OVERALL DEVELOPMENT

AND

EMPLACEMENT

VENTILATION

SYSTEMS

7.5.10 Muck Conveyors

Muck conveyors are a potential source of airborne dust. Muck from the excavated face, which is usually fairly wet when placed on the conveyor, dries out as it travels on the conveyor through the airstream. Water sprays placed at intervals along the conveyor will minimize dust from the conveyor contaminating the airstream. Conveyor transfer and drop points should be enclosed and provided with water sprays. Scraper and spray wash will wash return belts and idlers.

7.5.11 Airways, Haulage Ways, Mine Cars and Dumping Stations

a) Airways and rail haulage ways

Cleaning the walls and floors of airways and rail haulage ways, by periodically washing down or vacuuming, will remove many potential dust sources. Concrete lined openings facilitate cleaning. Residual dust and dirt should not be allowed to accumulate in the airways and haulage ways as these represent potential dust sources.

b) Mine cars

Keeping the muck in the mine cars wet reduces the potential for creating dust. Overloading cars must be avoided as it can lead to spillage which then becomes another potential dust source. Washing mine cars regularly will keep them free of dirt and dust, and parking a loaded mine car for a long periods should be avoided as this allows the muck to dry out. If feasible, major route of mine cars should not be along primary intake airways.

c) Dumping Stations

Subsurface muck car dumping stations represent major potential dust sources. Enclosure and bypass airways can be installed to avoid high velocity air/dust contact. Water spray at dump activated during dumping will wet the muck and suppress dust. Local dust scrubbers located at the dumps will clean dusty air that escapes from the dump station enclosures. Choice of location and equipment for dump stations must prioritize dust control.

7.5.12 Leakage and Recirculation of Contaminated Air from Exhaust Ducts

Leakage from exhaust ducts containing contaminated air and subsequent recirculation of the leakage contributes to dust problems. Measured leakage during ESF construction

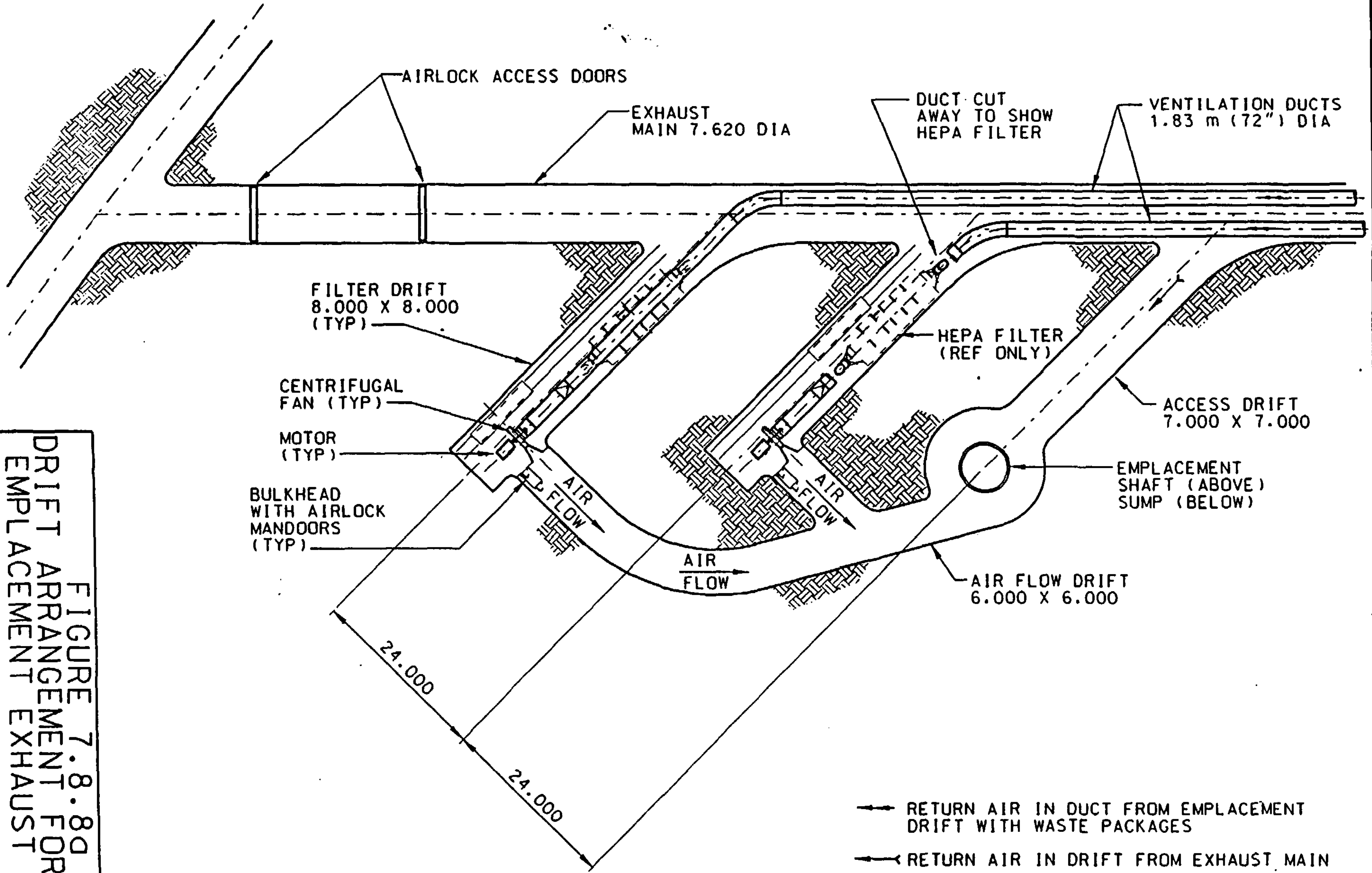

FIGURE 7.8.8a
DRIFT ARRANGEMENT FOR AUX EMPLACEMENT EXHAUST FANS

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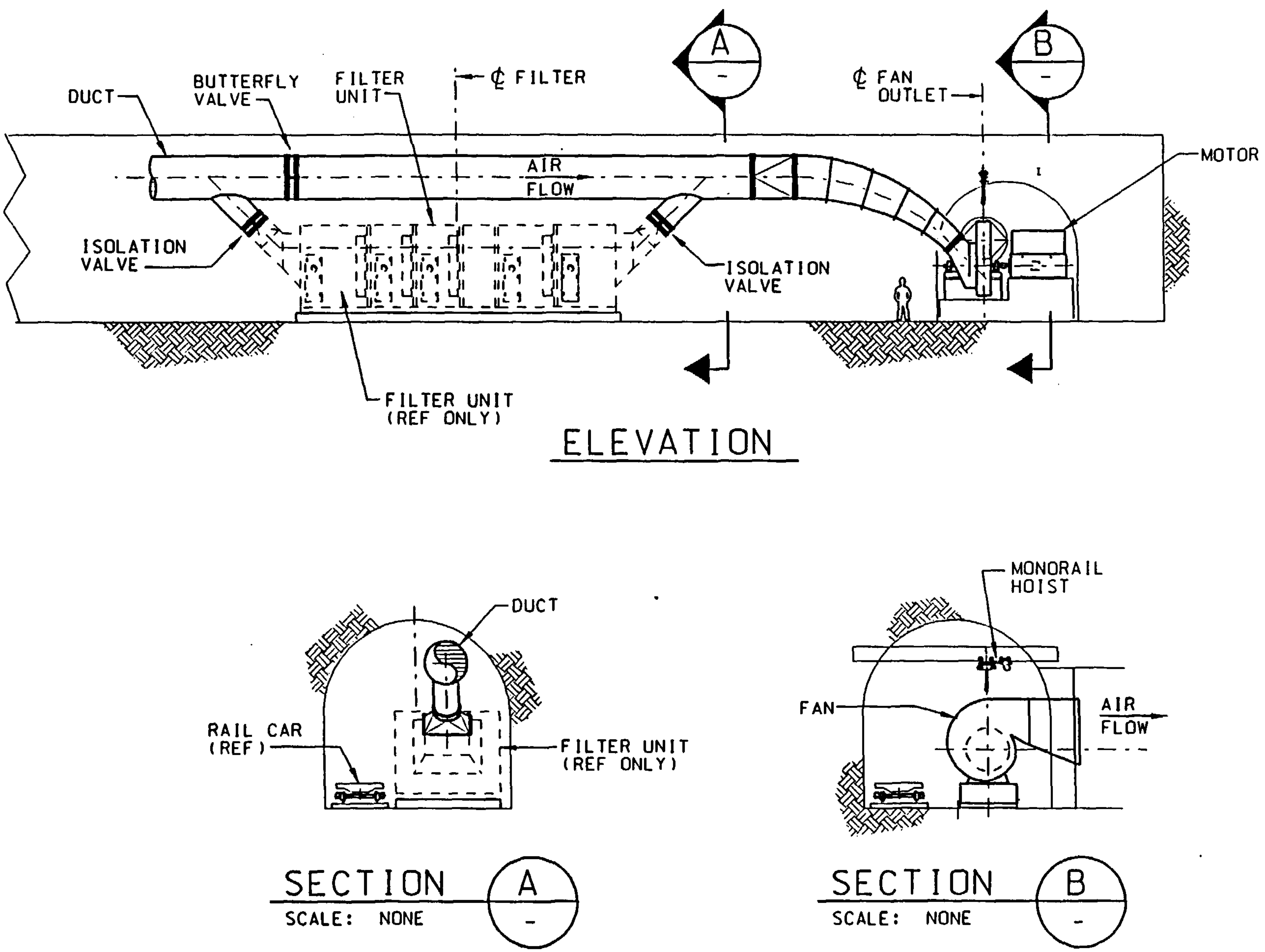

FIGURE 7.8.8b
AUXILIARY EMPLACEMENT EXHAUST
FAN ELEVATION ARRANGEMENT

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Design Analysis Cover Sheet

Complete only applicable items.

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TABLE OF CONTENTS

List of Figures

List of Tables

1. PURPOSE

The purpose of this analysis is to develop an overall ventilation system plan for the repository subsurface emplacement operations and development activities. The objective is to provide an overall ventilation design that meets applicable subsurface ventilation requirements of the current waste isolation strategy.

The scope of this analysis covers defining the overall ventilation strategy for emplacement and development side ventilation systems, and separation of these systems in compliance with requirements. The ventilation system will be designed for normal and abnormal situations with flexibility to handle all phases of repository construction and operations. The task includes developing ventilation approaches, and analyzing primary airflow networks and air control systems for the construction, development, emplacement, performance confirmation, caretaker, and potential retrieval, backfill, and closure phases. The emplacement drift ventilation approach will address airflow control through the access control doors. The overall ventilation design will address the quality and quantity of ventilation air required for personnel and equipment, cooling necessary for human and equipment access in openings subjected to heating from emplaced waste, and means for controlling dust created by construction activities. The analysis will also address scenarios for cooling of the emplacement drifts during the preclosure period. The analysis will identify the primary and auxiliary ventilation equipment needed for repository construction and operations.

The scope of this analysis does not include examination of the requirements for HEPA filters on the emplacement side exhaust air shaft and design of these systems, the design of the emplacement drift access control doors, and design of the isolation airlocks (barriers) between the emplacement and development activities. These items and more detailed examination of airflow control in the emplacement drifts will be covered in other analyses.

2. QUALITY ASSURANCE

The ventilation system will support life safety, construction and operation of the repository. This analysis covers the temporary ventilation during construction and the permanent ventilation of the repository during operation and caretaker phases until closure. The quality assurance classification of repository ventilation structures, systems, and components has not been performed in accordance with QAP-2-3, *Classification of Permanent Items*. However, repository emplacement ventilation is on the *Q-List* (Reference 5.1) by direct inclusion.

This ventilation design activity for the repository emplacement side has been evaluated in accordance with QAP-2-0, *Conduct of Activities*, and has been determined to be quality affecting and subject to the requirements of the *Quality Assurance Requirements and Description* (QARD)

(Reference 5.2). The analysis is subject to quality assurance controls in accordance with NLP-3-18, *Documentation of QA Controls on Drawings, Specification, Design Analyses, and Technical Documents.*

Some of the input data used in this analysis are preliminary and unqualified and, therefore, the outputs are also unqualified. Unqualified input will be noted as TBV, however, because of the preliminary nature of this analysis, the formal tracking of TBVs described in NLP-3-15, *To Be Verified (TBV) and To Be Determined (TBD) Monitoring System* is not applicable. This analysis will not be used for procurement, fabrication, or construction.

3. METHOD

3.1 Analytical methods are used in the following steps:

3.1.1 Repository subsurface layout from other analyses are identified. Ventilation configuration and requirements are established.

3.1.2 Auxiliary ventilation and local airflow requirements applicable to specific type of construction method are determined.

3.1.3 Primary ventilation circuitry and general equipment requirements are analyzed using appropriate computer software.

3.1.4 Features of ventilation operation, maintenance and dust control are addressed.

3.1.5 Conclusions and recommendations are provided to serve as the implementation guide for the repository ventilation system during the viability assessment phase of the repository design.

3.2 Abbreviations of Ventilation Terms Used

ahp	air horsepower, energy
bhp	brake horsepower, energy
cfm	cubic feet per minute, air quantity
Db	dry bulb, temperature
fpm	feet per minute, air velocity
ft	feet, measure of length or distance
HEPA	High Efficiency Particulate Air
k	kilo
kPa	kilo Pascals, pressure
kg	kilogram, weight or mass

lb	pound, weight or mass
m	meter, measure of length or distance
m/s	meters per second, air velocity
m^3/s	cubic meters per second, air quantity
RPU	VNETPC Computer input for resistance units
w	watt, energy
Wb	wet bulb, temperature
wg	water gauge, measure of pressure

4. DESIGN INPUTS

4.1 DESIGN PARAMETERS

4.1.1 The current VA repository layout (Reference 5.5) shown in Figure 7.1 is used to establish the general configuration of the ventilation system. Airway distances used are measured from the layout shown in References 5.32 and 5.33. All drift lengths and sizes are TBVs except the ESF openings. A simplified VA layout and distances of branches or nodes are shown on page 2 of Attachments I, II and III. These data are TBVs used as computer input to determine resistances of the airways.

4.1.2 The repository ventilation design is based on non-gassy mine classification operation as currently established in the ESF operation (Reference 5.29). This classification will remain in force for the repository operation unless methane gas is detected in the repository development.

4.1.3 The construction sequence is based on the current VA subsurface construction and development schedule (References 5.21 & 5.22)

4.1.4 Waste packages will be placed center in-drift, on pedestals, using gantry emplacement (Reference 5.9).

4.1.5 Joy and Howden Buffalo fan curves (References 5.11 & 5.31) were used to size the major fans in the computer model. These fan curves (TBV) are shown in Attachments I, II and III.

4.1.6 The thermal loading study (Reference 5.17) calculated the heat flow and temperatures of emplacement drifts as a series of finite drift segments and divided the entire ventilation time period of interest into a number of short time steps. The outcome formed a comprehensive description of the heat transfer process for the entire drift at different times after emplacement.

In this report the areal mass loading was 83 MTU/acre with continuous ventilation through a 600 m long emplacement drift. The maximum temperature occurred at a certain period after emplacement and is summarized in Table 4.1.6.

Table 4.1.6 Calculated Maximum Air Temperature in Emplacement Drift for Continuous Ventilation

Continuous Ventilation at Air Quantity m^3/s (cfm)	Year After Emplacement When Maximum Temperature Occurs Year	Maximum Exit Air After 200 m From Intake °C	Maximum Exit Air After 400 m From Intake °C	Maximum Exit Air After 600 m From Intake °C
0.1 (212)	73.0	108	133	141
0.6 (1,271)	44.0	74	104	121
1.0 (2,118)	26.5	63	89	107
2.0 (4,237)	19.5	49	68	83
5.0 (10,593)	14.0	37	47	56
10.0 (21,186)	8.5	32	38	43

4.1.7 The repository thermal loading management analysis (Reference 5.18) evaluated drift temperature on the basis of the new repository layout used in the viability assessment analysis. This is the layout used in this analysis. The results indicated that without ventilation, an emplacement drift loaded with WPs having an average thermal output will reach a maximum wall rock temperature of 172 °C about 40 years after emplacement. The cases modeled have drift spacings of 28 m at the currently recommended areal mass load of 85 MTU/acre. The analysis did not calculate drift temperatures with continuous ventilation. However, it is anticipated that emplacement drifts loaded with WPs and continuously ventilated will have drift temperatures considerably lower than 172 °C. This trend is illustrated by previous thermal modeling analysis for 83 MTU/acre shown in Table 4.1.6.

The temperature data shown in Table 4.1.6 are the only available information on continuous ventilation. Because of close relationship between the thermal models of 83 and 85 MTU/acre, the data in Table 4.1.6 will be used in this analysis.

4.2 CRITERIA

The design criteria for the underground facility ventilation system were developed based on the requirements from the Repository Design Requirements Document (RDRD) (Reference 5.3).

