OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT ANALYSIS/MODEL COVER SHEET

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Page: 1 of 32

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Type of Analysis

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☐ Performance Assessment

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Intended Use of Analysis

☐ Input to Calculation

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☐ Input to Technical Document

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1. PURPOSE

The scope of this analysis is to examine the existing, constructor installed, physical ventilation installations located in each of the Exploratory Studies Facility (ESF) Topopah Springs (TS) Loop Alcoves #1, #2, #3, #4, #6, and #7. Alcove #5 is excluded from the scope of this analysis since it is an A/E design system. Each ventilation installation will be analyzed for the purpose of determining if requirements for acceptance into the A/E design technical baseline have been met. The ventilation installations will be evaluated using *Occupational Safety and Health Administration* (OSHA) standards and *Exploratory Studies Facility Design Requirements* (ESFDR) (YMP 1997) requirements.

The end product will be a technical analysis that will define ventilation installation compliance issues, any outstanding field changes, and use-as-is design deviations that are required to bring the ventilation installations into compliance with requirements for acceptance into the A/E design technical baseline. The analysis will provide guidance for alcove ventilation component design modifications to be developed to correct any deficient components that do not meet minimum requirements and standards.

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2. QUALITY ASSURANCE

No Quality Assurance (QA) Controls are applicable to the items or activities addressed in this design analysis. The items addressed in this analysis are temporary and therefore have not been classified in accordance with QAP-2-3, *Classification of Permanent Items*. There are no Determination of Importance Evaluations (DIE) controls associated with the ventilation systems covered in this analysis (CRWMS M&O 1999a, section 13.3). A QAP-2-0 evaluation has been completed (CRWMS M&O 1999b) and this document is not subject to the U.S. Department of Energy (DOE), Office of Civilian Radioactive Waste Management, DOE/RW-0333P, *Quality Assurance Requirements and Description*. This analysis was prepared in accordance with AP-3.10Q Rev. 02, *Analysis and Models*, and the associated AP-2.13Q Development Plan (CRWMS M&O 2000a).

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3. COMPUTER SOFTWARE AND MODEL USAGE

Not Used

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4. INPUTS

4.1 DATA AND PARAMETERS

4.1.1 Alcove Ventilation Duct and Suspension Method

Table 1. Alcove Ventilation Duct and Suspension Method

Alcove	Vent Duct	Support	Description
#1 Inside the alcove	36" Ø fiberglass	Annealed #9 gage wire	Basket arrangement looped around duct, passed through split set bolt washer hole, twisted off underneath duct
#1 Outside the alcove	36" Ø galvanized steel	¼" wire rope	Basket arrangement, looped around duct, attached to eye-bolt or steel set cross braces, aluminum swage connector
#2	36" Ø galvanized steel	¼" wire rope	Basket arrangement looped around duct, passed through split set bolt washer hole, aluminum swage connector or Crosby clamps
#3	24" Ø galvanized steel	Annealed #9 gage wire	Basket arrangement looped around duct, passed through split set bolt washer hole, twisted off underneath duct
#4	24" Ø galvanized steel	Annealed #9 gage wire	Basket arrangement looped around duct, passed through split set bolt washer hole, twisted off underneath duct
#6	24" Ø galvanized steel	Annealed #9 gage wire	Basket arrangement looped around duct, passed through wire mesh, twisted off underneath duct
#7	24" Ø galvanized steel	Annealed #9 gage wire	Basket arrangement looped around duct, passed through wire mesh, twisted off underneath duct

Alcove #1 and Alcove #2 are on the north side of the TS Loop drift and in close proximity to the North Portal entrance. They share a common exhaust fan located near the North Portal access. Alcove #1 ventilation duct joins the exhaust conduit, originating from Alcove #2, at right angles through the use of a "tee-section".

