E system design. The radon levels are measured by Health Physics (HP) personnel throughout the tunnel complex by means of monitoring stations located in the TS Loop, Cross Drift, and alcoves (Ref 5.23). Minimization of radon exposure to the lowest reasonably achievable value in system design is necessary to reduce the amount of personnel controls and exposure.

The velocity of the airstream underground is important for mitigation of radon hazards. The faster the air velocity, the shorter the time that radon gas resides in underground areas, thus reducing the exposure and potential harmful effects to personnel. The ventilation of the Cross Drift alcoves/niches has been changed to a reuse system that intakes air into the ventilation duct at the terminal end of the alcove/niche and exhausts the air into the Cross Drift. The alcove vent duct and fan have been designed to provide air independent from the Cross Drift ventilation system. This will allow the air stream in the Cross Drift to be maintained at its maximum flow and thus the shortest transit times for radon removal.

7.4.2 System requirements

The alcoves and niches planned for the Cross Drift have varying cross-sectional dimensions. The largest designed cross-section will be approximately $6\text{ m} \times 5\text{ m} = 30\text{ m}^2$ (the 5 m width is based on a 4 m packer string plus 1 m for insertion clearance, Input 4.1.3) and will be used for determination of ventilation flow requirements. Vent duct fittings will vary in number and type (e.g. 30°, 45° or 90° elbows, etc.) dependent on the layout of the Cross Drift and the alcoves/niches.

The system will consist of a duct routed along back or right rib of the alcove/niche and having a vane-axial fan installed in the duct located in the Cross Drift. The system will be an exhausting system that will intake air into the ventilation duct in the terminal end of each alcove or niche and exhaust it into the Cross Drift downstream from the alcove/niche breakout. This should be done by installation of the steel duct and fan inside of the alcove/niche. The end of the steel duct would extend to the opening of the alcove/niche and from this point a short section of flexible spiral vent duct should be used to exhaust the air into the Cross Drift downstream and past the alcove opening to prevent recirculation of the air. By installation of flexible air duct in the Cross Drift instead of steel duct, removal of the vent duct for passage of equipment in the Cross Drift will be easier. This type of air reuse system will allow the Cross Drift ventilation to continue to perform at original design flows and will prevent robbing air from the system as alcoves/niches are constructed. This allows maximum air velocity to be maintained in the Cross Drift and thereby mitigate potentially high radon gas working levels.

During the excavation of the alcoves/niches a dust collection and filtration system will be used to prevent accumulation of dust in the subsurface working area and also prevent the intake and exhaust of dust to the surface, via the ventilation system. The necessary equipment and configuration of the system will be described in a revised ESF and Cross Drift Ventilation System Plan (Ref 5.14).

7.4.3 Duct and fittings sizes

The size of the duct used for ventilation of the alcoves and niches is determined based on the required minimum velocity of air in the alcoves during construction. The minimum velocity requirement for non-dusty environments is 30 fpm in accordance with OSHA 1926.800 (4.4.1). The required drift air velocity during excavation and other construction activities is dependent on the amount of dust being generated. A value of 100 fpm has been established in past analysis for ventilation of dust generating areas in the ESF (Input 4.1.16) and will be used here for areas where drilling and other dusty activities may be occurring other than excavation.

The maximum drift cross-sectional area is approximately $6 \text{ m} \times 5 \text{ m} = 30 \text{ m}^2$ (Ref 5.3). Using the required minimum air velocity in the alcove/niche of 100 fpm to provide sufficient air volume for potential dust generating activities the required air flow is calculated as $30 \text{ m}^2 \times 10.76 \text{ ft}^2/\text{m}^2 \times 100 \text{ fpm} = 32,280 \text{ cfm} \approx 32,500 \text{ cfm}$. From this the vent duct diameter required in the alcoves/niches was determined based on the following calculations:

From the friction loss table (Ref 5.15, page 6) the friction loss for 30 m ($\cong 98 \text{ ft}$) (Input 4.1.13) of a selected 36-inch (3 ft.) diameter round steel duct for an air flow of 32,500 cfm is 0.57 inches per 100 ft of duct.

Correction factor for temperature and elevation are $K_t = .96$ (Input 4.1.10)(at 80° F , Ref 5.5) and $K_e = .89$ (Input 4.1.10) (at 3500 ft elevation, Input 4.1.17) thus corrected loss = $0.96 \times 0.89 \times 0.57 = .49$ inches.