4.2.1 The underground facility ventilation system shall be designed to:

1. Control the transport of radioactive particulates and gases within the underground facility; [RDRD 3.7.5.B.1]

2. Assure continued function during normal operations and under accident conditions; [RDRD 3.7.5.B.2]

3. Separate the ventilation of excavation and waste emplacement areas; [RDRD 3.7.5.B.3]

4. Ensure that ventilation leakage between the emplacement system and the development system will always be from the development system to the emplacement system; [RDRD 3.7.5.B.4]

5. Take into account geologic conditions encountered during in situ monitoring, testing, or development of subsurface facilities, which affect air contaminant levels, temperatures, or other conditions; [RDRD 3.7.5.B.5]

6. Supply air to and exhaust adequate quantities from underground working areas such that operator safety, health and productivity requirements are maintained; [RDRD 3.7.5.B.6]

7. Contain safety features in accordance with 30 CFR 57. [RDRD 3.7.5.B.7, RDRD 3.3.6.6.G]

4.2.2 The ventilation components important to safety are designed to permit periodic inspection, testing, and maintenance as necessary to insure their continued functioning and readiness. [RDRD 3.5.1]

4.2.3 All underground airways needed for repository operation, monitoring and performance confirmation shall be provided with ventilation for accessibility and maintainability until closure. [RDRD 3.7.5.E.5, RDRD 3.2.1.3]

4.2.4 Not used.

4.2.5 Not Used.

4.2.6 Specific criteria for gas and dust control shall be based on the threshold limit values adopted by American Conference of Governmental Industrial Hygienist (ACGIH). [RDRD 3.3.11.1.C]

4.2.7 Not Used.

4.2.8 The repository shall be designed to provide means to limit concentration of radioactive material in air, means to monitor and control dispersal of radioactive contamination. [RDRD 3.7.7.A.1, RDRD 3.7.7.A.4]

4.2.9 Subsurface repository operation involves continuous ventilation of repository airways until closure. To provide radiological protection to repository workers, and to have a positive control on potential radiological exposure to as low as is reasonably achievable (ALARA), the subsurface repository ventilation design will include isolated return airways, isolation barriers and separate ventilation between emplacement and development. Use of HEPA filters and absorbers are covered by a separate analysis. [RDRD 3.2.1.1.D, RDRD 3.2.1.2.C, RDRD 3.2.1.3, RDRD 3.2.1.4.C, RDRD 3.2.2.1.A, RDRD 3.2.2.1.B, RDRD 3.2.2.1.D, RDRD 3.2.2.2.A, RDRD 3.2.2.2.C]

4.2.10 Repository underground ventilation system shall be constructed with flexibility so as not to preclude expansion of its basic mission (e.g., increased disposal capacity). RDRD 3.2.8]

4.2.11 Safety and Health protection systems shall be provided in underground spaces as required by 30 CFR 57, 29 CFR 1926 to afford the greatest protection. [RDRD 3.3.6.5]

4.2.12 Rock drilling (or face excavation) shall be controlled by use of water, dust collector ventilation or other approved methods or devices that are effective in controlling dust [RDRD 3.7.5.G.1]

4.2.13 System, Structure and Component Reliability (SSCs) that are important to safety shall be designed and located so that they continue to perform their safety function effectively during and after credible fire and explosion conditions in the GROA. [RDRD 3.2.5.1.3]

4.2.14 The ventilation system shall be designed to support the repository maintainable service life of 100 years or as authorized by the license granted by NRC. (RDRD 3.2.5.4.A)

4.2.15 The ventilation system is a utility service important to safety, and shall be designed so that essential function can be performed under normal and accident conditions. (RDRD 3.2.5.1.4.A)

4.2.16 The underground air environment shall be monitored for air constituents such as gases and dust, and air quantity. [RDRD 3.7.3.7.E, 3.3.11.1.C]

4.2.17 Critical ventilation fan systems shall have electrical standby power to retain full operational function when primary power is lost. A reduced level of ventilation necessary to support critical activities will be acceptable, since repository operations will be curtailed during a power outage. (RDRD 3.7.3.2.A, RDRD 3.7.3.2.D)

4.2.18 Ventilation equipment shall be provided with noise attenuators as required by OSHA. (RDRD 3.3.11.7)

4.3 ASSUMPTIONS

The assumptions contained in the *Controlled Design Assumptions Document* (CDA), B00000000-01717-4600-00032 Rev. 04 (Reference 5.4) are used. Some parts of this analysis evaluated and justified these assumptions to be acceptable. When referred and quoted, the CDA document assumptions in this section contain only the items that have been used in the evaluations of the subsurface ventilation system. Justifications for assumptions from the CDA are contained in that document.

4.3.1 No human entry is planned in emplacement drifts while waste packages are present. The waste emplacement/retrieval equipment may use robotics and/or remote control features to perform operations and monitoring within the emplacement drifts. Under abnormal conditions, human entry will be considered if protection to the workers can be provided. (Reference 5.4, CDA, Key 013) (Used throughout the analysis).

4.3.2 The repository will be designed for a retrievability period of up to 100 years after initiation of emplacement. (Reference 5.4, CDA, Key 016) TBV (Used in Section 7.4.5 and 7.11.1)

4.3.3 Surface, subsurface and waste package designs will be based on a reference thermal load of 80-100 MTU per acre. (Reference 5.4, CDA, Key 019) TBV (Used throughout the analysis)

4.3.4 For the reference mass loading of 80-100 MTU per acre, the repository horizon will be located mainly in the TSw2 geologic unit within the primary area. (Reference 5.4, CDA, Key 022) TBV (Used throughout the analysis)

4.3.5 The primary method of tunnel excavation will be mechanical. (Reference 5.4, CDA, Key 027) (Used in Section 7.4.1)

4.3.6 Backfill in emplacement drifts is not required. However, the repository ventilation design should not preclude the use of emplacement drift backfill at the end of the preclosure period. (Reference 5.4, CDA, Key 046) (Used throughout the analysis)

4.3.7 The proposed repository waste handling and administrative surface facilities will be located adjacent to the north portal. (Reference 5.4, CDA, Key 047) TBV (Used in Section 7.6.1.2 and 7.8.1)

4.3.8 Repository design and operation shall provide facilities, access, instrumentation, recording, maintenance, and support for measuring/monitoring the performance confirmation (Reference 5.4, CDA Key 061) (Used throughout the analysis)

4.3.9 Waste packages will be placed center in-drift, on pedestals, using gantry emplacement. (Reference 5.4, CDA, Key 066) This emplacement mode is the confirmed method to be used in the VA analysis (Reference 5.9) (Used in Section 7.4.1.3)

4.3.10 Blast Cooling will be used if the drift must be cooled for maintenance or WP retrieval. Emplacement drift ventilation will be maintained at a low, controlled volume for monitoring purposes. (Reference 5.4, CDA, Key 067) (Used in Section 7.4.1.4)

4.3.11 The North Ramp will be used for waste transport. (Reference 5.4, CDA, Key 068) TBV (Used in Section 7.8.1)

4.3.12 Maximum allowable air velocity in:

Ramps:	7.6 m/s
Ventilation Shaft:	20.3 m/s
Personnel Shaft:	11.7 m/s
Emplacement Drifts during Construction:	3.0 m/s
Exhaust Mains:	10.2 m/s
Service Mains:	7.6 m/s
Waste Handling Main:	7.6 m/s
Ductwork:	30.5 m/s

(Reference 5.4, CDA, DCSS 016) TBV (Used throughout the analysis)

4.3.13 Minimum required air velocity in:

	(For Active Excavation)	(For Development Maintenance)
Ramps:	0.51 m/s	0.31 m/s
Shafts:	0.51 m/s	0.31 m/s
Emplacement Drifts:	0.51 m/s	0.31 m/s

Exhaust Mains:	0.51 m/s	0.31 m/s
Service Mains:	0.51 m/s	0.31 m/s
Waste Handling Main:	0.51 m/s	0.31 m/s
Ductwork:	12.7 m/s	10.2 m/s

(Reference 5.4, CDA, DCSS 017) TBV
(Used throughout the analysis)

4.3.14 Minimum required air volume per:

Diesel kW:	0.0791 (m^3/s)kW
Underground Worker:	0.0944 (m^3/s)/person

(Reference 5.4, CDA, DCSS 018) Section 4.4 (Used in Section 7.4)

4.3.15 Maximum allowable air temperature in emplacement drifts during:

Construction:	27°C effective
Emplacement:	50°C dry-bulb, only in portion requiring access
Caretaker:	no limit, determined by rock temperature
Retrieval:	50°C dry-bulb, only in portion requiring access
Backfilling:	50°C dry-bulb

(Reference 5.4, CDA, DCSS 019) TBV
(Used throughout the analysis)

4.3.16 Maximum allowable air temperature in access (ventilation intake) mains during:

Construction:	27°C effective
Operations:	27°C effective
Caretaker:	27°C effective
Retrieval:	27°C effective
Backfilling:	50°C dry-bulb

(Reference 5.4, CDA, DCSS 020) TBV
(Used throughout the analysis)

4.3.17 "K" factors for ventilation airflow in:

Shafts:	
Ventilation Shaft	0.0030 kg/m^3
Man-and-Material Shaft	0.0176 kg/m^3
Ramps:	
Waste Ramp	0.0056 kg/m^3
Tuff Ramp	0.0111 kg/m^3
Exhaust Mains:	0.0111 kg/m^3

Service Mains:	0.0130 kg/m^3
TBM Launch Mains:	0.0130 kg/m^3
Waste Main:	0.0111 kg/m^3
Emplacement Drifts:	
Without Waste Packages	0.0130 kg/m^3
With Waste Packages	0.0158 kg/m^3
Emplacement Exhaust Pipe/Duct	0.002 kg/m^3

(Reference 5.4, CDA, DCSS 022) TBV
(Used throughout the analysis)

4.3.18 Maximum allowable air temperature in exhaust mains during:

Construction:	27°C effective
Operations:	50°C dry-bulb
Caretaker:	50°C dry-bulb
Retrieval:	≤ emplacement drift rock surface temperature
Backfilling:	50°C dry-bulb

(Reference 5.4, CDA, DCSS 029) TBV
(Used throughout the analysis)

4.3.19 The ventilation systems for the emplacement and development areas shall be designed such that there is a net pressure differential between development and emplacement areas by approximately higher than 189-531 Pa (0.76 to 2.14 inches water gage). The development area shall be higher than the emplacement area to direct air leakages from development to emplacement side. (Reference 5.4, CDA, DCSS 039) TBV (Used in Section 7.4.8)

4.3.20 VNETPC input values, equivalent resistance for net leakages. One VNETPC unit is 1/10 $in.min^2/ft^6 = 0.1117 \times 10^9\ N.s^2/m^8$ These are general practice ventilation control equivalents used in computer modeling of ventilation network to determine system leakages. (Reference 5.6).

Airlock Doors	1000 units
Emplacement Door Regulators (Range)	1 to 500 units
Gate Valve Regulators (Range)	0.21 to 99,000 units
Development/Emplacement Barrier, each	1000 units
Total Fan Bulkhead	2000 units

The units are appropriate and reasonable for repository VA ventilation design.
TBV (Used in Section 7.10)

4.3.21 Not used.

4.3.22 The temperature (Db) reaching the emplacement drift inlet varies from 10 to 26.7 °C (50 to 80 °F) at 20 to 40% relative humidity. This is based on current experience of the ESF and NTS tunnels during winter and summer seasons (References 5.20 and 5.27) TBV (Used in Sections 7.4.1.4 and 7.4.9.3)

4.3.23 Equivalent length used to account for joints and minor misalignment is +10% of the total duct or drift length. These are general practice equivalents used for computer modeling (Reference 5.6) (Used in Section 7.10).

4.3.24 Power cost is preliminarily estimated at ten cents per kilowatt-hr. This input to the program is used to estimate and to compare the cost of flow in individual airways. Any future change of this cost will not have any significant effect on the outcome of this VA ventilation analysis. (Used in Section 7.10)

4.4 CODES AND STANDARDS

4.4.1 30 CFR 57 - Safety and Health Standards - Underground Metal and Nonmetal Mines, 7/1/96

4.4.2 29 CFR 1926 - OSHA Safety and Health Regulations for Construction, 7/1/96

4.4.3 29 CFR 1910 - Occupational Safety and Health Standards, 7/1/96

4.4.4 40 CFR 51 - Requirements for Preparation, Adoption, and Submittal of Implementation Plans, 7/1/96

4.4.5 1994-1995 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices, American Conference of Governmental Industrial Hygienist (ACGIH).

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Rev.00, CRWMS M&O.

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5.18 *Repository Thermal Loading Management Analysis*, B00000000-01717-0200-00135 Rev. 00, CRWMS M&O.

5.19 *Second International Mine Ventilation Congress* (Chapters 2 through 5), SME 1980, P. Mousset Jones, Editor.

5.20 *Subsurface Ventilation Analysis - Construction Phase*, BABFAD0000-0171-0200-00001 Rev. 00, CRWMS M&O

5.21 *Subsurface Construction and Development Analysis*, BCA000000-01717-0200-00014, Rev.00, CRWMS M&O

5.22 *Subsurface Construction and Development Schedule Analysis*, BCA000000-01717-0200-00013, Rev.00

5.23 *Report Letter of Dr. Fred Kissel from the U.S. Department of Health and Human Services, NIOSH to Charlie Parker of CRWMS M&O, on ESF SF_6 Test Result* dated April 8, 1997, Batch Number MOY-970819-02.

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5.27 *ESF Underground Temperature Data, August 1995 to January 1997 for Stations 1+70, 7+54 and 28+26* - IOC Kramer to File, LV.RD.NK. 4/97-013., CRWMS M&O

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5.29 *Non-Gassy Mine Classification Analysis*, BABE00000-01717-0200-00015 Rev. 00, CRWMS M&O

5.30 *Not Used.*

5.31 *Buffalo Howden Fan Catalog*, Buffalo Forge, The Howden Fan Company

5.32 *Figure 7-1a Subsurface Repository Layout for VA Design*, BCA000000-01717-0200-00008 REV 00, Batch Number MOY-970708-04, CRWMS M&O.

5.33 *Figure 7-11a Performance Confirmation Facilities for VA Design*, BCA000000-01717-0200-00008 REV 00, Batch Number MOY-970708-04, CRWMS M&O.

6. USE OF COMPUTER SOFTWARE

VNETPC VERSION 3.1, Ventilation Simulation with Gas Distribution computer software and Lotus 1-2-3 for Windows spreadsheet are used in this analysis.

6.1 VNETPC VERSION 3.1 SOFTWARE

6.1.1 Software Verification and Validation

VNETPC Software, Version 3.1 is used to simulate the overall repository ventilation flow network. The application of the software is only used within the validated range as described in the Verification and Validation documentation of VNETPC Software No. CSCI 20.93.3003-AAu3.1 (Reference 5.13).

6.1.2 VNETPC Software Use and Function

VNETPC software is appropriate for simulating the repository ventilation operation. It is a self-contained package of programs commercially available and widely used by the mining industry for mine ventilation modeling. When given the input data that describe the geometry of the mine network, airway resistances or dimensions, the locations and characteristic curves of fans, and the site emission rate of gas sources, the program will produce tabulated listings and graphical plots of the following: branch airflows; frictional pressure drop; pressure at junctions; airway resistances; air power losses in airways; ventilation cost per airway; fan operating points (pressure and airflows); duties required by regulators and booster fans; gas flows in branches; and gas concentration in branches. (Reference 5.12)

6.1.3 General Steps to Simulate Ventilation Computer Model

The general steps taken to model the repository ventilation are as follows:

a) Primary intake and exhaust airways are identified.
b) Construction sequence and general airflow requirements are established.
c) Ventilation schematics appropriate for various stages of operation are designed.
d) Primary main and booster fans (if needed) are located.
e) Critical auxiliary systems are selected. These are systems for heat isolation and potential radionuclide removal in the emplacement area, and dust control systems in the development area.
f) Resistances for all branches are calculated
g) Computer model of the phased ventilation system is built.
h) Simplified head loss calculation and initial mine fan characteristics are determined.
I) Ventilation network simulation cases are run to satisfy specific ventilation requirements. These are accomplished by adjusting selected resistances, fan performances, regulators and ventilation controls until a computer output satisfies a viable model. Alternate setups are also considered from the standpoint of operational flexibility and safety.
j) Output of simulated models that satisfy the ventilation goals are printed and plotted, and are included as attachments to this analysis. Conclusions and recommendations are based on the computer model results.

Input and output listings of the computer model are shown in Attachment I, II and III of this report.

6.2 LOTUS 1-2-3 FOR WINDOWS SPREADSHEET

Lotus 1-2-3 for Windows, Release 5 is a common, off-the-shelf computer spreadsheet program. It is used to calculate the following parts of the analysis:

6.2.1 Attachment I - Calculation spreadsheet for airway resistances used as input to VNETPC software during early emplacement/early development.

6.2.2 Attachment II - Calculation spreadsheet for airway resistances used as input to VNETPC software during late emplacement/late development.

6.2.3 Attachment III - Calculation spreadsheet for airway resistances used as input to VNETPC software during caretaker.

6.2.4 Attachment IV - Calculation spreadsheet to compare various development ventilation options at base 100 and 30 fpm minimum air velocity in drifts. The spreadsheet calculates the length and size of ducts, energy requirements and number of fans needed in the option.

6.2.5 Attachment V - Calculation spreadsheet for air psychrometry to predict air characteristics through inlet and outlet of emplacement drifts, and the heat stress index (effective temperature) at low air velocity of repository environment.

6.2.6 Attachment VI - Calculation spreadsheet for operational flexibility of fans and comparative performance of ventilation pipes as emplacement exhaust duct.

7. DESIGN ANALYSIS

7.1 INTRODUCTION

This analysis addresses the ventilation system design for all phases of repository construction and operations. The intent is to provide a design with a degree of flexibility to handle both the normal and abnormal (unforseen) situations. The analysis develops ventilation approaches and analyzes primary airflow networks and air control systems for the construction, development, emplacement, performance confirmation, caretaker, retrieval, backfill, and closure modes. The analysis addresses the quality and quantity of ventilation air needed for personnel and equipment, and develops an approach for separation of the emplacement and development area ventilation systems.