The section of ventilation duct inside Alcove #1 is 36" Ø fiberglass ducting. This section of duct is suspended from the back of the alcove with #9 gage wire. The #9 gage wire supports the duct in a loop that forms a basket arrangement. The wire is twisted off several turns on the underside of the duct.

The portion of the ventilation duct outside Alcove #1 is 36 " Ø galvanized steel duct. It consists of a single straight piece (that mates to the fiberglass ducting) and several elbows that elevate and fix the duct into the "tee-section". Galvanized wire rope, ¼" Ø (aircraft cable), suspends the duct in a loop that forms a basket arrangement. The wire rope is looped through eyebolts and either has a swaged aluminum sleeve connection or Crosby clamps are used to bind the free ends.

Alcove #2 has 36 " Ø galvanized steel ventilation duct throughout. A series of elbows elevate and direct the ducting along the TS Loop drift to the "tee-section" where it is joined by the conduit from Alcove #1. Galvanized wire rope, ¼" Ø (aircraft cable), suspends the duct in a series of loops that forms a basket arrangement. Either aluminum sleeves swage or Crosby clamps bind the cable free ends together.

The ventilation duct in Alcove #3 is 24" Ø galvanized steel duct. A combination of 90° elbows to elevate and connect the ventilation duct into the main 66" Ø exhaust ventilation pipe at a right angle. This alcove does not have a dedicated exhaust fan but relies on the vacuum created by the main ventilation fan to create airflow. The alcove duct is suspended from the back with #9 gage wire. The #9 gage wire supports the duct in a loop that forms a basket arrangement. The wire either passes through the hole in a split set bolt washer, the ring end of the bolt itself or the wire mesh used for ground control. The wire is twisted off several turns on the underside of the duct.

The ventilation duct in Alcove #4 is 24" Ø galvanized steel duct. A combination of 90° elbows to elevate and connect the ventilation duct into the main 66" Ø exhaust ventilation pipe at a right angle. This alcove does not have a dedicated exhaust fan but relies on the vacuum created by the main ventilation fan to create airflow. Alcove #4 ventilation duct is suspended in the same manner as described above for Alcove #3.

Ventilation for Alcove #6 is provided by an independent system. The ventilation arrangement evacuates exhaust air from the terminal face of the alcove and discharges it into the TS Loop drift exhaust air stream. The ventilation duct in Alcove #6 is 24" Ø galvanized steel duct. Adapter section sections are used to facilitate connection to the 36" Ø ventilation fan. The ventilation duct is suspended from the back of the alcove with #9 gage wire. The #9 gage wire supports the duct in a loop that forms a basket arrangement. The wire is twisted off several turns on the underside of the duct. The exhaust fan is supported in the same manner described in Section 4.1.6.

Ventilation for Alcove #7 is provided by an independent system. The ventilation arrangement evacuates exhaust air from the terminal face of the alcove and discharges it into the TS Loop drift exhaust air stream. The ventilation duct in Alcove #7 is 24" Ø galvanized steel duct. Adapter pieces are used to facilitate connection to the 36" Ø ventilation fan. The ventilation duct is suspended from the back of the alcove with #9 gage wire. The #9 gage wire supports the duct in a loop that forms a basket arrangement. The wire is twisted off several turns on the underside of the duct. There are two exhaust fans in series. One is located inside the alcove and one is located outside the alcove in the TS Loop. They are supported in the same manner described in Section 4.1.6.

Suspension systems were observed during a site visit.

4.1.2 Ventilation Duct Weight

The ventilation duct is 18 gage, galvanized steel. The 24" Ø ventilation duct weighs 15.3 pounds per lineal foot. The 36" Ø ventilation duct weighs 23.0 pounds per lineal foot (UMC 1989, pp. 54, 55).

4.1.3 Mechanical Properties of #9 Gage Wire

The diameter of black annealed, #9 gage wire is 0.148-inch. Tensile strength of black annealed, #9 gage wire is 45,000 to 57,000 psi (Goodin 2000).