The total pressure loss at the abrupt intake of the duct can be determined using the following equations from Reference 5.15:

$$\text{TPu-d} = K_d \times \text{VPd} \text{ (page 34)}$$

Where TPu-d is the total entrance pressure loss

K_d is the loss coefficient = 0.5 for abrupt pipe entrances (Input 4.1.18)

VPd is the Velocity pressure downstream = $(V / 4005)^2$ (page 5)

Where V is the velocity of the air in the duct

$V = Q/A$ (page 5), where Q is the air flow in cfm and A is the cross sectional area of the duct and $A = \pi R^2$

$$V = 32,500 / (3 \text{ ft}/2)^2 \times \pi = 4597 \text{ fpm}$$

$$\text{and VPd} = (4597 / 4005)^2 = 1.3 \text{ inches w.g.}$$

Duct entrance loss $T_{pu-d} = 0.5 \times 1.3 = 0.65$ inches w.g., and

Total duct loss for 150 ft duct length = total friction + entrance loss = $0.49 (1.5) + 0.65 = 1.4$ inch w.g.

The alcove/niche steel duct will be a 36-inch diameter duct with round spiral lockseam construction, fabricated from galvanized steel, and will be suitable for operation pressures of ± 10 inches w.g. pressure. The duct will be constructed in minimum 20 ft section lengths and shall have a flange ends suitable for use of Ductmate Industries "Ventmate" closure rings, or approved equal. Duct fittings will be made of galvanized steel and shall also be designed for operation pressures of ± 10 inches w.g. and will have connections compatible with the duct. An inlet bell (United McGill Corporation 36" SRSBM or approved equal) will be installed at the intake of each alcove/niche duct to reduce shock loss.

Each alcove/niche will require the installation of a fan. The fan type that is required, based on the maximum static head requirements calculated above and including velocity pressure of the fan and the required flow rate was selected as a Joy Series 2000 axivane fan Model 48-26-870, or equal. The total pressure requirement of static + velocity pressure using this fan is found to be $1.4 + .41 = 1.81$ inches w.g.

Fans to be procured for the alcoves/niches will be axivane type fan with direct drive totally enclosed air-over electric (TEAO) motor suitable for operation on 480/3/60 electric power with a 1.15 service factor, adjustable pitch blades, inlet/outlet safety screens, mounting clips, performance of 32,500 cfm at 2.0 inches w.g. 70° F and 3500 ft above mean sea level, inlet bell, including combination reversing motor starter, fan to 36" diameter duct adapter, if required, compatible for use with Ductmate Industries "ventmate" duct closure ring, and silencers, if required, to achieve a maximum total sound pressure level of the fan 86 dBA at 5.0 ft. (Reference 5.9).

The steel ventilation duct will be suspended using 900 mm Split Set type rockbolt pins and plates, or equal, anchored into the back of the alcove and installed in accordance with manufacturers recommendations. These rockbolt pins are tested, as described in previous analysis (Ref 5.12), to a 2000 lb non-destructive load. Aircraft cable ¼-inch in diameter with a minimum load capacity of 6000 lbs will be used with appropriate manufacturer's recommended cable fasteners to secure the duct and fittings to the rockbolt plates. The rockbolt plates have a recommended manufacturer's load capacity of 2000 lb (Ref. 5.19). Using the rockbolt pins, plates and aircraft cable will thus provide a minimum of 2000 lb load carrying capacity per pin. The 20 ft vent duct section will be supported at nominal 10 ft intervals with two pins. This provides a total load carrying capacity of 8000 lb per section of duct (4 pins per section). The calculated weight of 48-inch vent duct, including seismic load and dust loads used in the Cross Drift, is 1300 lbs per 10 ft or 2600 lbs per 20 ft section of duct (Ref 5.13) and is less than the load capacity of 8000 lbs, thus the load capacity, including seismic, for hanging 36-inch diameter vent duct will also be adequate.

Each ventilation fan will be supported from the drift back by four Split-Set type 0.9 m long rockbolt pins and plates. Aircraft cable and connectors used to support the duct will also be used to support the fan from each of the rockbolts.