The current reference VA repository layout as shown in Figure 7.1 (Section 4.1.1) is used in the analysis as a basis for developing the overall ventilation system. The construction sequence from early development and emplacement phases and the construction schedule (Section 4.1.3) provides a basis for design of the ventilation system phases. The requirements and environments differ substantially between the construction and development, and the emplacement sides of the subsurface facility. During construction and development the ventilation design must consider the needs of personnel and equipment working in potentially dusty conditions resulting from excavation and drilling, heat from equipment, and the complexity of constructing multiple headings at the same time - each with different air requirements. Thus, although the repository is not a mine by definition, the process of ventilation design is similar to a moderately complex mine ventilation system. The emplacement side will have clean conditions with concrete lined openings and little or no potential for creation of dust except for airborne dust and pollen from surface and small quantities of residual concrete dust. The emplacement ventilation design must address heat build up from emplaced waste and the potential personnel exposure to radioactive leakage from the waste packages contaminating the subsurface openings.

SHAFT COORDINATE DATA

		EMPLACEMENT	DEVELOPMENT
SHAFT CENTER	N	235 580.00	230 890.00
	E	170 790.00	170 360.00
COLLAR EL		1455.00	1452.00

NOTES

1. SPACING OF EMPLACEMENT DRIFTS = 28
2. NUMBER OF EMPLACEMENT DRIFTS = 105
   NUMBER OF CONTINGENCY DRIFTS = 15
3. ELEVATIONS REFER TO DRIFT INVERT (BOTTOM OF EXCAVATION)
4. ED DENOTES EMPLACEMENT DRIFT
5. EM DENOTES EXHAUST MAIN

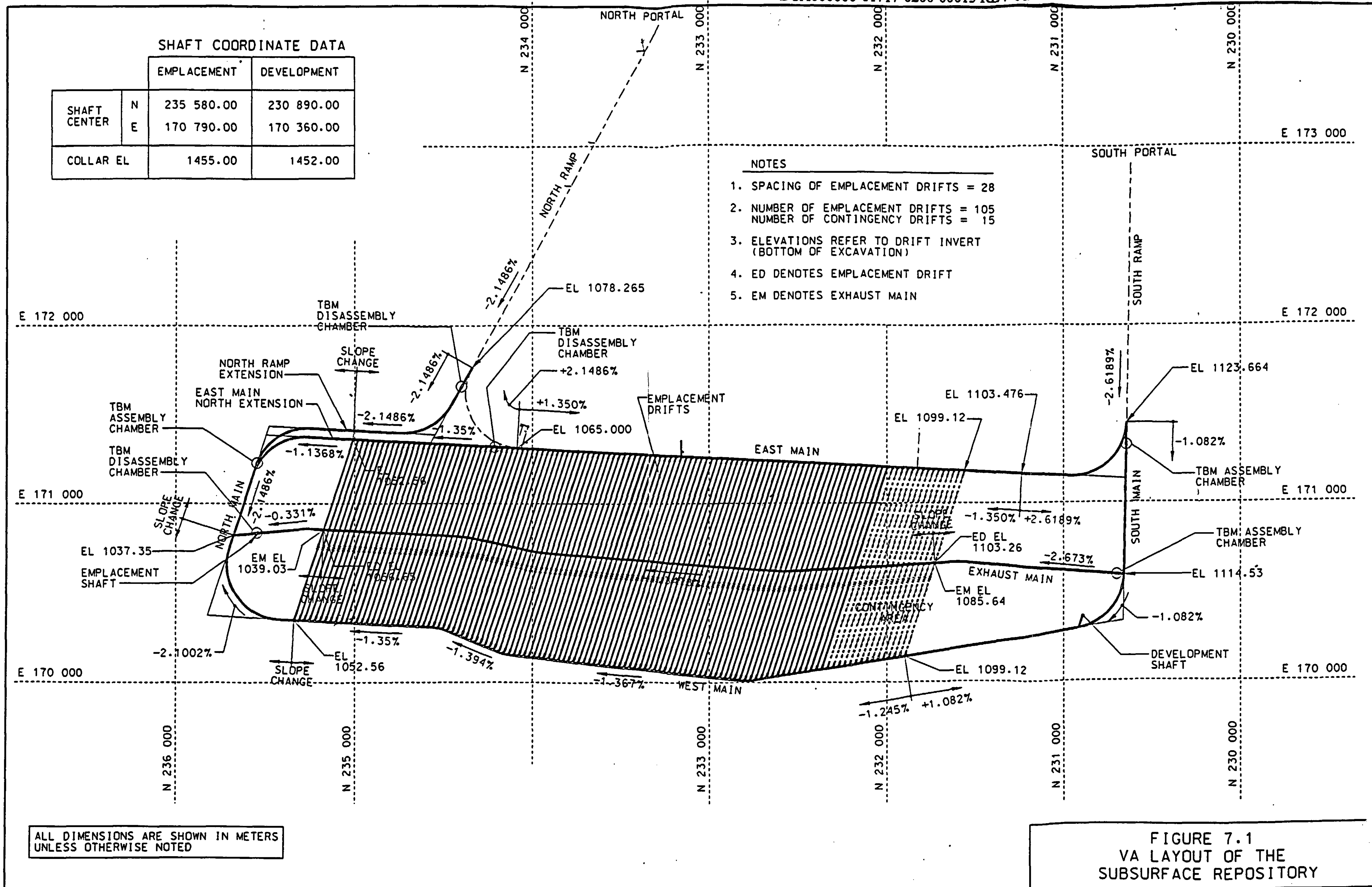

FIGURE 7.1
VA LAYOUT OF THE SUBSURFACE REPOSITORY

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7.2 SUBSURFACE VENTILATION DESIGN FEATURES

The purpose of ventilation is to supply enough air for human and equipment needs. The subsurface ventilation system delivers air to required areas of the facility at a quality and quantity to meet specific needs. Because of the large quantity of air needed due to the size of the facility, and the distance that air must travel from the surface to the working face, the ventilation system is complex. It is therefore good practice to simplify the design and to utilize wherever possible the excavated openings as passages for air travel. Restricted and rough airways should be avoided, and the use of ducts and pipes minimized to avoid costly maintenance and energy bills.

Subsurface ventilation must cope with environmental hazards, such as noxious contaminants (gases and dust), heat, and humidity. Application of established ventilation controls are used throughout this analysis for developing design solutions to deal with these hazards, particularly the airborne contaminants. In order of preference and effectiveness of application, the controls are:

1. Prevention or avoidance of contaminants
2. Removal or elimination of contaminants
3. Suppression or absorption of contaminants
4. Containment or isolation of contaminants
5. Dilution or reduction of contaminants

Controls #1 through #4 are considered priorities, although #5 - dilution, often becomes the ultimate solution for dealing with contamination of subsurface air. With sufficient airflow in drifts and travel ways, contaminants such as airborne dust and gases will be diluted to levels below threshold limits, and with enough air velocity, contaminants are removed from the subsurface openings. Inadequate air movement will cause contaminants to remain in the subsurface openings often with resulting health and safety concerns. Excessively high drift air velocity should also be avoided so as not to stir and create dust along airways.

If control of a dust hazard is the objective, the above five steps should be evaluated and applied in the order given. The following example dealing with dust from TBM or Roadheader face excavation illustrates application of the ventilation design controls. Engineering controls # 1 and # 2 are not applicable because face excavation can not be prevented or removed. The alternative excavation method which is to drill and blast or to use hydraulic mining is not acceptable in the repository. The next control # 3 - suppression or absorption of the dust, is applied by suppressing the dust from excavation with water sprays. If water sprays do not suppress all the dust a combination of controls # 4 & 5 are then applied. If feasible #4 (containment or isolation) is applied by curtaining off or enclosing the dust with a dust shield, then sweeping with sufficient volume of air across the face (control # 5) to direct the dust away from workers into a dust collector. The clean air from dust collectors can be reused to ventilate other construction

activities. Return air that may contain some residual dust can be diluted (control #5) and reused or can also be captured in an exhaust tube for discharge at the surface, which represents a further application of control #4.

7.3 RELATED WORK

The analysis on *Repository Underground Ventilation System Concepts* (Reference 5.16) identified the repository ventilation requirements, developed a ventilation design methodology, and evaluated airflow rates and concepts of air distribution.

In that analysis, the construction ventilation was evaluated with airflow requirements for underground personnel, dilution of diesel emission, air velocity, air cooling, and special mining operations and equipment. The air quantity for the construction of the repository would be comparable to the ventilation requirements of general underground mining industry practice.

The analysis also investigated emplacement air quantities needed to control drift temperatures during emplacement activities and for other normal and abnormal conditions. For retrieval and backfill options, the analysis indicated that blast cooling (rapid cooling with high airflow rates) a loaded emplacement drift will effectively reduce drift temperatures to 50 °C or less in a short period of time. Cooling will allow reentry within one to four weeks to a hot emplacement drift that could have been closed for an extended period of time.

The same analysis discussed the general concepts of airflow distribution and repository ventilation interface with ESF design. The preliminary evaluations indicated that the ESF/Repository interface layouts, under development at that time, allowed sufficient flexibility for efficient ventilation design of development and emplacement activities.

7.4 VENTILATION DESIGN FACTORS

The repository ventilation design must comply with the OSHA requirements for a minimum air velocity of 0.15 m/s (30 fpm) in all active openings under construction and must meet the OSHA air quality requirements (Section 4.4.2). Subsurface environmental standards must be maintained in accordance with the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV) (Criteria 4.2.6).

The overall ventilation design is based on delivering effective air velocity to produce an adequate air quantity and quality for all subsurface working places and travelways. The ventilation design provides sufficient drift air velocity to prevent stratification of respirable dust and to cool drifts for equipment and personnel.

The current repository design does not consider the use of diesel powered equipment because of Performance Assessment (PA) concerns with organic contaminants (Reference 5.21), although diesel may be considered in the future for certain construction activities if exhaust effluents can be kept at low enough levels to allay these concerns. Use of diesel equipment has not been evaluated in this analysis. If diesel is needed in the future, it will be evaluated against the requirements in effect at the time.

The ventilation requirement for subsurface personnel is 0.094 m^3/s (200 cfm) per person (Section 4.4.2). Usually subsurface personnel are spread throughout the facility and their air quantity requirements are insignificant compared to the quantity of air provided to satisfy minimum drift airflows needed for dust control and cooling.

7.4.1 Drift Air Velocities

Drift air velocities are calculations for single headings used to produce the volume requirements which are then used for VNETPC to model the total ventilation system.

7.4.1.1 Tunnel Construction

Mechanical tunnel excavation creates airborne dust comprised of different particle sizes. It has been established that dust particles smaller than 10 microns (.0004 in.) have no significant weight or inertia, and hence can remain suspended indefinitely in the atmosphere (Reference 5.6, p 84). These are the same particle size that get into the inner parts of human lungs to cause serious consequences to the health and safety of personnel.

The U.S. Department of Interior's Bureau of Mines research established that potential stratification for particulates, smoke, and gases occurs when air velocity in drifts is less than 0.457 m/s (90 fpm) (Reference 5.14, p. 25-24 & 25). To minimize these hazards, the U.S. Department of Interior, Bureau of Reclamation, has mandated a safety minimum air velocity requirement of 0.51 m/s (100 fpm) (Reference 5.15, Section 23.3.2.i.4) for all tunnels, shafts and other underground workings constructed under their jurisdiction. The air quantity is calculated by multiplying the gross area of the drift by 0.51 m/s (100 fpm). The US Bureau of Reclamation requirement for 0.51 m/s (100 fpm) is substantially higher than the OSHA requirement of 0.153 m/s (30 fpm) but is considered a reasonable basis for the complex system required for the repository subsurface facility with flexibility to deal with unforseen circumstances.

The repository ventilation design will assure satisfaction of the minimum 0.51 m/s air velocity near the working face. The design delivery should be comparable with mining industry practice which averages 0.736 m/s (145 fpm) from a survey of 15 operating mines (Reference 5.20). A key factor in the repository ventilation design is the dust problems experienced during the ESF construction. The lessons learned (References 5.24

& 5.25) from the ESF dust problems are indicators that the repository ventilation design will need significant improvement compared to the ESF construction ventilation.

The TSw2 unit at the potential repository horizon has a cristobalite content ranging from 18 to 28% and other quartz minerals from 1 to 5% (Reference 5.25). The presence of these minerals have a major impact on the ventilation design as they can have serious and irreversible damage to human lung tissues. The ACGIH TLVs for respirable cristobalite dust is 0.05 mg/m^3 and quartz dust 0.1 mg/m^3.

To assure a minimum 0.51 m/s air velocity near the face of construction, a ventilation design delivery at the start should have enough capacity to allow for fluctuations and leakage losses. In previous project studies of subsurface construction airflows (Reference 5.20), the average design velocity of the ventilation system was found to be 0.8 m/s (157 fpm) for active construction drifts based on the following calculation:

a) The start minimum air velocity is 0.51 m/s (100 fpm) (Section 4.3.13). To assure compliance a maximum fluctuation in air velocity of 15% is provided to account for equipment movement, position of doors and regulators, transition phases, and atmospheric pressure changes.

   0.51/(1-0.15) = 0.60 m/s (118 fpm)

b) A leakage and contingency allowance of 15 to 25%, depending upon the length of ducts or airways is added (Reference 5.20). For repository application, 0% for short headings such as turnouts and 25% for long headings such as the mains have been allowed.

   0.60/(1-0.25) = 0.80 m/s (157 fpm)

The velocity of 0.80 m/s (157 fpm) represents an equivalent velocity assuming the opening size to be uniformly consistent and equal to the opening size near the face. It is used to determine the quantity of fresh air at the intake point of the drift necessary to provide the required velocity near the face with the allowance for leakage and fluctuation. It does not necessarily represent the velocity at any point in the drift.

The ventilation air delivery rate of 0.8 m/s (157 fpm) average air velocity in drifts applies to construction of the west main and perimeter drifts, ramp extensions, cross block drifts, exhaust main, performance confirmation drifts, emplacement drifts and shafts, see Table 7.4.2.

Turnouts are short drifts about 30 to 38 m long, excavated along the East and West Mains (Reference 5.21), used for launching and recovering the 5.5 m TBM during construction

of emplacement drifts. Because of their short length, ventilation air delivery allowance for leakages and contingencies is not needed. These drifts can be provided with sufficient ventilation at 0.6 m/s (118 fpm) to maintain the drift air velocity at minimum 0.51 m/s (100 fpm) with a 15% fluctuation buffer. Similarly other short drifts and alcoves as deep as 50 m (165 ft) will have no allowances for leakages and contingencies and can be supported by a ventilation design delivery at an air velocity of 0.6 m/s (118 fpm) (Table 7.4.2).

Ventilation for construction of the 2 m diameter ventilation raise from the emplacement drifts to the exhaust main, and from PC or cross block drifts to the Mains is based on the airflow requirements of the access drifts connecting the raise. Usually, workers are in the access drift to support the construction of the raise. The cross-sectional areas of the access main drifts are used then to determine the airflow requirements at an average air velocity of 0.8 m/s (157 fpm).

7.4.1.2 Idle Drifts (Development Area)

Idle drifts are emplacement drifts used for human access, maintenance, materials transfer and storage. Though these drifts still have the potential for dust hazard, such as dust stratification caused by foot traffic and storage activities, the potential dust source is less than during drift construction.

a) Starting with a minimum air velocity of 0.31 m/s (60 fpm) (Section 4.3.13), a fluctuation allowance of 15% is added to ensure the compliance with the 0.31 m/s air velocity.

   0.31/(1-0.15) = 0.365 m/s (71 fpm)

b) A leakage allowances of 0 to 15% depending upon the length of ducts or airways is added. For repository application allow a minimum of 0% to an average maximum of 15% leakage and contingency. Use 15% for design delivery.

   0.365/(1-0.15) = 0.422 m/s (83 fpm)

c) The 0.422 m/s (83 fpm) average air velocity is adopted for idle drifts used for human access or as storage areas in the development area.

Drifts not used for human access need not be provided with ventilation and will be closed off temporarily to prevent access.