4.1.4 Mechanical Properties of ¼" Wire Rope

The wire rope that is used to suspend the ventilation duct is ¼", 7X19 GAC (Galvanized Aircraft Cable). This was observed during a site visit. The nominal strength of this wire rope is 7000 pounds (Wire Rope Users Manual 1985, p 95).

4.1.5 Fan and Silencer Weights

The fan and silencer combination weights are as follows: a common fan services Alcove #1 and #2 with silencers. The combined weight is 2350 pounds. Alcove #3 and #4 do not have a dedicated ventilation fan. Alcove #6 has one fan with silencers and the combined weight is 2350 pounds. Alcove #7 has two fan/silencer combinations. One fan and silencer unit weighs 2350 pounds. The other fan weighs 719 pounds. The silencers were fabricated on site and do not have recorded weight. (Refer to Section 5.5) (CRWMS M&O 2000b)

4.1.6 Fan and Silencer Suspension Method

The common exhaust ventilation for the two alcoves is located a short distance inside the North Portal access. It has an intake side silencer and an exhaust side silencer as well. This assembly is suspended from the back with two loops of ½" wire rope in a basket arrangement. The fan/silencer assembly has four points of support. Each wire rope free end goes around a thimble set in a steel bracket. The bracket is bolted to the back with a split set bolt. The wire rope is secured with two Crosby clamps.

The ventilation fans are suspended from the back within two loops of ½" wire rope in a basket arrangement. The typical fan/silencer assembly has four anchor points for termination. Each wire rope free end is set in a thimble, which in turn passes through a steel bracket. The bracket is bolted to the back with a split set bolt. The wire rope is secured with two Crosby clamps. This suspension system was observed during a site visit.

4.1.7 Mechanical Properties of ½" Wire Rope

The wire rope that is used to suspend the ventilation fans for the alcoves is ½", 6X19 IWRC XIPS. This was observed during a site visit. The nominal strength of this wire rope is 13.3 tons (Wire Rope Users Manual 1985, p 81).

4.1.8 Density of Settled Dust

The density of dust that has settled in the bottom of the ventilation duct is 100 pounds per cubic foot. (CRWMS M&O 1998a, p. 3)

4.1.9 Ventilation Flow

Table 2. December 1999 Ventilation Data

Date	Alcove Ventilation Airflow (cfm)					
	Alcove #1, Upper Tiva Canyon	Alcove #2, Bow Ridge Fault	Alcove #3 Upper Paintbrush Tuff	Alcove #4 Lower Paintbrush Tuff	Alcove #6 Northern Ghost Dance Fault	Alcove #7 Southern Ghost Dance Fault
12/02/99	17,200	13,300	0	13,100	N/a	14,200
12/09/99	17,800	13,200	0	11,700	13,600	14,200
12/16/99	16,300	13,700	0	11,900	14,300	14,600

SOURCE: Dresel, R. R. 2000; Elkins, N. 1996

4.2.0 Alcove Cross-sectional Area

Table 3. Alcove Cross-sectional Area

Alcove	Width (m)	Springline Height (m)	Radius of Arch (m)	Cross-sectional Area (m ²)	Reference
1	8	19	9.5	322	CRWMS M&O 1994
2	6	12	6	131	CRWMS M&O 1995a
3	6	12	6	131	CRWMS M&O 1995b
4	6	12	6	131	CRWMS M&O 1995b
6	6.5	13	6.5	147	CRWMS M&O 1996
7	6.5	13	6.5	147	CRWMS M&O 1997b

4.2 CRITERIA

The following criteria were developed to respond to the requirements presented in the ESFDR (YMP 1997) that specifically apply to this analysis.

4.2.1 Seismic Design Criterion

The permanent and temporary items of the ESF shall be designed to withstand the applicable seismic environment specified in Appendix A of the ESFDR. The seismic design of the ESF temporary subsurface facilities will be 0.3 g peak ground acceleration at the earth's surface (YMP 1997, Section 3.2.1.2.1.2.A).