A combination of steel and flexible ventilation duct will be used to provide ventilation through alcove and niche bulkheads (See Figure 2). A 250 mm to 1000 mm long section of 36-inch steel vent duct will be installed through each bulkhead and the perimeter of the duct will be sealed to prevent leakage around the duct and through the bulkhead. The flexible ventilation duct will be attached to the section of steel vent duct passing through the bulkhead when the bulkhead is opened. This can be done using a flexible to hard duct adapter. The 36-inch flexible duct will be removed from the steel duct and the end of the steel duct sealed when the bulkhead is closed. The flexible vent duct shall be designed for operation pressures at - 10 inches w.g. (Schauenburg Flexadux Corporation flexible spiral vent duct, or equal). A 36" to 36" diameter vent duct tee with damper will be installed at the portal side of the alcove bulkhead to adjust the amount of flow through the bulkhead and also in the access drift of the alcove/niche. A second damper will be installed after the tee to adjust the airflow behind the alcove or niche bulkhead, when opened and to meet the minimum 30 fpm velocity requirement (4.4.1). The dampers will be single blade type made of galvanized steel. The damper blade shall be permanently mounted on a steel axle. Damper frame shall be made from galvanized steel. Dampers shall be suitable for operation up to 4900 fpm air velocity and 10" w.g. differential pressure. Provide locking quadrant on damper for maintaining adjusted position.

The flexible spiral vent duct will be suspended from the drift back using a 1/4-inch steel messenger cable suspended by nominal 900 mm long split-set type pins and plates at maximum 10 m spacing. Using an approximate weight of 10 lbs/ft for flexible vent duct (Ref 5.22) and adding a conservative value for accumulated dust in the vent line used for the 48-inch steel duct 20.1 lbs/ft (Ref 5.13), gives approximately 30 lbs/ft. Thus, the total dead load for a 10 m (32.8 ft) length of duct is $32.8 \text{ ft} \times 30 \text{ lbs/ft} = 984 \text{ lbs}$. Including a seismic increase factor of 1.3 gives $984 \text{ lbs} \times 1.3 = 1280 \text{ lbs}$. Since a single rockbolt pin and plate is sufficient to support a 2000 lb load (Ref. 5.19), a maximum spacing of 10 m between bolts is adequate for support of the flexible duct. The cable will be fastened using recommended cable manufacturer's fasteners and shall be attached to rockbolt plates. Any sharp edges along rockbolt plate holes shall be smoothed to prevent cable abrasion. Cable clips or other smooth non abrasive connections that have a minimum 2000 lb load rating may be used to string the cable instead of passing it directly through the rockbolt plate hole. The messenger cable will be installed and aligned to minimize bends or sagging in the flexible duct.

The alcove/niche ventilation system utility is designed, as has been the Cross Drift system, to meet the requirements of temperature and humidity since the ductwork and fans are design for underground environments and not affected by temperatures outside the limits given in the ECRB-RD. The system is also maintainable and temporary to the

extent practical, since it is installed using temporary supports and can be easily removed, with the exception of the rockbolt pins. The design of the system also considered test criteria input in its design to meet testing requirements.

8. CONCLUSIONS

- 8.1** Water shall be supplied to the alcoves/niches from a minimum 1-inch service outlet located in the Cross Drift non-potable water header near the alcove entrance. The service outlet will be a 1-inch shut-off type valve with a minimum operating pressure rating of 200 psi. A minimum 200 psi rated and minimum 1-inch diameter bull hose located on the invert will be used to supply water to the necessary equipment in the alcove from the ball valve.
- 8.2** Compressed air shall be supplied to the alcoves/niches from a 3-inch service outlet located in the Cross Drift compressed air header near the alcove entrance. The service outlet will be a 3-inch shut-off type valve with a minimum working pressure rating of 200 psi. A minimum 3-inch diameter bull hose (minimum 200 psi rating) located on the invert will be used to supply air to the necessary equipment in the alcove from the shut-off valve. A manifold header will be required at the end of the bull hose during test drilling operations to provide air connections for the drill rig, dry scrubber and ancillary equipment.
- 8.3** Waste water shall be removed from the alcove/niches using a portable pump and a minimum 200 psi rated, minimum 1-inch diameter bull hose located on the invert and connected to a service inlet in the Cross Drift waste water header located near the alcove entrance. The service inlet will be a minimum 1-inch diameter with a minimum 1-inch one-way flow-check valve installed between the header and a 1-inch shut-off type valve with an operating pressure rating of 200 psi. The check valve will be installed to prevent back flow of wastewater from the header into the alcove/niche.
- 8.4** The alcove/niche ventilation system will consist of a 36-inch diameter duct with fan that will provide an exhausting system for each alcove/niche. A combination of flexible vent duct and steel duct will be used at each bulkhead location. The system will intake air into the ventilation duct in the terminal end of each alcove or niche and exhaust it into the Cross Drift down stream from the alcove/niche breakout. This should be done by installation of the steel duct and fan inside of the alcove/niche. The end of the steel duct would extend to the opening of the alcove/niche and from this point a short section of flexible spiral vent duct should be used to exhaust the air into the Cross Drift downstream and past the alcove opening to prevent recirculation of the air.
- 8.5** After mining is complete a galvanized steel vent duct will be installed that intakes air at the terminal face of the drift and exhausts it into the Cross Drift. The ventilation duct will be suspended using minimum 900 mm long Split Set type rockbolt pins anchored into the back or ribs of the alcove. Aircraft cable ¼-inch in diameter with a minimum load