7.4.1.3 Emplacement Drifts Actively Accepting Waste Packages

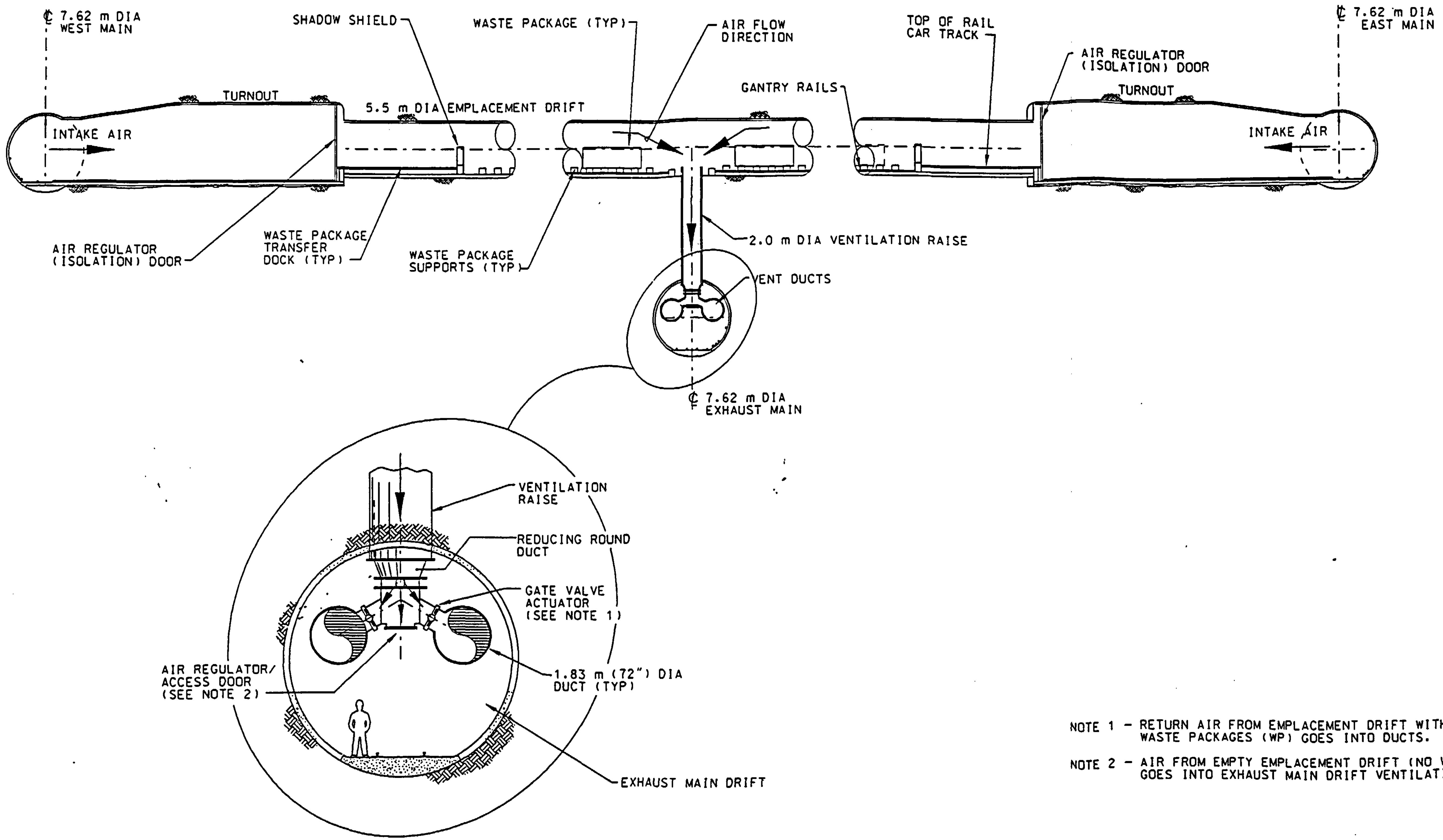
Intake air for emplacement drifts is supplied from either the West or East Mains as shown in Figure 7.4.1.3. There is no construction or muck movement on this side of the repository. Dust sources are minimal as drifts are concrete lined (Reference 5.21) and will be cleaned as part of the commissioning process. During waste emplacement the gantry carrying the waste package will operate in fresh intake air, which ensures that the gantry will remain at close to the main drift ambient air temperatures (less than 50 °C dry bulb).

During waste emplacement operations the emplacement drift will require a minimum air quantity of 10 m^3/s (21,200 cfm) (Reference 5.26) to maintain air movement in the emplacement drift and to provide cooling for gantry operation. This is equivalent to approximately 0.51 m/s (100 fpm) of air velocity. The ventilation arrangement in the emplacement area is not critical or sensitive to fluctuation and leakages, and airflows are regulated by fans, valves and doors.

To manage the thermal loading during waste emplacement (Reference 5.22) waste packages will be emplaced in up to three emplacement drifts at a time, which equals six emplacement headings emplacing waste packages from both the east and west sides of the block. The drift where waste is being emplaced will be provided with minimum 0.51 m/s (100 fpm) air velocity, and the other drifts with a reduced velocity of 0.15 to 0.3 m/s (30 to 60 fpm) (Table 7.4.2) to prevent heat build up between emplacement operations. To support this strategy, a total ventilation quantity of 28.3 to 42.5 m^3/s (60,000 to 90,000 cfm) will be needed.

Return air expands in volume as it is heated by contact with the waste packages, although expansion during active emplacement will not be significant because of the continuous ventilation and cooling. For purposes of network analysis, the available 28.3 to 42.5 m^3/s (60,000 to 90,000 cfm) will be considered the same volume at the exhaust side.

Return air from active emplacement drifts will be contained in an exhaust system away from human contact and the breathing zone (Section 4.2.9). The return air from each emplaced drift downcasts through the raise into either one of two 1.83 m (72 inches) diameter insulated metal ducts located in the Exhaust Main drift (Attachment VI, page 3). The two metal ducts route the return air to the bottom of the emplacement exhaust shaft for discharge to the surface.



NOTE 1 – RETURN AIR FROM EMPLACEMENT DRIFT WITH WASTE PACKAGES (WP) GOES INTO DUCTS.

NOTE 2 – AIR FROM EMPTY EMPLACEMENT DRIFT (NO WPs) GOES INTO EXHAUST MAIN DRIFT VENTILATION.

FIGURE 7.4.1.3
EMPLACEMENT DRIFT VENTILATION

In the event of a release of radioactive particulates or gases from a waste package, the exhaust air will be automatically routed through banks of HEPA filters to capture the particulates and adsorption units to capture the radioiodine. The exhaust air stream then passes to the surface for release to the atmosphere. Details of HEPA filters and iodine absorbers are covered by a separate analysis.

Airflow through the emplacement drift is regulated by doors/valves and fan suction pressures in any increment desired by the operator. The system has a design capability to increase airflow in a particular emplacement drift up to 47.2 m^3/s (100,000 cfm) if needed. This limit is imposed by the feasible size of the exhaust duct, expanded air volume caused by heat, exhaust main drift transportation envelope, and factors related to fan negative pressures and energy usages (Attachment VI, page 3). The monitoring of potential contaminants and airflow quantity control in the emplacement drifts and exhaust duct system is covered by separate analyses (Reference 5.26).

7.4.1.4 Emplacement Drifts with Waste Packages and Caretaker Phase

Fully loaded emplacement drifts will have a regulated average air quantity of 0.1 m^3/s (212 cfm) to maintain the proper airflow direction in the emplacement drift to prevent hot air as it expands backing out into the access main (Table 7.4.2). This air quantity assures movement of air from the east or west mains to the exhaust duct in the exhaust main drift. Justification of this air quantity is covered by a separate analysis (Reference 5.26). The emplacement drift doors (at the entrance to the drift) and valves (at the bottom of the ventilation raise) will act as an airlock to regulate the airflow in the emplacement drifts for pre-cooling, retrieval, backfill, clean-up and maintenance, and during the caretaker phase.

As during emplacement, exhaust air from the fully loaded emplaced drifts will be contained in an exhaust system away from human contact and the breathing zone. This is described in an earlier section of this analysis.

Without ventilation, the wall rock temperature will reach a temperature of around 172 °C, 40 years after emplacement (Reference 5.18). For this analysis a continuous average airflow of 0.1 m^3/s (212 cfm) per drift is allowed for monitoring and airflow direction control (Reference 5.26). In this scenario, the exit air temperature of the emplacement drift, 600 m long, will maximize at about 141^0 C dry-bulb (Table 4.1.6), 73 years after emplacement.

Predicted psychrometric properties for drift air inlet and outlet are tabulated in Attachment V. Page 3 of this attachment shows a predicted range of dry bulb temperatures for air at the inlet (supply side) of the emplacement drift, between 10 and

26.7 °C (50 to 80 °F) (Section 4.3.22) and at relative humidities between 20 and 40 %. At this humidity, the same page shows the calculation of moisture content of the inlet air to be in the range between 1.7 and 10 g/kg (12 to 70 grains per pound) of air.

The air in the emplacement drift will be heated as it passes along the waste packages. It will also pick-up some moisture from the emplacement drift, if moisture is available. The outlet air temperature will have new psychrometric properties as it leaves the emplacement drift based upon the addition of heat and moisture. For hypothetical discussion, the continuous ventilation with a quantity of 0.1 m^3/s per emplacement drift may heat the outlet air up to 141 °C, and may increase the moisture content by a range between 3.71 and 28.6 g/Kg (26 to 200 grains per pound) air. This analysis will not determine the water influx of the emplacement drift during continuous ventilation, but will show possibilities of changes in the air characteristics if the emplacement drift water influx increases the mass of air moisture by 200 to 1,650%.

Attachment V, pages 4 to 10 has tabulated calculation showing the heated air properties between 35 to 200 °C (95 to 392 °F) dry bulb and with moisture content between 3.71 and 28.6 g/Kg (26 to 200 grains per pound) air. It is more likely that the outlet air from emplacement drift will fall in the range given in Attachment V. For example, the average outlet temperature of 141 °C Db from the emplacement drift has various psychrometric characteristics depending upon the moisture content as shown in Attachment V, lines 18. The air psychrometry can be summarized and shown in Table 7.4.1.4:

Table 7.4.1.4 Emplacement Outlet Air for Continuous Ventilation of 0.1 m^3/s (212 cfm)

Dry-bulb Temperature °C	(°F)	Wet-bulb Temperature °C	(°F)	Relative Humidity (RH) %	Moisture Content g/kg	(Grains/lb)
141	(285.8)	37	(98.7)	0.14	3.72	(26)
141	(285.8)	38.2	(100.7)	0.26	7.14	(50)
141	(285.8)	40.3	(104.5)	0.52	14.3	(100)
141	(285.8)	41.9	(107.4)	0.72	20.0	(140)
141	(285.8)	43.3	(110)	0.92	25.7	(180)
141	(285.8)	44.0	(111.2)	1.02	28.6	(200)

The above table shows an outlet air relative humidity of about 0.14% to 1.02%. Hot air expands in volume and for the VA analysis, the ventilation design considers a conservative maximum 150% expansion (Reference 5.26) of the exhaust air coming from the loaded emplacement drifts.

7.4.1.5 Empty Emplacement Drifts Awaiting Waste Packages

Several empty emplacement drifts will be available after a panel of emplacement drifts is turned over to emplacement operation (Reference 5.22). These drifts are either idle or used for bypass ventilation to provide the proper airflow in the exhaust main drift.

Instrumentation will be located in the Exhaust Main for monitoring and controlling the air discharged from the empty emplacement drifts into the exhaust main drift .

Empty emplacement drifts and cross block drifts will be used to provide airflow from the East and West Mains to the Exhaust Main for ventilation and cooling. Empty

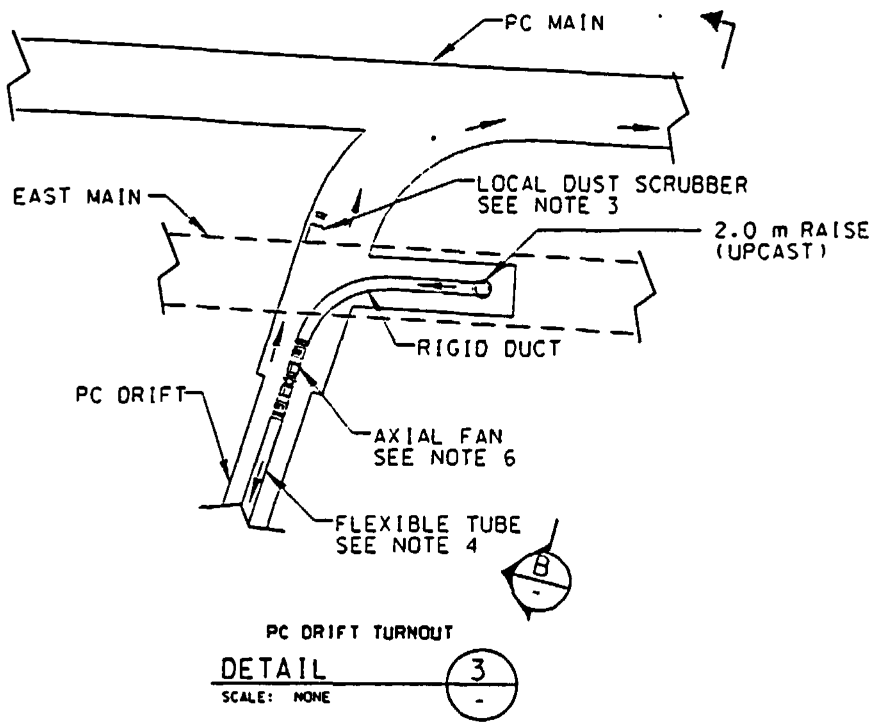
emplacement drifts have a capacity of up to 47.2 m^3/s (100,000 cfm) (Attachment VI, page 3) regulated airflow (Table 7.4.2). The total airflow from these drifts plus that from the cross block and performance confirmation drifts (Section 7.4.1.6) amounts to 188.8 m^3/s (400,000 cfm). This airflow volume added to return air coming from the discharge of the two 1.83 m (72 inches) diameter ducts gives a total emplacement side airflow volume of 283.2 to 306.8 m^3/s (600,000 to 650,000 cfm). This maximum design volume is based on unexpanded ambient air flowing through the North Ramp at a velocity not exceeding 7.62 m/s (1500 fpm) (Section 4.3.12) for safety of personnel traveling in the North Ramp and for economic reasons. Higher air velocities increase power consumption and hence costs.

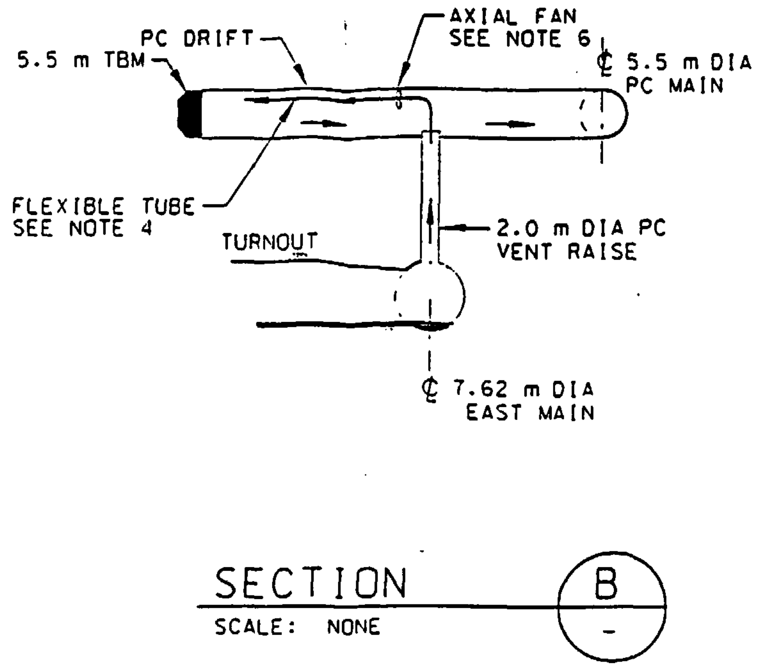
Emplacement drifts not used for any purpose other than awaiting emplacement of waste packages will be closed from human access. Emplacement doors and valves will be closed, and there will be no ventilation for these drifts.

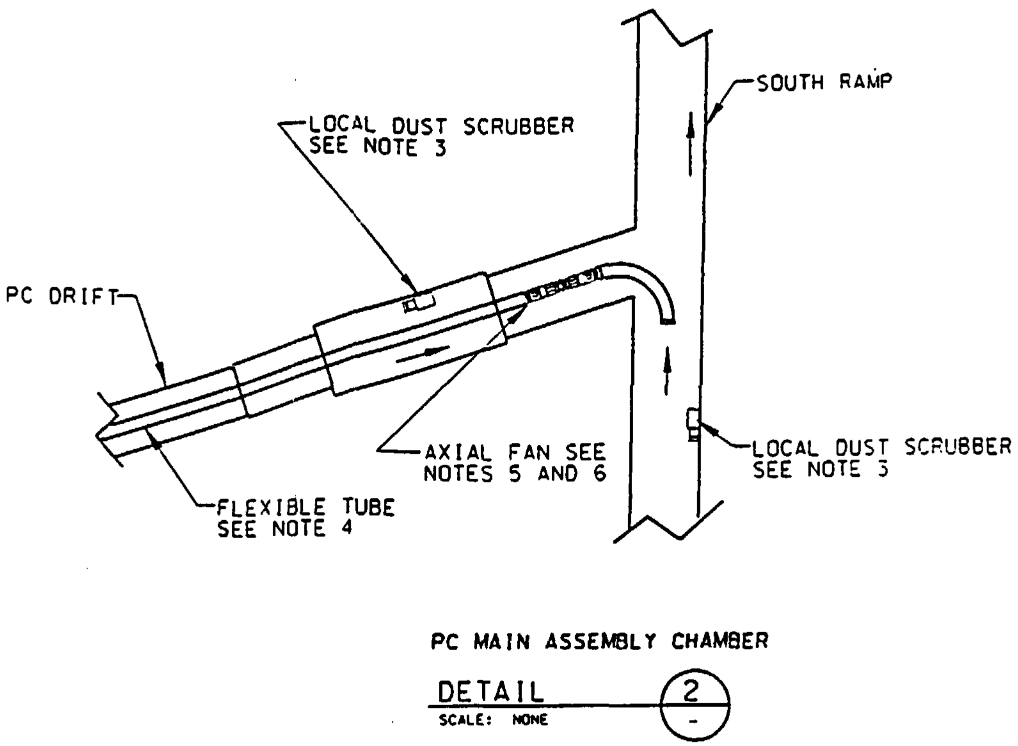
7.4.1.6 Performance Confirmation and Cross Block Drifts

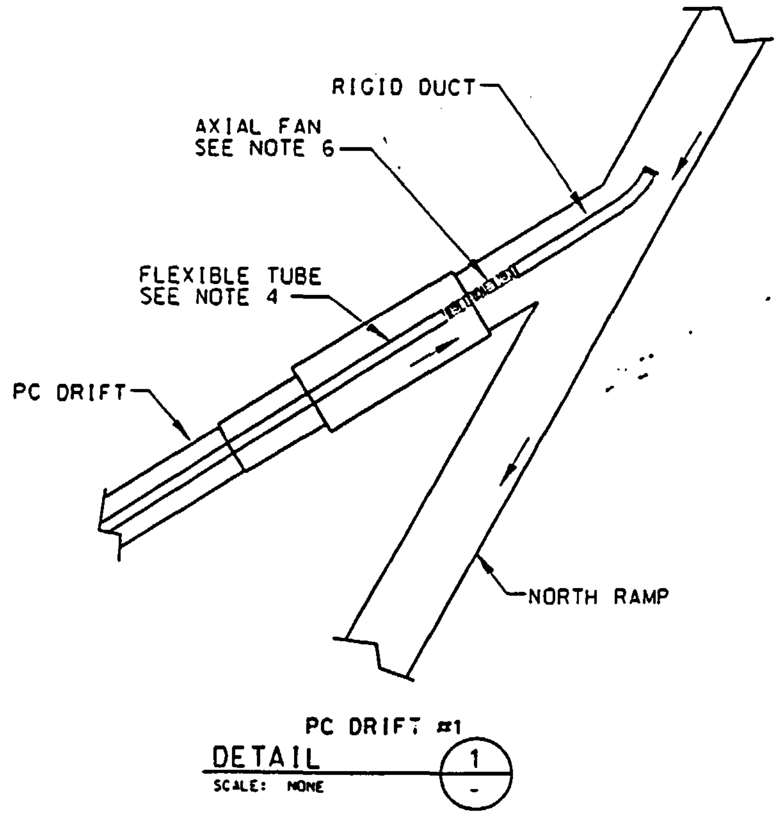
As the cross block and performance confirmation (PC) drifts become part of the emplacement operation side, they will be provided with regulated ventilation. This airflow then contributes to the 188.8 m^3/s (400,000 cfm) total exhaust main air described in the previous section These drifts will allow human access in the emplacement side and may also be used as ventilation bypasses for the exhaust main. As such these drifts will be provided with an airflow velocity range from 0.15 to 1.98 m/s (30 to 390 fpm) (Table 7.4.2).