4.2.2 Dust Operational Environment

The ESF subsurface facilities and equipment shall be designed to withstand and operate in dusty environments (YMP 1997, Section 3.2.1.2.1.2.B).

4.2.3 Temperature Operational Range

The ESF subsurface facilities and equipment shall be designed to withstand and operate in temperatures ranging from a low of 50 degrees F to a high of 70 degrees F (YMP 1997, Section 3.2.1.2.1.2.C).

4.2.4 Relative Humidity Operational Range

The ESF subsurface facilities and equipment shall be designed to withstand and operate in a relative humidity environment of 13 to 71% (YMP 1997, Section 3.2.1.2.1.2.D).

4.2.5 Service Life Criterion

The ESF non-permanent items shall be designed for a 25-year maintainable service life (YMP 1997, Section 3.2.1.2.2.A).

4.2.6 Electrical Standby Power

Electrical standby power shall be provided to the ventilation system to retain operational function when primary power is lost. A reduced level of ventilation necessary to support critical activities is acceptable (YMP 1997, Section 3.8.2.2.1.A).

4.2.7 Ventilation System Leakage

The ventilation system shall minimize leakage to the extent practicable (YMP 1997, Section 3.8.2.5.1.F).

4.2.8 Ventilation Performance Requirement

Underground ventilation shall dilute and/or remove particulate matter, blasting fumes and other flammable and noxious gases from the working areas, and shall divert exhaust air to the exhaust openings in conformance with the applicable federal regulations (YMP 1997, Section 3.8.2.5.1.J).

4.2.9 Ventilation System Monitoring Requirements

The ventilation system shall support the ventilation monitoring requirements for site characterization tests and health and safety requirements (YMP 1997, Section 3.8.2.5.1.O).

4.2.10 Ventilation System Availability Criterion

The subsurface ventilation system shall have a minimum availability of 98.95 % (YMP 1997, Section 3.8.2.5.1.Q).

4.3 CODES AND STANDARDS

4.3.1 Code of Federal Regulations

The applicable code is 29 CFR 1926 Labor: Safety and Health Regulations for Construction. July 1, 1999

The United States Department of Labor in 29 CFR 1926.800, *Code of Federal Regulations, Labor*, requires:

- The linear velocity of airflow in underground work areas shall be at least 30 feet (9.14 m) per minute where conditions of dust, fumes, mists, vapors, or gases in harmful or explosive quantities are present. [29 CFR 1926.800 (k) (3)],
- A minimum of 200 cubic feet (5.7 m³) of fresh air per minute shall be supplied for each employee underground. [29 CFR 1926.800 (k) (2)],
- The direction of mechanical airflow shall be reversible. [29 CFR 1926.800 (k) (4)],
- At least 100 cubic feet (2.8 m³) of air per minute for each brake horsepower of a diesel engine in addition to the air requirements for personnel. [29 CFR 1926.800 (k) (10) (ii)].

5. ASSUMPTIONS

5.1 DUST LOAD IN DUCT

Assumption: A four-inch layer of dust is deposited in the bottom of the duct. (CRWMS M&O 1998a, p. 3). This assumption is used in Section 6.4.

Rationale: Existing airflows in the alcoves and the ventilation system are relatively free of dust therefore the accumulation of dust in the ventilation duct is not likely. However, conditions may change in the future resulting in greater dust generation, which could deposit in the ductwork.

5.2 DUCT MATERIAL GAGE

Assumption: The galvanized steel used to fabricate the 24" and 36" Ø duct is 18 gage. This assumption is used to select the weight per lineal foot for the duct referenced in Section 4.1.2.

Rationale: The 48" Ø galvanized steel duct is 18-gage (CRWMS M&O 1998a). Therefore, 36" Ø galvanized steel duct gage used in calculations will be considered 18-gage.