capacity of 6000 lbs will be used with appropriate manufacturer's recommended cable fasteners to secure the duct and fittings to the Split-Set rockbolt plates. The 20 ft vent duct section shall be supported at nominal 10 ft intervals and at two places per 20 ft section. The ventilation fan will be supported by 4 rockbolt pins and ¼ inch steel aircraft cable.

- 8.6 The alcove duct will be 36-inch diameter duct with round spiral lockseam construction, fabricated from galvanized steel, and will be suitable for operation pressures of ± 10 inches w.g. pressure. The duct sections shall be a minimum of 20 ft and have flanged ends suitable for use with Ductmate Industries "Ventmate" couplings, or equal. Vent duct fittings will be made of galvanized steel and shall also be designed for pressures of ± 10 inches w.g. and will have flanged ends compatible with the ductwork couplings.
- 8.7 A combination of steel and flexible spiral ventilation duct will be used to provide ventilation through alcove and niche bulkheads. A 250 mm to 1000 mm long section of 36-inch steel vent duct will be installed through each bulkhead and the perimeter of the duct will be sealed to prevent leakage around the duct and through the bulkhead. The flexible ventilation duct will be attached to the section of steel vent duct passing through the bulkhead. The 36-inch flexible duct will be removed from the steel duct and the end of the steel duct sealed when the bulkhead is closed. The ventilation intake will be installed along the back or rib in a manner and far enough from the bulkhead to not obstruct ventilation flow.
- 8.8 A 36" to 36" diameter vent duct tee with damper will be installed at the portal side of the alcove bulkhead to adjust the amount of flow through the bulkhead and also in the access drift of the alcove/niche. A second damper will be installed after the tee to adjust the airflow behind the alcove or niche bulkhead, when opened and to meet the minimum 30 fpm velocity requirement.
- 8.9 The flexible spiral vent duct will be suspended using a ¼ inch steel aircraft messenger cable (minimum 6000 lb load capacity) suspended by nominal 900 mm long split-set type pins and plates. The pins shall have a maximum spacing of 5 meters. The cable will be fastened using recommended cable manufacturer's fasteners and shall be attached to rockbolt plates. Any sharp edges where the cable is attached to the holes in the rockbolt plate shall be smoothed to prevent cable abrasion. Cable clips or other smooth non abrasive connections that have a minimum 2000 lb load rating may be used to string the cable instead of passing it directly through the cable plate hole. The messenger cable will be aligned to minimize bends or sagging in the flexible duct. Manufacturer supplied hangers, or approved equal, shall be used to attach flexible duct to messenger.
- 8.10 Fans to be procured for the alcoves/niches will axivane type fan with direct drive totally enclosed air-over electric (TEAO) motor suitable for operation on 480/3/60 electric power with a 1.15 service factor, adjustable pitch blades, inlet/outlet safety screens, mounting clips, performance of 32,500 cfm at 2.0 inches w.g. 70° F and 3500 ft above mean sea level, inlet bell, including combination reversing motor starter, fan to 36-inch

diameter duct adapter compatible for use with Ductmate Industries "ventmate" duct closure ring, if required, and silencers, if required, to achieve a maximum total sound pressure level of the fan 86 dBA at 5.0 ft.

- 8.11** Dampers will be single blade type made of galvanized steel. Blade shall be permanently mounted on a steel axle. Damper frame shall be made from galvanized steel. Dampers shall be suitable for operation up to 4900 fpm air velocity and 10" w.g. differential pressure. Provide locking quadrant on damper for maintaining adjusted position.
- 8.12** An inlet bell (United McGill Corporation 36" SRSBM or approved equal) will be installed at the intake of each alcove/niche duct to reduce shock loss.
- 8.13** The flexible vent duct shall be designed for operation pressures at - 10 inches w.g. (Schauenburg Flexadux Corporation flexible spiral vent duct, or equal).

9 Attachments

Not Used