Figure 7.4.1.6a and 7.4.1.6b show the ventilation arrangement during construction and emplacement modes of PC drifts. A ventilation barrier will be installed on a PC drift to separate the PC ventilation activities between emplacement and development areas.









NOTES:

1. PC DENOTES PERFORMANCE CONFIRMATION. PC DRIFTS ARE 5.5 m DIAMETER.
2. PC VENTILATION RAISES ARE 2.0 m DIAMETER.
3. LOCAL DUST SCRUBBER INSTALLED ALONG DRIFT AS NEEDED.
4. FLEXIBLE TUBE FROM TBM CASSETTE DISPENSER IS INSTALLED FOLLOWING THE ADVANCING TBM. FLEXIBLE TUBE WILL BE REMOVED AS SOON AS FLOW-THROUGH VENTILATION IS ESTABLISHED.
5. BOOSTER FANS IN SERIES WILL BE NEEDED TO COMPLETE THE PC MAIN DRIFT DRIVE.
6. AXIAL FAN MODEL 48-26-1180/125 HP. PERFORMANCE AT 19.0 m^3/s @ 2.5 kPa (40,300 cfm@10 INCHES WATER GAGE) TOTAL PRESSURE. SPECIFIC LOCATION WILL BE DETERMINED IN THE FIELD.

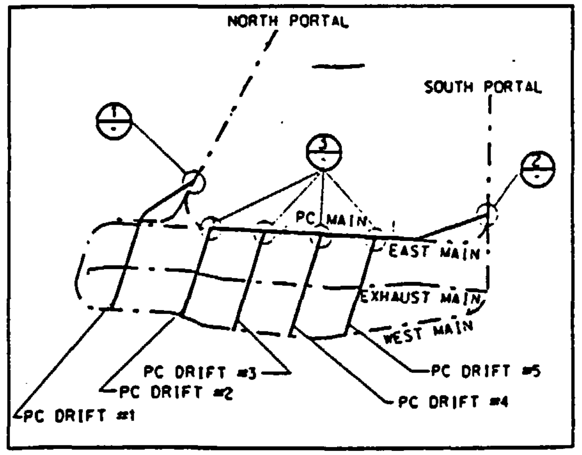
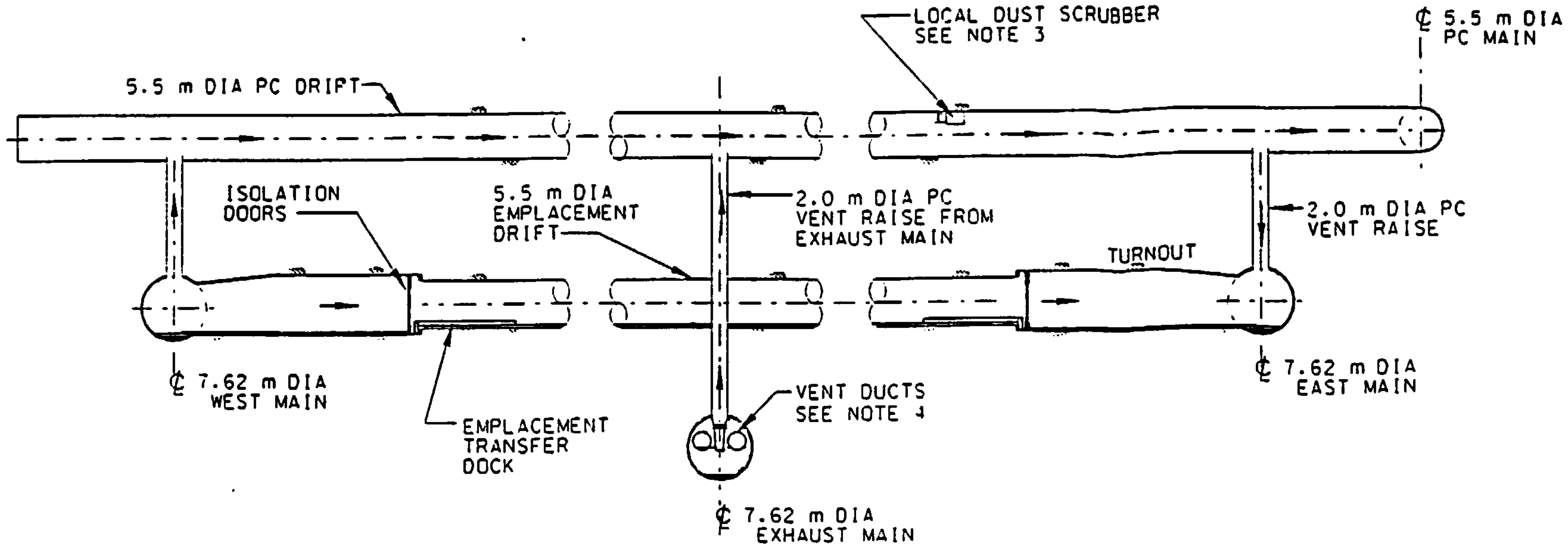


FIGURE 7.4.1.6A
PC DRIFT VENTILATION
EARLY CONSTRUCTION MODE



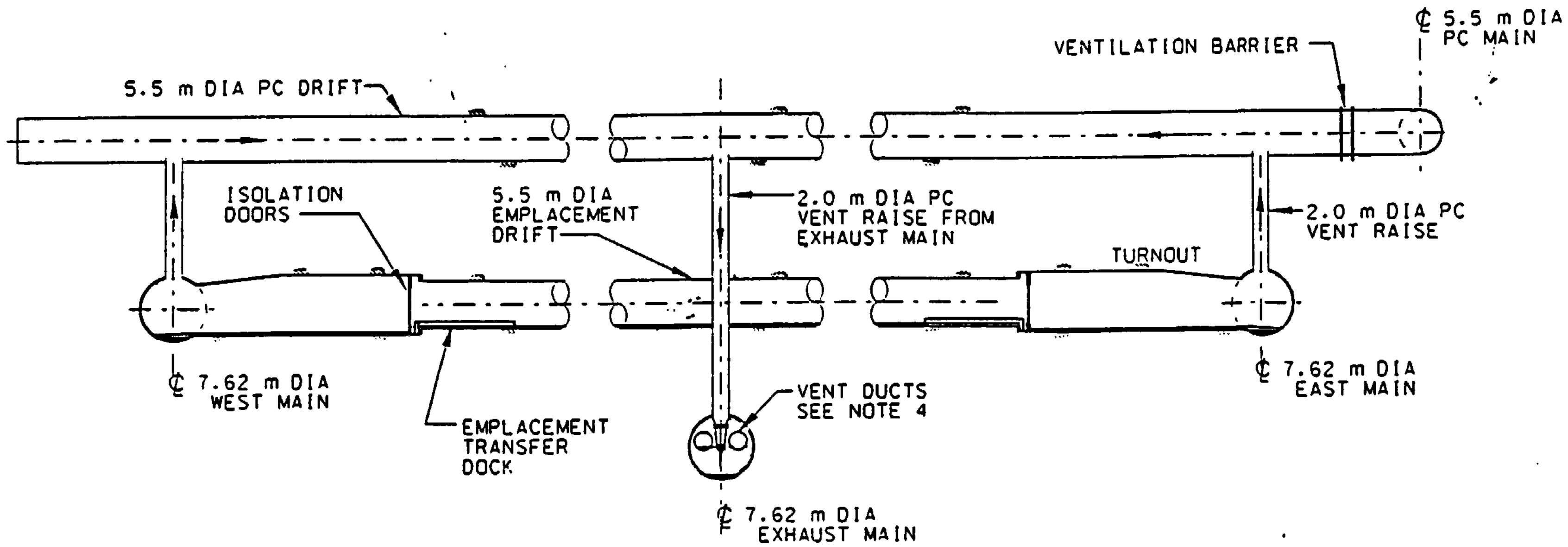
SECTION (A)
SCALE: NONE

NOTES:

1. PC DENOTES PERFORMANCE CONFIRMATION. PC DRIFTS ARE 5.5 m DIAMETER.
2. PC VENTILATION RAISES ARE 2.0 m DIAMETER.
3. LOCAL DUST SCRUBBER INSTALLED ALONG DRIFT AS NEEDED.
4. VENT DUCTS ARE NOT CONNECTED TO VENT RAISE.

PC VENTILATION-DEVELOPMENT MODE

SCALE: NONE



PC VENTILATION-EMPLACEMENT MODE

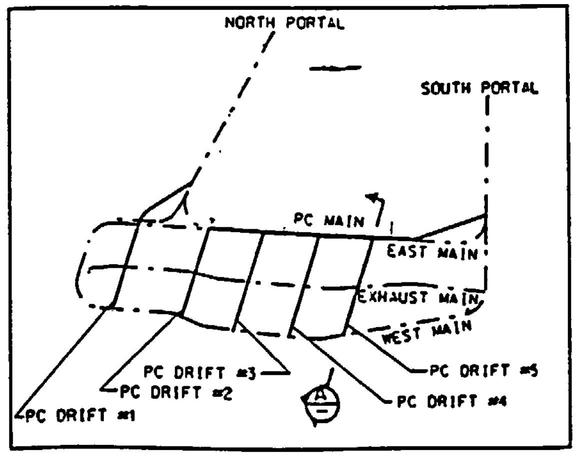


FIGURE 7.4.1.6b
PC DRIFT VENTILATION
DEVELOPMENT & EMPLACEMENT MODES

7.4.2 Repository Airflow Quantity During Construction and Emplacement

Based on Section 7.4.1 analysis, the repository ventilation design will establish a range of air delivery to support various activities during the construction and emplacement modes, as shown in Table 7.4.2.

Table 7.4.2 Typical Average Ventilation Design Air Delivery

Construction/ Development and Emplacement Activities	**Gross Cross-Sectional Area**	**Air Velocity Design Delivery**	**Average Air Quantity** **Ventilation Design Delivery***
[1] **Development Area** 7.62 m (25 ft) dia TBM for East Main Perimeter or Exhaust Main: Excavation, conveyor haulage, ground support, installation of inverts and rails, concreting, installation of trolley wires, utilities & exhaust ducts	45.60 m^2 (491 ft^2)	0.8 m/s (157 fpm)	36.5 m^3/s (77,300 cfm)
[2] **Development Area** 8x8 m (26.2x26.2 ft) Roadheader Turnout - horseshoe shape: Excavation, muck car haulage, ground support, installation of rails, concreting, installation of trolley wires and utilities	57.13 m^2 (615 ft^2)	0.6 m/s (118 fpm)	34.3 m^3/s (72,700 cfm)
[3] **Development Area** 5.5 m (18 ft) dia (unlined) TBM for Cross Block and Performance Confirmation Drifts: Excavation, muck car haulage, ground support, installation of inverts, rails, trolley wires, ducts, & instruments	23.76 m^2 (256 ft^2)	0.8 m/s (157 fpm)	19.0 m^3/s (40,300 cfm)

[4] **Development Area** 5.5 m (18 ft) dia TBM for standard Emplacement Drift reduced to 5.1 m (16.7 ft) dia. by concrete liner: Excavation, muck car haulage, ground support, installation of inverts and concrete segments, rails, wire conductors & waste package support	20.43 m^2 (220 ft^2)	0.8 m/s (157 fpm)	16.3 m^3/s (34,500 cfm)
[5] **Development Area** 6.1 m (20 ft) dia Shaft (finished inside liner, applicable to both development intake and emplacement exhaust shafts) Vertical Boring/excavation, ground support, installation of liners, guides, hoist and ducts	29.2 m^2 (314 ft^2)	0.8 m/s (157 fpm)	23.3 m^3/s (49,300 cfm)
[6] **Development Area** 5.1 m (16.7 ft) dia Emplacement Drift Idle and used for human access and storage areas	20.43 m^2 (220 ft^2)	0.42 m/s (83 fpm)	8.6 m^3/s (18,300 cfm)
[7] **Development Area** 5.1 m (16.7 ft) dia Emplacement Drift Idle and not used at all	20.43 m^2 (220 ft^2)	Closed off	No ventilation
[8] **Emplacement Area** 5.1 m (16.7 ft) dia Emplacement Drift Actual loading of waste packages	20.43 m^2 (220 ft^2)	0.51 m/s (100 fpm) (Approx.)	10.0 m^3/s (21,200 cfm) (Ref. 5.26)
[9] **Emplacement Area** 5.1 m (16.7 ft) dia Emplacement Drift Actively accepting but not actually loading waste packages -Variable quantity	20.43 m^2 (220 ft^2)	0.15 to 0.3 m/s (30 to 60 fpm)	3.1 to 6.1 m^3/s (6,600 to 12,900 cfm)

[10] **Emplacement Area** 5.1 m (16.7 ft) dia Emplacement Drift Design airflow flexibility for any emplacement drift loaded or not loaded with waste packages to handle abnormal scenario	20.43 m^2 (220 ft^2)	2.3 m/s (455 fpm)	47.0 m^3/s (100,000 cfm)
[11] **Emplacement Area** 5.1 m (16.7 ft) dia Emplacement Drift Fully loaded with waste packages and long term caretaker mode	20.43 m^2 (220 ft^2)	Nil	Average 0.1 m^3/s (212 cfm)
[12] **Emplacement Area** 5.1 m (16.7 ft) dia Emplacement Drift Empty and idle Emplacement Drift (5.1 m dia) used as regulated ventilation bypass for exhaust main including maximum flexibility	20.43 m^2 (220 ft^2)	0.15 to 2.3 m/s (30 to 455 fpm)	3.1 to 47.0 m^3/s (6,600 to 100,000 cfm)
[13] **Emplacement Area** 5.1 m (16.7 ft) dia Emplacement Drift Empty and idle. Used as human access or storage area	20.43 m^2 (220 ft^2)	0.15 to 0.30 m/s (30 to 60 fpm)	3.1 to 6.2 m^3/s (6,600 to 13,200 cfm)
[14] **Emplacement Area** 5.1 m (16.7 ft) Emplacement Drift Empty and idle Emplacement Drift (5.1 m dia) not used for anything	20.43 m^2 (220 ft^2)	Closed off	No ventilation
[15] **Emplacement Area** 5.5 m (18 ft) dia Performance Confirmation or Cross Block drift Used as ventilation bypass to exhaust main, human access, or storage area	23.76 m^2 (256 ft^2)	0.15 to 1.98 m/s (30 to 390 fpm) (Section 7.4.1.6.)	3.57 to 47 m^3/s (7,700 to 100,000 cfm)

Note: The air quantity figures provide a guide for computer modeling. Output from the model may show that some air is recirculated, and some drifts may receive greater air

quantities than indicated. These are normal results obtained in a system balance.

7.4.3 Reuse of Air

The repository ventilation has a flow through system where reuse of air is unavoidable. Portable or mobile dust scrubber units will be installed as needed to maintain the quality of reused air. Reuse of air as part of the overall air quantity requirement is often subjective and becomes a matter of engineering judgement. However, such judgement must be used cautiously to assure a sound ventilation system with minimal recirculation in the case of an emergency. Credit for reused air in determining the overall airflow quantity will be shown in this analysis through computer models. The ventilation system will have the flexibility to increase or decrease the amount of reused air by operating the variable speed of the primary fan motor.