5.3 SAFETY FACTOR

Assumption: A safety factor of 1.5 is used in the calculation for the load bearing capacity of the #9 gage wire and the wire rope. Used in Section 6.5.

Rationale: The tensile strength of the #9 gage wire ranges from 45,000 to 57,000 psi (Section 4.1.3). Using the low value of 45,000 psi combined with a 1.5 safety factor is adequate for design. Similarly, the wire rope nominal strength (Section 4.1.4 and 4.1.7) is used for design calculations, which combined with a 1.5 safety factor is adequate.

5.4 SEISMIC LOAD FACTOR

Not Used.

5.5 ALCOVE #7 VENTILATION FAN SILENCER WEIGHT

Assumption: In Alcove #7 a fan/silencer set does not have a documented silencer weight. It is assumed to weigh the same as the typical alcove fan/silencer combination. This is 2350 pounds. Used in Section 6.5.

Rationale: The silencers have the same diameter as the fan. Dimensionally the locally fabricated silencer is similar to the manufactured silencer. Therefore, it is assumed that the weight will be similar.

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6. ANALYSIS/MODEL

6.1 INTRODUCTION

This analysis examines the existing ventilation ducting and fans that were installed by the constructor, as temporary utilities, to ventilate the TS Loop alcoves. The ventilation duct and fans in these alcoves were installed during construction of the alcove and are not part of the design technical baseline. This analysis examines each alcove system and determines, based on OSHA and ESFDR requirements, if the system installations are adequate. If the existing systems do not meet the identified requirements, recommendations are made for modification to correct the deficiencies. A walk down was performed to observe the ventilation system configuration in each alcove. This included the location of dampers, fans and monitoring stations. This information was confirmed by design input transmittal (CRWMS M&O 1999c). In addition, the ventilation duct size, the ventilation fans and the suspension system in each alcove were noted during the walk down. Refer to Figure 1. For a general arrangement view of the alcove locations.

6.2 ALCOVE VENTILATION ARRANGEMENT

6.2.1 Alcove Ventilation Duct

The duct size and the suspension system in each alcove were noted during the walk down. They are identified in Table 4. (Section 4.1.1)

Table 4. Alcove Duct Size and Suspension Method

Alcove	Ventilation Duct	Support
#1 Inside the alcove	36" Ø fiberglass	Annealed #9 gage wire
#1 Outside the alcove	36" Ø galvanized steel	1/4" wire rope
#2	36" Ø galvanized steel	1/4" wire rope
#3	24" Ø galvanized steel	Annealed #9 gage wire
#4	24" Ø galvanized steel	Annealed #9 gage wire
#6	24" Ø galvanized steel	Annealed #9 gage wire
#7	24" Ø galvanized steel	Annealed #9 gage wire

6.2.2 Alcove Ventilation Fans

The fan/silencer arrangement was noted during the walk down (section 4.1.6). The weights are provide by the site engineering (Section 4.1.5). This is described in Table 5.

Table 5. Combined Fan and Silencer Weight

Alcove	Weight (lb)	Support
1 and 2 (common fan & silencer)	2350	two loops of 1/2" wire rope, four point anchor, free end around thimble set in a steel bracket spilt set bolted to the back, each secured with two Crosby clamps.
3	N/A	No fan
4	N/A	No fan
6	2350	two loops of 1/2" wire rope, four point anchor, free end through a steel bracket spilt set bolted to the back, each secured with three Crosby clamps.
7 (fan inside alcove)	2350*	
7 (fan outside alcove)	2350	

* Section 5.5

Figure 1. TS Loop General Arrangement
(Alcove location and fan location)

6.3 VENTILATION SYSTEM COMPARISON TO ESFDR REQUIREMENTS

6.3.1 Seismic

The seismic factor has been included in the design of the supports used for fans and ductwork. All installed ventilation equipment must meet the seismic design requirement of 0.3-g peak particle acceleration (Section 4.2.1). The capability of #9 gage wire and the ¼" wire rope as a ventilation system component are evaluated in Section 6.4.

6.3.2 Dust

The alcove ventilation system is in compliance with the criterion for operating in a dusty environment (Section 4.2.2). The fans used in the underground ventilation system are manufactured for the purpose of underground construction use where dusty conditions are common.

6.3.3 Temperature

The alcove ventilation system is in compliance with the criterion for operating in the specified temperature range (Section 4.2.3). The fans used in the underground ventilation system are manufactured for use in varying temperatures.

6.3.4 Relative Humidity

The alcove ventilation system is in compliance with the criterion for operating in the specified humidity range (Section 4.2.4). The fans used in the underground ventilation system are manufactured for use in the relative humidity range.

6.3.5 Service Life

The alcove ventilation system is in compliance with the criterion expressed for service life (Section 4.2.5). The ventilation duct and fans are installed overhead at the alcove back. This allows unobstructed movement of men and materials during construction and the operational/testing phases. Installation of the fans and ductwork in the alcoves and throughout the ESF allows removal and maintenance or replacement of items as necessary.

6.3.6 Standby Power

Electrical standby power is available in critical areas of the ESF to maintain operational function. Electrical standby power for the alcove ventilation systems addressed in this analysis is outside the scope of the criteria (Section 4.2.6). The alcoves are ancillary excavations not critical to the operation of the ESF, therefore, standby power is not a requirement.

6.3.7 Leakage

The existing alcove ventilation duct connections are made using couplers that are standard in industry and designed to minimize ventilation leakage (Section 4.2.7).

6.3.8 Performance

The alcove ventilation system is in compliance with the performance criterion (Section 4.2.8). The alcove ventilation systems are configured to remove dust from each alcove and direct the exhaust air into the flow-through ventilation air stream or the main exhaust duct in the TS Loop. Re-circulation of the ventilation air is prevented by exhausting directly out the North Portal through the 66" Ø ventilation duct or, by exhausting air from the alcove to the air stream in the TS Loop, which in turn is exhausted out the South Portal

6.3.9 Monitoring

The alcove ventilation system is in compliance with the criterion for monitoring (Section 4.2.9). The ventilation duct in each alcove is equipped with a monitoring station with a field verified location (CRWMS M&O 1999c). Pitot tube monitoring stations are located in each of the alcove ventilation ducts to allow monitoring by testing or Industrial Hygiene personnel.

6.3.10 Availability

The alcove ventilation system is in compliance with availability criterion (Section 4.2.10). Availability has been determined in excess of 98.95 percent (CRWMS M&O 1997a).

6.4 CALCULATION FOR WEIGHT PER FOOT OF DUST LADEN DUCT

Exhaust airflow in each alcove ventilation duct is free from heavy dust generation and accumulation of dust in the ductwork would not be likely. However, for conservatism in the event that large dust generating conditions could occur, the weight of the alcove ventilation duct will include a 4-inch layer of material in the bottom of the duct (Section 5.1). The following sample calculation is performed for a 36" Ø galvanized steel duct

Figure 2. Duct Cross-Section

- Calculation of Chord Angle

$$\text{Cosine } \alpha = 14/18 = 38.94^\circ \quad A = 38.94^\circ \times 2 = 77.88^\circ$$

- Cord Length

$$\text{Chord} = 2r \sin A/2 \quad (\text{CRWMS M\&O 1998a, p.3})$$

$$c = 2(18) \sin 38.94 = 22.62 \text{ inches}$$

- Arc Length

$$\text{Arc Length} = \pi r A/180 \quad (\text{CRWMS M\&O 1998a, p.3})$$

$$a = \pi (18) (77.88/180) = 24.46 \text{ inches}$$

- Contained Area

$$\text{Contained Area} = [(a r) - c(r-b)]/2 \quad (\text{CRWMS M\&O 1998a, p.3})$$