7.4.4 Heat Flow Control from Emplacement Drifts

Ambient dry bulb temperature in the primary intake airways and in the intake side of the emplacement drifts will be kept below 27 °C (81 °F) effective temperature as currently experienced in the ESF (Reference 5.27). The hot return air, which may be as high as 141 to 172 °C (285.8 to 342 °F) from the emplacement drifts (References 5.17 & 5.18), will be contained in the two 1.83 m (72-inch) insulated metal ducts which discharge at the bottom of the emplacement exhaust shaft (Attachment VI, page 3). None of the emplacement return air will be in contact with the human accessible environment until it is on the surface where it will be diluted to ambient surface temperature.

7.4.5 Insulated Exhaust Ducts, Auxiliary Fans, and Alternative Airways

Hot exhaust air from the emplacement drifts is controlled and directed away from human contact through the exhaust duct which will be insulated to reduce temperatures in the Exhaust Main. This arrangement allows access in the Exhaust Main for maintenance (Section 4.2.14) and frees it from potential radionuclide contamination. It also facilitates monitoring of air quality and quantity from each emplacement drift (Section 4.2.8).

The two insulated metal ducts function primarily as heat isolators and as containment for radioactive contamination for abnormal scenarios. The ducts will be maintainable over the life span of the repository operation. Details of duct maintenance will be covered in future analysis.

Centrifugal fans located at the discharge end of each duct will ensure negative pressure in the exhaust ducts. The fans will be installed near the bottom of the emplacement exhaust shaft. The centrifugal fan has variable speed, adjustable to demand.

A split exhaust main or a second similar size exhaust drift parallel and at the same level as the exhaust main drift may be considered as an alternative to replace the two insulated exhaust ducts. The second exhaust airway will be connected to each of the emplacement raises by a three way regulator valve. The regulator valve will allow the return air from each emplacement drift to be shut off or to go either the first or second exhaust main. This alternative will provide redundancy of exhaust airways for maintenance and monitoring. A second exhaust airway will also have the flexibility to ventilate the emplacement drifts at lower energy costs than moving return air through the two steel ducts. This VA analysis considers the two 1.83 m (72 inches) insulated exhaust ducts in the exhaust main as a viable concept (Attachment VI, page 3). The alternative concept will require further analysis in the future. The second exhaust airway alternative may be evaluated as an option should there be a specific requirement to provide continuous air ventilation and cooling of emplacement drifts requiring airflow greater than 0.1 m^3/s (212 cfm). Note, that Table 4.1.6 shows that continuous ventilation of each emplacement drift at 2.0 m^3/s (4,237 cfm) or more will prevent the emplacement drift from attaining a boiling temperature over a 100 year retrievability period.

7.4.6 Dust Control

Dust control is an important part of the ventilation system and is discussed separately in Section 7.5 of this analysis.

7.4.7 Noise Control of Ventilation Equipment

Ventilation equipment, such as fans, with a potential to exceed noise levels limit will be equipped with silencers. Prudent specification and choice of ventilation equipment that is potentially less noisy will also be considered. The ESF ventilation equipment is equipped with silencers.

7.4.8 Separation of Emplacement and Development Sides

The maintenance of net pressure differential of at least 189 Pa (0.76 inch wg) between the development and the emplacement sides (Section 4.3.19) is used to assure direction of any leakages from development (construction) side towards the emplacement side. In this way potential radionuclide releases cannot enter the construction area.

A pressure differential between the emplacement and development areas will allow the development air to continually migrate to the emplacement side through the ventilation barrier. The barrier will be instrumented to monitor pressure differential, dust, and other contaminants.

Two major ventilation components will ensure compliance with this requirement:

a) Ventilation Barriers

Ventilation (isolation) barriers installed between the development and emplacement sides will isolate one from the other. The ventilation barrier will be fitted with an emergency access door so that personnel can move to safety in case of an abnormal event such as a fire. The barrier must be constructed to withstand a range of operating pressure differentials [0.42 to 3.38 kPa (1.7 to 13.6 inches wg) (Sections 7.10.1.2, 7.10.2.2 and 7.10.3.2) shown in the ventilation computer models in Attachments I, II, and III. Details of this ventilation barrier are covered by a separate analysis.

b) Primary Fans

The primary intake fan for the development area installed at the Development Intake Shaft collar will push air into the subsurface development areas with positive pressure on the ventilation barriers. Return air from the development side will exhaust through the South Ramp.

On the emplacement side the primary fan for the emplacement area will be installed at the emplacement exhaust shaft collar, and will pull (exhaust) the return air from the emplacement area with negative pressure on the ventilation barriers. Intake air for emplacement area enters through the North Ramp.

The overall effect of this arrangement ensures a minimum 189 Pa (0.76 inch wg) pressure differential between the development and emplacement areas as shown in Attachments I and II.

7.4.9 Heat Stress Index, and Cooling and Heating of Primary Intake Airways

7.4.9.1 Effective Temperature for Repository Environment

Repository ventilation generally has to provide a comfortable environment, not exceeding the maximum effective temperature of 27 °C (81 °F), to work places and access areas (Section 4.3.16). Effective temperature is a simple heat stress index widely used by the mining industry. It is based on the combined effects of air velocity and dry-bulb and wet-bulb temperatures. Figure 7.4.9.1a (Reference 5.7, p1033 & 5.6, p584 & 587) is a nomograph to determine effective temperature. Figure 7.4.9.1b is another graph showing the effects of increasing the effective temperature on worker productivity. The graph shows that work efficiency of subsurface personnel steeply decreases as effective temperature is increased beyond 27 °C (81 °F).

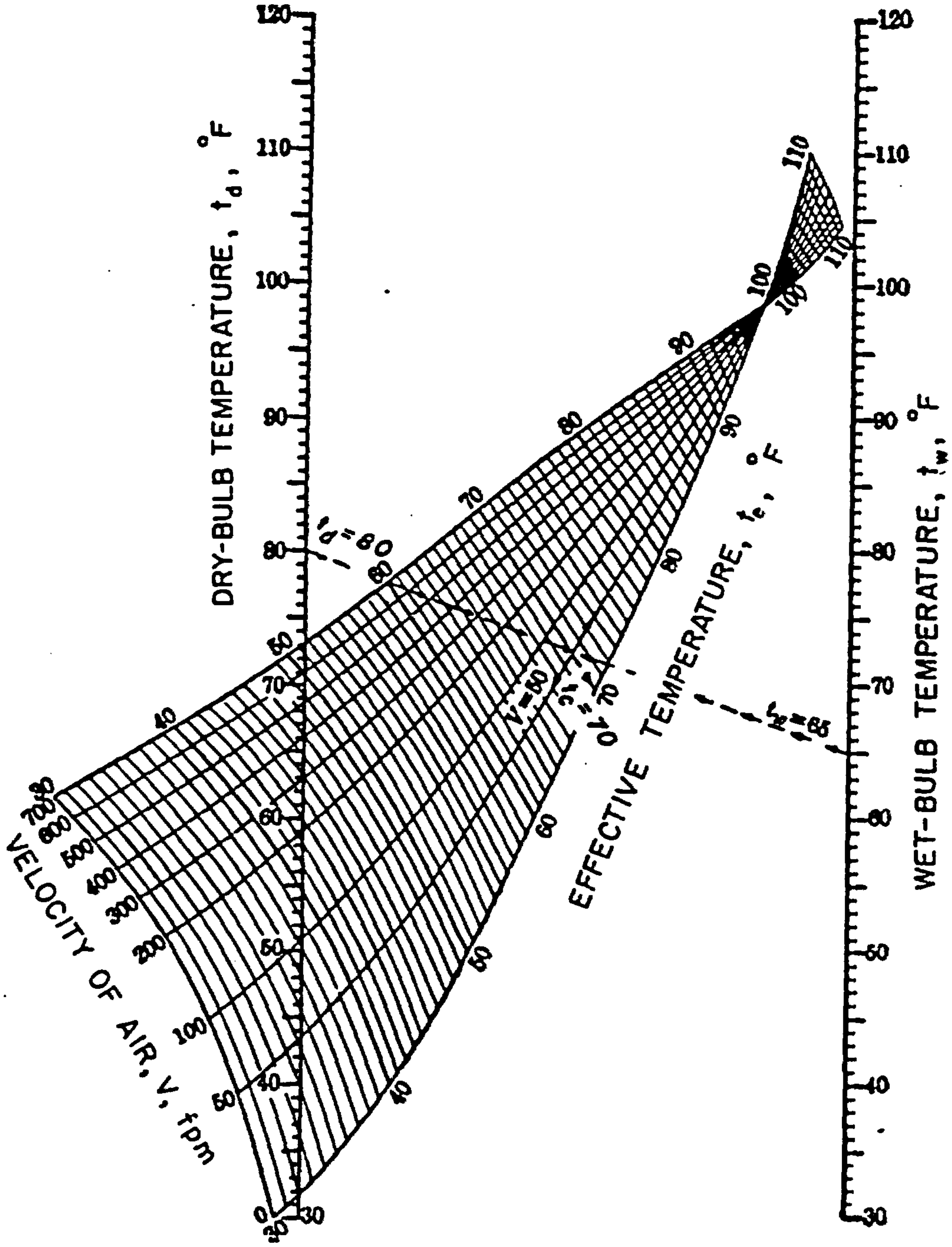


Figure 7.4.9.1a Effective temperature scale. Basic chart for personnel stripped to the waist and at rest or doing light work. Example: t_d = 80 °F (27 °C), t_w = 65 °F (18 °C), V = 50 fpm (0.25 m/s), t_e = 70 °F (21 °C). (Source Reference 5.6, p 587)

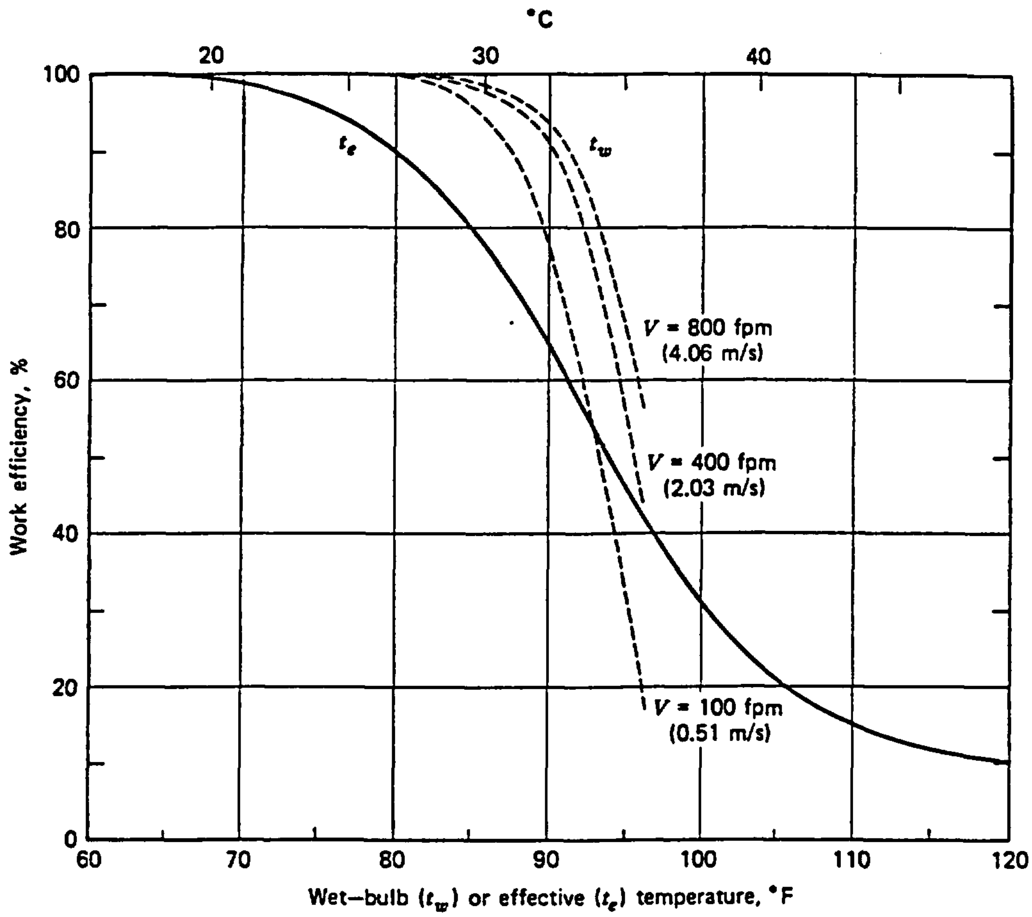


Figure 7.4.9.1b Effect of wet-bulb and effective temperatures on work efficiency. Results for t_w at three air velocities are based on acclimatized mine workers. Results for t_e are based on industrial workers. (Source Reference 5.6, p 584).

Graphical interpretation of effective temperature at 27 °C (81 °F) can be satisfied by maximum combinations of the following air characteristics shown in Table 7.4.9.1.

Table 7.4.9.1 Combination of Low Air Velocity and Maximum Temperature to Maintain Heat Stress Index of 27 °C (81 °F) Effective Temperature

Drift Air Velocity		Wet-Bulb Temperature		Dry-Bulb Temperature		Calculated Relative Humidity %
m/s	(ft/min)	°C	(°F)	°C	(°F)	(Attachment V)
0.25	(50)	26.7	(80)	30.0	(86)	78
0.25	(50)	23.9	(75)	35.0	(95)	41
0.25	(50)	21.1	(70)	39.4	(103)	20
0.25	(50)	15.6	(60)*	48.9	(120)	0*
0.50	(100)	26.7	(80)	32.2	(90)	66
0.50	(100)	23.9	(75)	36.1	(97)	38
0.50	(100)	21.1	(70)	40.6	(105)	18
0.50	(100)	15.6	(60)*	48.9	(120)	0*
1.01	(200)	26.7	(80)	33.9	(93)	58
1.01	(200)	23.9	(75)	37.8	(100)	33
1.01	(200)	21.1	(70)	41.7	(107)	16
1.01	(200)	15.6	(60)*	48.9	(120)	0*

* Low wet-bulb temperature and zero humidity will not occur in a normal mine environment.

Table 7.4.9.1 provides a reference to show the relationship between low air velocities and maximum air temperatures for satisfying compliance with the maximum effective temperature of 27 °C (81 °F). These values are shown to demonstrate what combination of conditions must be maintained in local working areas within the repository to avoid the potential for heat stress among workers. The ventilation system is designed to provide sufficient air volume with flexibility to do field adjustment to maintain comfortable environment below these maximum conditions.

Related calculation of air psychrometry for Table 7.4.9.1 is found in Attachment V, page 11.

7.4.9.2 Major Heat Sources Affecting Subsurface Environment

The repository subsurface ventilation will be affected by the variation of seasonal temperatures at the Yucca Mountain. As fresh air enters the subsurface openings, its temperature properties will be influenced by heat sources from the rock wall, machinery and lights, human metabolism, autocompression, oxidation, blasting, rock movement, service water, and pipelines such as water and air ducts. This study will not detail all these items but will only discuss the two major components that generally determine the temperature of the repository ventilation system, namely the rock wall and the air temperature of the intake source.

7.4.9.2.1 Rock Wall Temperatures and Cooling Effects

The temperature of the virgin rock in the repository is 19 °C (66 °F) near the portals (surface) and gradually increase to 23 °C (73.4 °F) at the potential repository horizon (Reference 5.28). The rock wall temperature of the potential repository horizon ranges from 22.2 to 23 °C (72 to 73.4 °F).

The rock wall is much cooler than the dry-bulb air temperature characteristics shown in Table 7.4.9.1 at maximum effective temperature of 27 °C (81 °F). Hence, the rock wall is generally considered a massive cooling media keeping repository air at an effective temperature below 27 °C (81 °F).

The subsurface mining industry experience usually requires mechanical refrigeration to maintain an acceptable work environment for mining operations where virgin rock temperature exceed 40.5 °C (105 °F) (Reference 5.6, p567). Since the repository horizon temperature is only 22.2 to 23 °C (72 to 73.4 °F), it is evident that mechanical refrigeration will not be necessary for normal repository construction and operation.

The continuous cooling effects of ambient air along the primary mains will maintain an ambient air temperature along the emplacement intake side unaffected by the waste package heat (Reference 5.17).

7.4.9.2.2 Intake Air Temperature and Surface Meteorological Data

The reference record for Yucca Mountain's meteorological data is summarized in Table 7.4.9.2.2 (References 5.20 & 5.28) together with the calculated heat stress index.

Table 7.4.9.2.2 Surface Meteorological Data and Heat Stress Index

1) Normal Summer Season (June through August):	
Temperature, Dry-bulb (Db)	
	Daily maximum average: 31.7 to 35.6 °C (89 to 96 °F)
	Daily minimum average: 10 to 13.9 °C (50 to 57 °F)
	Monthly average: 20.6 to 25 °C (69 to 77 °F)
Relative Humidity (R)	
	Nighttime Average: 25 to 43 %
	Daytime Average: 13 to 22 %
Barometric pressure (Pb) range: 85.84 to 88.67 kPa (25.42 to 26.26 inches Hg)	
	Average: 87.8 kPa (26.0 inches Hg)
Total rainfall average: 32.8 mm [(0.31+0.53+0.45) = 1.29 inches]	
Potential Intake Air Characteristics (High Side), Summer Time Wet-bulb temperature, 19.1 °C (66.4 °F) Wb Dry-bulb temperature, 35.6 °C (96 °F) Db Relative Humidity, 22% Effective Temperature at 0.25 m/s (50 fpm), 24.4 °C (76 °F) Wet-bulb temperature, 16.3 °C (61.4 °F) Wb Dry-bulb temperature, 35.6 °C (96 °F) Db Relative Humidity, 13% Effective Temperature at 0.25 m/s (50 fpm), 23.9 °C (75 °F)	

2) Extreme Summer Season (June through August):	
Temperature, Db	
	Highest recorded: 41.7 to 42.2 °C (107 to 108 °F)
	Lowest recorded: -1.67 to 4.4 °C (29 to 40 °F)
Potential Intake Air Characteristics, Extreme Summer Time Wet-bulb temperature, 19.6 °C (67.3 °F) Wb Dry-bulb temperature, 42.2 °C (108 °F) Db Relative Humidity, 12% Effective Temperature at 0.25 m/s (50 fpm), 27 °C (81 °F) (Rare & Short)	

The intake air characteristics during summer indicates a cooler temperature than the characteristics of air needed to maintain maximum effective temperature of 27 °C (81 °F) (Table 7.4.9.1). Hence, mechanical refrigeration of the intake air is not needed during summer time.