$$CA = [24.46 (18) - 22.62 (18-4)]/2 = 61.80 \text{ in}^2 = 0.429 \text{ ft}^2$$

- Dust Density = 100 lb/ft³ (Section 4.1.8)
- Weight of dust per Lineal Foot: 100 lb/ft³ (0.429 ft²) = 42.9 lbs./ft
- Weight of 36 " Ø 16-gage galvanized steel duct: 23.0 lb./ft (Section 4.1.2)
- Weight of Dust Laden Duct: 42.9 + 23.0 = 65.9 lbs./ft
- Weight of 20 ft Section of Dust Laden Duct: 1318 lbs.
- Seismic Load Factor 1.3 (Section 4.2.1)

$$\text{Adjustment For Seismic Activity: } 1.3 (1318) = 1713 \text{ lbs.}$$

Under a seismic load condition, a dust laden 20-foot section of 36" Ø galvanized steel duct could exert a force of 1713 pounds. Calculating this value for the 24" Ø galvanized steel duct will yield a 1292 pound force.

6.5 LOAD BEARING CAPACITY OF SUSPENSION ARRANGEMENT

Tensile strength of #9 gage wire varies between 45,000 psi and 57,000 psi (Section 4.1.3). In order to be conservative, the lower value is applied in the following calculation to determine the static load limit.

Wire diameter = 0.148 " (Section 4.1.3)

$$\text{Cross-sectional area of wire} = \pi r^2 = \pi(0.148/2)^2 = 0.0172 \text{ in}^2$$

Tensile strength = 45,000 psi (Section 4.1.3)

Static load supported by a single strand of #9 gage wire

Factor of safety 1.5 (Section 5.3)

$$0.0172 \text{ in}^2 (45,000 \text{ lbs/in}^2) / 1.5 = 516 \text{ lbs.}$$

The ventilation duct is described as being supported by a loop of #9 gage wire, routed under the duct, forming a basket arrangement. The free ends of the wire are fixed to the back by various methods (Section 4.1.1). The static load bearing capacity of two strands of #9 gage wire, in the aforementioned configuration, is four times that of the single strand, or 2064 pounds. Therefore, each 20 foot section of either 36" Ø or 24" Ø galvanized steel ventilation duct could theoretically be supported with two loops of #9 gage wire. However, in practice the #9 gage wire is not recommended to be used to support ventilation duct for the following reasons: The terminations are not consistent, ie. twisted off on the underside of the duct, passed through wire mesh and passed through the punched hole in the roofbolt washer (which exposes the wire to the sharp edge of the punched hole) (Section 4.1.1). This raises safety concerns for using #9 gage wire to support overhead loads. An accurate, defensible structural analysis is difficult to justify since the #9 gage wire does not have a design load such as wire rope (nominal strength) (Section 4.1.4).

Static load supported by an individual ¼" wire rope

Factor of safety 1.5 (Section 5.3)
Nominal Strength ¼" Wire Rope 7000 lbs (Section 4.1.4)

$$7000/1.5 = 4667 \text{ lbs.}$$

The ¼" wire rope will more than adequately support the ventilation duct.

Static Load supported by an individual strand of ½" wire rope

Factor of safety 1.5 (Section 5.3)
Nominal Strength ½" Wire Rope 26,600 lbs. (Section 4.1.7)

$$26600/1.5 = 17733 \text{ lbs.}$$

Maximum Fan/silencer Weight 2350 (Section 4.1.5)

The ½" wire rope will more than adequately support the fan/silencer unit. The ¼" wire rope can support the fan/silencer unit, however ½" wire rope is recommended for greater abrasion

resistance. The ½" wire rope should be attached to a fixture that has a minimum load bearing capacity of 2000 pounds (CRWMS M&O 1998b).

6.6 VENTILATION SYSTEM COMPARISON TO CODE REQUIREMENTS

Volume measurements of airflow taken in December 1999 (Dresel, R.R 2000), in the TS Loop alcoves are documented in Table 2 (Section 4.1.9). The corresponding linear velocity in each alcove is calculated in Table 6. The individual alcove cross sectional areas is documented in Table 3 (Section 4.2.0).

Table 6. Linear Airflow in Alcoves

Alcove	Average Flow, CFM (4.1.9)	Area, Sq. Ft. (4.2.0)	Velocity, FPM
Alcove #1, Upper Tiva Canyon	17,100	322	53
Alcove #2, Bow Ridge Fault	13,400	131	102
Alcove #3, Upper Paintbrush Tuff	0	131	0
Alcove #4, Lower Paintbrush Tuff	12,230	131	93
Alcove #6, Northern Ghost Dance Fault	13,950	147	95
Alcove #7, Southern Ghost Dance Fault	14,330	147	97

By inspection of Table 6., it can be noted that 29CFR1926.800(k)(3), linear air velocity of at least 30 fpm, is satisfied for all the alcoves except Alcove #3.

Using the lowest airflow value of 12,230 cfm in Alcove #4, as a benchmark, suggests that the maximum occupancy in an alcove is 61 people in order to be in compliance with 29CFR 1926.800(k)(2); 200 cfm of fresh air supplied to each person underground.

Again using Alcove #4 airflow as the benchmark suggests that a piece of diesel equipment with one operator should not register more than 120 brake horsepower. This horsepower rating would be reduced by 2 brake horsepower for each additional person that is in the alcove.

The requirement for 29CFR1926.800(k)(4), that mechanical induced airflow be reversible, can be satisfied with the installation of reversible ventilation fans to service the alcoves.

7. CONCLUSIONS

The following conclusions have been determined by this analysis:

1. The TS Loop Alcoves #1 through #7, excluding Alcove #5 which is not in the scope of this analysis, satisfy the criteria set forward in the ESFDR.
2. The TS Loop Alcoves #1, #2, #4, #6 and #7 satisfy 29CFR1926.800(k)(3), the linear airflow velocity. Alcove #3 requires corrective action to bring it into compliance with 29CFR1926.800(k)(3). The maximum number of persons allowed in an alcove (based on the alcove with the lowest airflow) is 61. This will satisfy 29CFR1926.800 (k)(2). In order to satisfy 29CFR1926.800(k)(10)(ii) the largest piece of diesel equipment, with an operator, that would be allowed in an alcove (based on the alcove with the lowest airflow) is limited to 120 hp. This would be decreased by 2 hp for each additional person that is in the alcove. The requirement for 29CFR1926.800(k)(4), that mechanical induced airflow be reversible, can be satisfied by using reversible ventilation fans to service the alcoves.
3. Replace the #9 gage wire that is used to suspend the ventilation duct in Alcoves #1, #3, #4, #6 and #7 with ¼" wire rope. Number #9 gage wire is not a structural support member. In addition, using wire twists for termination is not quantifiable, therefore, it can not be analyzed for load bearing capacity.
4. As a minimum, use two separate loops of ¼" wire rope to support each section of ventilation duct. The ¼" wire rope can support the fan/silencer unit, however ½" wire rope is recommended for greater abrasion resistance. As a minimum, use two separate loops of ½" wire rope to support the ventilation fan and silencers. This arrangement ensures four anchor points. Utilizing thimbles to prevent kinks in the wire rope and contact with sharp edges. Wire rope attachment and termination to wire mesh is not acceptable.
5. Terminate the free ends of the wire rope with either Crosby Clamps or swaged connectors following the manufacturers suggested guidelines.
6. Wire rope terminations should be secured to structurally definable fixtures, with a minimum 2000 pound load bearing capacity. These structurally definable fixtures include: rock bolts, eyebolts, load bearing brackets etc.

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8. INPUTS AND REFERENCES

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8.2 REGULATIONS, STANDARDS, AND DIRECTIVES CITED

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