3) Normal Winter Season (December through February)	
Temperature, Db	
	Daily minimum average: -6.7 to -3.9 °C (20 to 25 °F)
	Daily maximum average: 10.6 to 13.9 °C (51 to 57 °F)
	Monthly average: 2.2 to 5 °C (36 to 41 °F)
Relative Humidity	
	Nighttime Average: 57 to 71%
	Daytime Average: 32 to 53 %
Total snowfall average: 160 mm [(2.9+1.3+2.1) = 6.3 inches]	
Total rainfall average: 66 mm [(0.87+1.05+.68) = 2.6 inches]	
Barometric pressure range: 85.47 to 89.72 kPa (25.31 to 26.59 inches Hg)	
	Average: 87.8 kPa (26 inches Hg)

	Potential Intake Air Characteristics, Winter Time Daily minimum average: -6.7 to -3.9 °C (20 to 25 °F) Daily maximum average: 10.6 to 13.9 °C (51 to 57 °F)

The dominant rock temperature and the surface intake air characteristics are favorable for an acceptable year-round repository environment.

The winter dryness and the average temperature fluctuation during night and day indicate that freezing and potential accumulation of ice in the intake shaft or ramp may be gradual and controllable. This hazard can be avoided by timely removal of ice. An intake heater may not be necessary, and for this analysis is not recommended. During winter, confined areas near intake airways such as the shifter's offices, mechanics shops and warehouses may be provided with local electric space heaters for personnel comfort. Personnel exposed to low temperatures should be encouraged to wear proper working clothes. Utility lines should be insulated in freezing areas along intake airways.

7.4.9.3 Subsurface Ambient Air Experience

Two temperature recorders have been installed in the ESF underground to monitor the dry bulb temperatures (24 hours/day) since August, 1995. Based on the recorded temperatures (Reference 5.27), the repository horizon at Sta. 28+26 has been dominated by a dry bulb temperature range of 22.2 to 26.7 °C (72 to 80 °F). These are year round temperatures despite surface fluctuation caused by summer and winter seasons. Note, that these temperatures are only indicative of ESF construction when the TBM was still advancing towards the South Portal. More data will be gathered as soon as the ESF flow through ventilation is implemented. The ESF flow through ventilation will have a closer relationship to the repository operations.

For this analysis the underground intake temperatures experienced at the Nevada Test Site Tunnels are used (Reference 5.20). The dry-bulb temperature to reach the work areas is in the range of 10 to 26.7 °C (50 to 80 °F) at the repository horizon.

7.5 DUST CONTROL STRATEGY AND CONSTRUCTION FACE VENTILATION ARRANGEMENT

7.5.1 Dust Hazards and Dust Control Project Philosophy

Normal underground mechanical excavation process is generally a source of dust. The

repository horizon has high content of hazardous cristobalite and quartz minerals. The dust sources for repository construction are significant enough to require a comprehensive and effective dust control program. MSHA program policy manual states that dust exposures must be controlled to within safe limits through engineering controls. Respiratory protection is only considered as a means of protecting workers while engineering controls are being implemented (Reference 5.8). This section of the analysis focuses on broad engineering controls for a dust control program. A successful long term dust control program will require an intense and timely effort to attain and maintain safe subsurface working environment.

A successful dust control program is usually managed by a full time department which carries the duties and responsibilities of planning, monitoring, design, and implementation of ventilation and dust control systems. This type of organization is a common mining industry practice (Reference 5.19), although this aspect of ventilation control will not be further examined in this analysis.

7.5.2 Wet TBM and Roadheader Operations

The primary engineering control for dust in a typical TBM or roadheader face operation is suppression with water and application of wet scrubbers to remove dust from the exhaust air. The water sprays are applied so as to wet the face and broken rock removed by the TBM or roadheader mucking system. Experience with dry TBM operation and dry dust scrubber has generally not been positive because movement of dry muck creates additional dust sources in the work areas that are difficult to control. Efforts should be made to prevent dust from becoming airborne by effective use of water. Once dust, such as cristobalite, is airborne it is highly hazardous to the health and safety of personnel, and institution of controls at this point is costly and often counter productive to the general operation of the construction work.

Performance specifications for the TBMs and roadheaders for repository construction will include requirements for water sprays and wet dust scrubber, with mechanical fans to handle local airflow requirements. Effective water sprays will consider water spray pattern, water pressure and volume and location of application at TBM face (Reference 5.7). Drift ventilation and air delivery to the TBM or Roadheader area are shown in Table 7.4.2.

7.5.3 Use of Flexible Tube For TBM Operation

TBM excavation represents a dead-end operation, there being only one way in and out for personnel, materials, and ventilation air. Typically TBM drives are several thousand meters in length necessitating a reliable auxiliary ventilation system. Clean air at the face is provided by means of ducts and fans.

Two popular types of ventilation ducts are commonly used in the mining and tunneling industries, namely rigid ducts made of metal (often steel) or fiberglass, and flexible tube (often referred to as bagline) made from heavy duty brattice cloth. Flexible tube is available in various sizes up to 2.4 m (96 inches) inflated diameter, and must be operated at positive pressure, as high as 12.4 kPa (50 inches wg). Flexible tube has found wide spread application in tunnel boring operations through the use of preloaded cassette dispensers. For example, a commonly used heavy duty single section of 1.83 m (72-inch) diameter bagline 305 m (1,000 ft) long, is preloaded in a single cassette dispenser less than 6.1 m (20 ft) long (Figure 7.5.3a) (Reference 5.10). The cassette is installed on the last deck of the TBM and arranged to automatically release the tube as the TBM advances. The fan that powers the ventilation may be installed either at the inlet of the tunnel segment to blow the fresh air (blowing system) to the TBM area (Figure 7.5.3b), or in series with the cassette dispenser to exhaust the air from the TBM area (Suction System) to the starting point of the tunnel development (Figure 7.5.3c).

The preference for repository TBM ventilation is the blowing system. Clean air is pushed to the TBM face on positive pressure through the flexible tube and without contamination. Return air from TBM face will go to scrubbers before it is returned for drift ventilation. The air in the drift will be reprocessed for dust removal as needed as it travels back and joins again the primary airstream.

The suction system is configured for an exhaust fan on the last deck of the TBM to exhaust the TBM return air in positive pressure through the flexible tube. Supply air is coming through the tunnel drifts potentially contaminated with dust by drift activities such as conveyor and rail car haulage. The dust control process in this option is relatively more tedious. The noise of a high pressure exhausting fan near the TBM is also an additional health and safety disadvantage.

Fans can be installed at regular intervals along rigid duct provided positive pressures are avoided to minimize leakage and recirculation of dusty air. With flexible ducts additional fans must be selected and located so as not to overcome the positive pressure created by the previous fan, otherwise the tube will collapse. To ventilate over long distances, fans tend to be clustered near the intake end of the tube. The lower airflow resistance of the tube allows air delivery from a single fan (or set of fans) to greater distances than possibly with large corrugated ducts with higher resistance to airflow.

SCHAUENBURG VENTILATION

Cassette System designed for simple installation

Schauenburg's round or oval cassette system is manufactured for use in tunnel boring machine (TBM) applications. Schauenburg's strong all-steel construction is tough and durable for on-the-job conditions. Key to Schauenburg's cassette design is the simple installation and rapid payout of pre-loaded flexible duct.

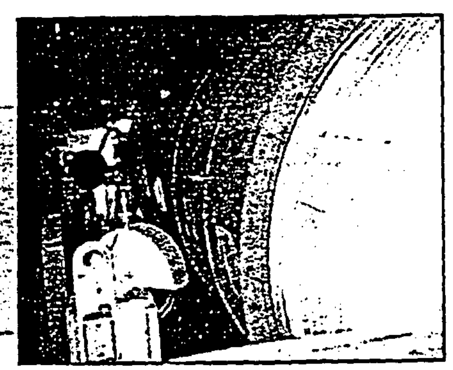
Brattice material choices

The cassette duct can hold 300' (100 m) to 1000' (300 m) of pre-loaded brattice material. Once expended, the cassette is refilled at the surface and taken to the TBM as a complete unit for additional payout of duct from the TBM. The following chart offers you a choice of duct brattice material for your application. Please specify upon ordering.

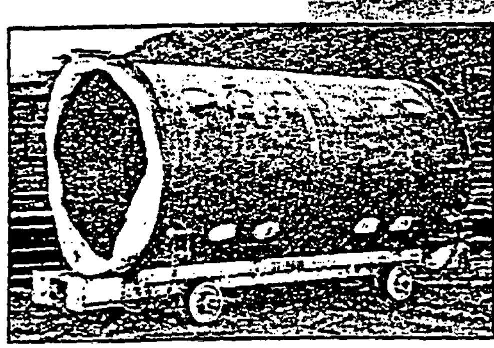
Fabric	Color	Weight	Scrim Count	Tear Strength
T25	Yellow	14 oz/sq yd (450 g/m²)	9 x 9	Fill 88 lbs/Warp 88 lbs (40 kg) (40 kg)
CD18	Yellow	18 oz/sq yd (600 g/m²)	9 x 9	Fill 137 lbs/Warp 135 lbs (62 kg) (61 kg)
CD24	White	24 oz/sq yd (800 g/m²)	18 x 18	Fill 150 lbs/Warp 190 lbs (68 kg) (86 kg)

All Schauenburg brattice materials are U.S. Mine Safety Health Administration (MSHA) approved for fire resistance.

Cassette mounted on machine



Payout of preloaded flexible duct underground



Second drum ready to go underground

SCHAUENBURG VENTILATION

A Half Century of Engineering Innovation Makes Schauenburg Cassette Systems a Smarter Choic[e]

Shape / Capacity & Material

➤ Round & Oval

➤ Diameters 18" - 96" (450 mm - 2500 mm)

Duct Capacity

➤ 300' to 1000' (100 m to 300 m)

Ventilation Duct

➤ Designed for the high pressures encountered in tunneling

➤ 14 - 24 oz/sq yd material (450 - 800 g/m²)

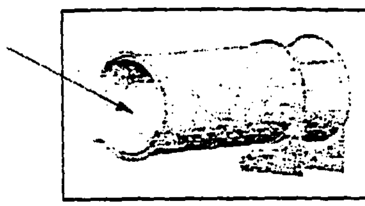
Options

➤ Optional messenger line reel allows tensioned playout of messenger line as TBM advances

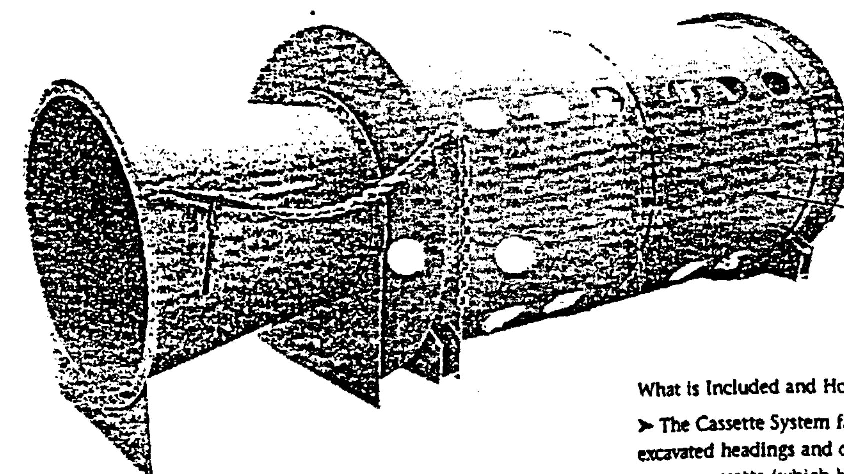
➤ Optional cassette brakes for high pressure suction systems (pressurizing fan running at cassette)

➤ Draw off cone attached to inner tube for orderly payout of ducting and smooth air flow through the cassette unit

Cassette with outlet cone



➤ System operates at positive pressure a[...]ws



➤ Utilizes a pre-loaded cassette that is refilled at the surface and taken to the work face as a complete unit

Cassette Outlet Cone:

➤ Allows gradual expansion of air to reduce shock loss or mounting of the reversing fan

➤ Directs the air from the pressure fan through the cone section while remaining attached to the fan during removal and installation of replacement cassettes

➤ Provides additional support for the cassette and a tight connection between the cassette and TBM ducting

Cassette Storage

➤ Site storage problems reduced as boxes holding duct can be stacked in small area

What is Included and How Does it Work?

➤ The Cassette System facilitates installation of flexible vent ducting in rapidly excavated headings and consists of three basic components: the outlet cone, the duct storage cassette (which houses the ventilation duct) and the ventilation duct.

➤ The unit is normally mounted at the face on the cutting machine, TBM continuous miner, etc. and moved forward with the unit. As the flexible ventilation ducting is hung in the tunnel, the action of the TBM causes the duct to be automatically removed from the cassette and extended in the excavation. When the cassette unit is exhausted and is then substituted for a spare unit holding a full section of ducting, the empty unit is reloaded on the surface by support personnel.

Figure 7.5.3a Preloaded Bagline Cassette Dispenser

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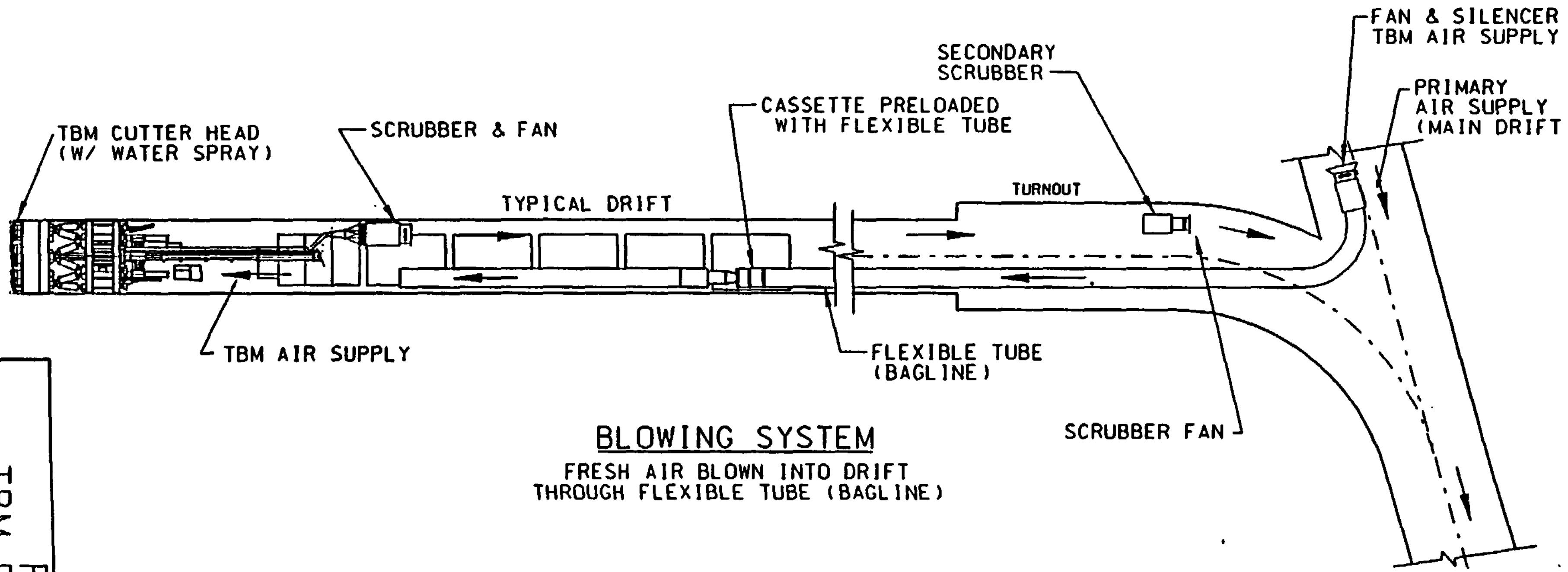

FIGURE 7.5.3b
TBM FACE VENTILATION
BAGLINE BLOWING SYSTEM

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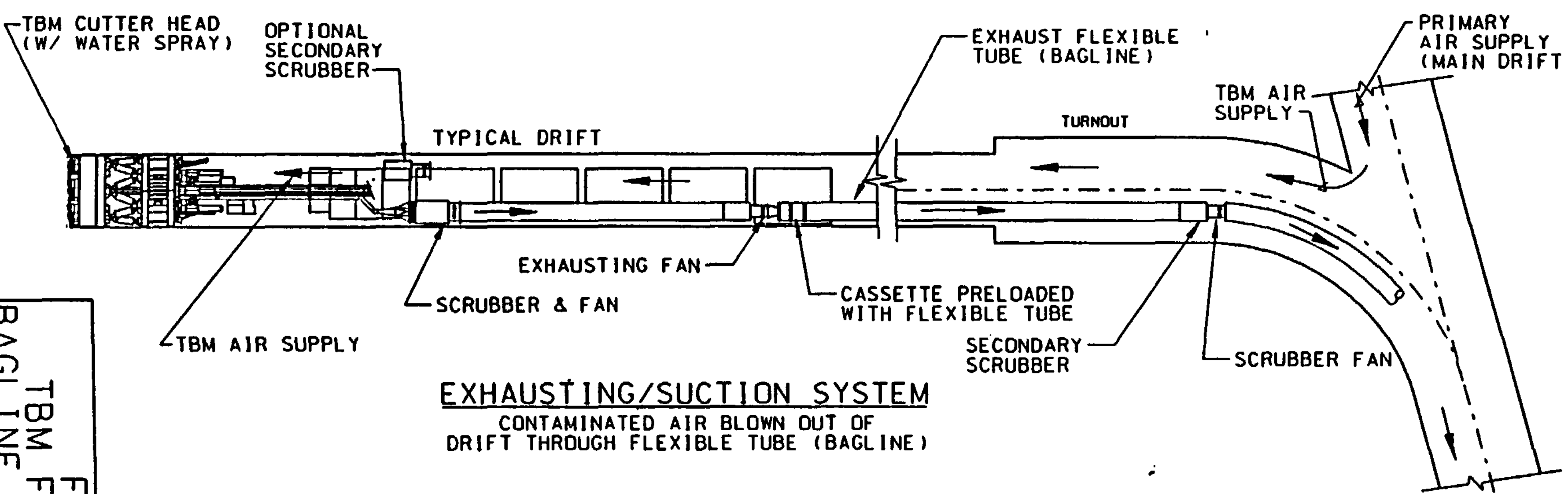

FIGURE 7.5.3C
TBM FACE VENTILATION
BAGLINE EXHAUSTING SYSTEM

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Application of flexible tube fabricated from heavy duty brattice cloth and hang on messenger wire along repository drifts has advantages over short sections of 1.68 m (66 inches) diameter and 6.1 m (20 ft) long corrugated metal duct as used for ESF construction. The advantages of flexible tube are summarized as follows:

1. Flexible tube is less expensive than metal duct in initial capital investment, and requires less effort for handling and installation (Reference 5.10).
2. A cassette preloaded with a single section of 305 m (1000 feet) long flexible tube requires a single installation effort as opposed to multiple efforts for short sections of duct, and requires less support at the tunnel crown. Equivalent metal duct in 6.1 m (20 ft) section needs labor intensive installation to keep up with the advancing TBM.
3. Installing a series of flexible tubes, 305 m long per section, will have a potential leakage source at the joints which are 305 m apart. Installing a section of metal duct, 6.1 m (20 ft) long per section, will have a potential leakage source on every joint, which represent 305/6.1 = 50 times greater leakage potential. Despite costly efforts to minimize leakages at the joints, the current ESF experience showed minimum measurements of 32% recirculation (Reference 5.23) over 3000 m of metal ducts. Recirculation of contaminated exhaust air was identified as a root cause of dust problems. The 32% is higher than the projected 25% leakage allowance used in the VA design.
4. Flexible tube is more adaptable to minor curves and bends than metal ducts which needs adapters in this situation, and has a lower resistance factor and hence lower energy cost to move the air. Large metal ducts need considerable corrugation to maintain structural rigidity which increases resistance and consequently energy requirements.
5. Flexible tube is easy to recover and recycle. All subsurface ventilation equipment and accessories for construction are temporary and must be removed. Flexible tube is made from heavy duty materials that can be washed and reloaded onto the cassette dispenser for reuse. This feature will facilitate installation and removal of ventilation tube for emplacement drift excavation.
6. Flexible tube is easier to maintain and repair than are metal ducts which require highly skilled personnel to detect and repair leakage.

Application of flexible tube in preloaded cassettes can be expected to increase TBM utilization, and it is recommended that bagline dispensers be used as a standard ventilation component on repository TBMs.

7.5.4 TBM Face Ventilation Arrangements

7.5.4.1 Perimeter Drifts and Exhaust Main, 7.62 m diameter TBM Drive

An early construction face ventilation arrangement for TBM operation is shown in Figure 7.5.3.b. The supply air is blown by a series of axial fans to the work area through bagline under positive pressure. The 250 bhp two stage axial fan as used for ESF construction is ideal for this arrangement. The flexible tube 1.83 m (72 inches) diameter and in 305 m (1000 ft) sections will be dispensed from a cassette located on the last deck of the TBM.

The arrangement delivers clean air to the TBM personnel. A local exhaust auxiliary ventilation system at the TBM supplies air to sweep the TBM face to remove airborne dust and heat. This air is then ducted to the primary TBM dust collection system. After the air is cleaned it will be diluted with fresh air and reused to ventilate the TBM drift and then returned to join the supply air in primary airways.

Flow through ventilation will be carried as close as possible to the TBM face by utilizing cross block drifts developed ahead of the TBM advance. Based on the repository layout (Reference 5.5), this will shorten the source of supply air to the TBM face from a potential maximum distance of about 8500 m (South Ramp takeoff to East Main intercept) to 3700 m (Cross Block #35/West Main to East Main intercept)

7.5.4.2 Emplacement, Performance Confirmation, and Cross Block Drifts

Based on the repository layout, these are relatively short drifts 1000 to 1300 m (3280 to 4250 ft) in length (Reference 5.5) between the East and West Mains, excavated by a 5.5 m TBM. Launching of the TBM will be from the East Main side and recovery on the West Main side, where the TBM will be partially disassembled and moved back through the drift for relaunching (Reference 5.21). With the repeated sequence of launching and recovering, the TBM ventilation can best be supported by bagline as discussed earlier. Supply air will be blown by an axial fan unit to the work area through heavy duty bagline under positive pressure.

For this application a 1.37 m (54 inch) diameter bagline, 152 m (500 ft) (Reference 5.10) is recommended by a manufacturer of this equipment. The shorter length (152 m) of bagline contained in a cassette is based on practical experience and convenience to refill the cassette dispenser.

A low speed and low noise axial fan (e.g., a two stage Model 48-26-1180/125 hp fan) will be installed at the East Main side to push the supply air, 19.0 m^3/s at 2.49 kPa (40,300 cfm at 10 inches wg) to the TBM area. This will be the only fan needed for the 1300 m long TBM drive, and booster fans will not be required in the drift. The last deck of the

TBM will carry the pre-loaded cassette which will automatically release bagline as the TBM advances. After completion of the drift, baglines will be recovered and brought to the surface for cleaning and reloading in cassette dispensers for reuse.

7.5.5 Roadheader Face Ventilation Arrangement

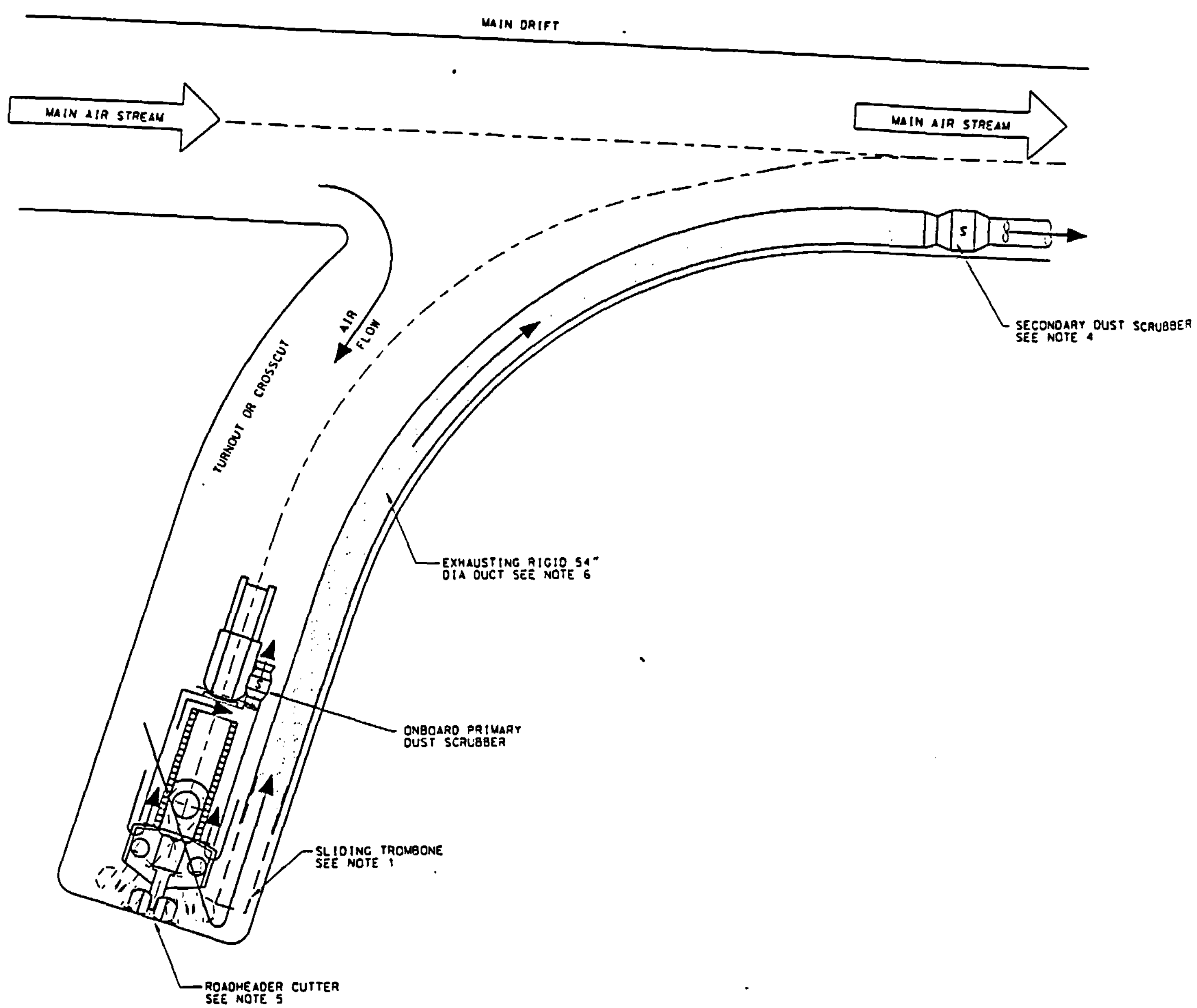
Face ventilation for a roadheader excavating inside a turnout or in a drift is similar to the TBM system. Modern roadheaders typically have built-in face water sprays, wet dust scrubbers, and fans to suppress and remove dust created by cutting the rock. For typical excavation of the short (approximately 30 to 38 m long) turnouts, the roadheader fan will be sized to handle the local face airflows.

When starting the turnout the cutter head and body of the roadheader will be in the main drift creating a greater potential to contaminate the primary air supply with dust. The cutter head and frame of the roadheader once inside the drift is not in contact with the high velocity airflow of the primary airways. Dust from the roadheader excavation can be prevented by installing a ventilation bypass (overcast) or air curtain around the roadheader as shown in Figure 7.5.5. In either case, the air leaving the roadheader activity must be scrubbed to remove dust adequately. This will allow the air to be returned to the main drift as ventilation air. The primary surface fan will be sized to handle the pressure loss resulting from the resistance of the bypass.

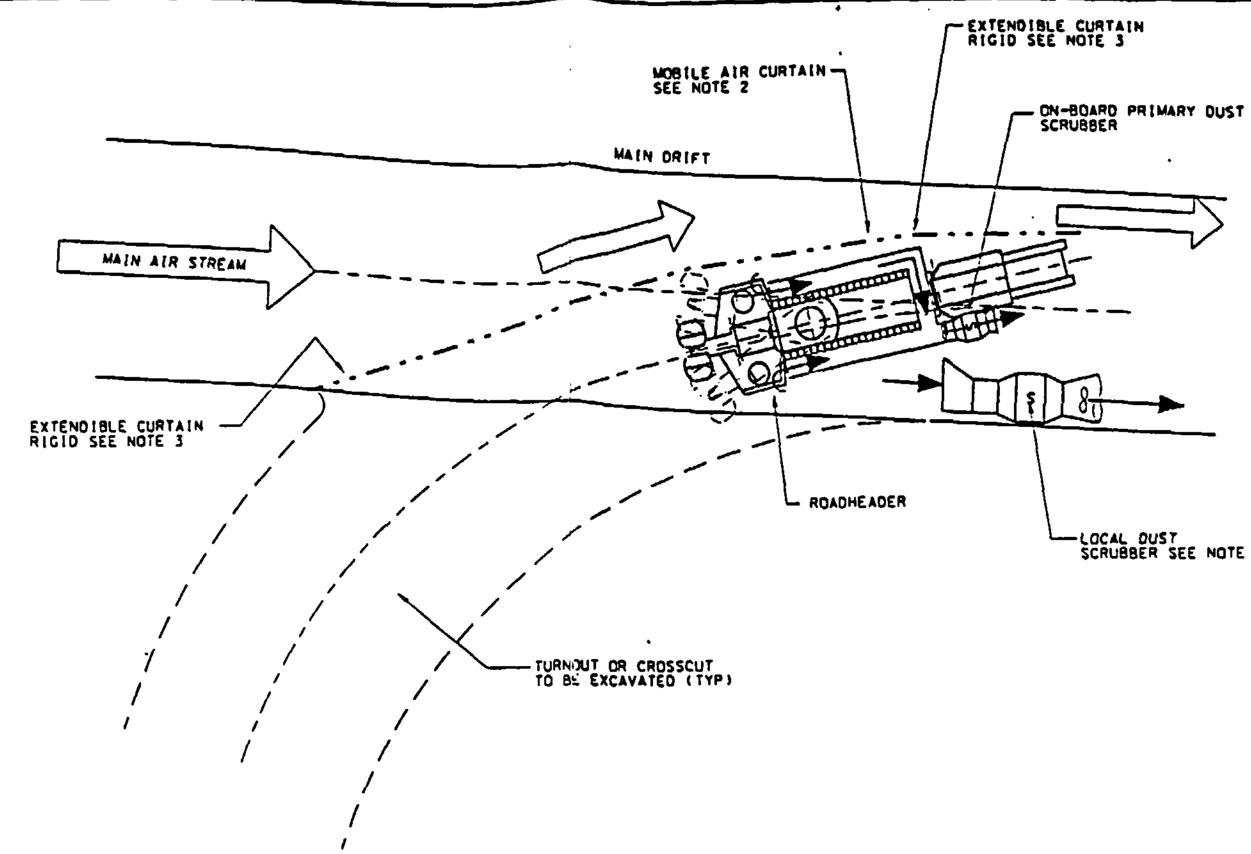
An alternative to installing a ventilation bypass is to schedule initial turnout excavation during times when contamination of primary airways is not critical to downstream users of the ventilation system. This approach would, however, create fugitive dust in the airways which may have to be dealt with later.

7.5.6 Shaft Construction

The development intake and emplacement exhaust shafts will be excavated by raise borer and down reaming (Reference 5.21) in three phases as follows: a) blind drilling a 0.305 m diameter hole from the surface to the repository level, b) upreaming the pilot hole to a 2.4 m diameter pilot raise from the repository level to the surface, and c) vertical boring the raise to a 6.7 diameter shaft (6.1 m diameter after liner) from the surface to the repository level. Steps b) and c) create potential dust sources when excavated rock falls to the repository level for disposal.



ROADHEADER FACE VENTILATION



ROADHEADER INITIAL CUTTING AND DUST CONTROL BYPASS - ALONG MAINS (TYP)

NOTE 7

TYPICAL RELATIONSHIP OF AIRFLOW AND ROADHEADER ADVANCE

NOTES:

1. SLIDING TROMBONE EXTENDS AS CLOSE AS FEASIBLE TO THE FACE. DUST BACKFLOW FROM ROADHEADER CUTTING HEAD WILL EXHAUST INTO DUCT AND INTO DUST SCRUBBER WITHOUT PASSING THROUGH PERSONNEL BREATHING AREA NEAR FACE.
2. MOBILE AIR CURTAIN MOUNTED ON FLAT CAR TO MOVE IN POSITION NOT TO DISTURB ROADHEADER ACTIVITY.
3. RIGID CURTAIN WALL WITH EXTENDIBLE HEIGHT AND LENGTH TO FIT NEEDS OF BLOCKING HIGH VELOCITY AIR INTO ROADHEADER ACTIVITY. CURTAIN HAS GRIPPERS TO STABILIZE POSITION.
4. LOCAL DUST SCRUBBER INSTALLED ALONG DRIFT AS NEEDED.
5. ROADHEADER CUTTING WITH WATER SPRAY ARRANGEMENT WILL BE INCLUDED IN ROADHEADER SPECIFICATION.
6. AIR QUANTITY DELIVERY INSIDE DUCT IS DESIGNED TO PRODUCE NOMINAL 0.6 m/s (118 fpm) OF AIR VELOCITY ALONG DRIFT.
7. ROTATE IMAGE AS NEEDED FOR SPECIFIC ROADHEADER FACE VENTILATION ARRANGEMENT.

FIGURE 7.5.5
ROADHEADER FACE VENTILATION

Water sprays on the raise borer and down reamer heads suppress airborne dust and wet down the excavated rock. Well sealed enclosures in the shaft access drifts on the repository level will contain most dust from the drop area. An apron feeder or chain conveyor located away from the impact of falling rocks will be installed for loading muck into shuttle cars. A cushion of muck will seal the drop area from the repository haulage, and a local dust collector will be provided to capture any dust leakage from drop area and loading points. Additional water sprays can be used where needed.

The boring machine will be supplied with fresh air from the surface through a 1.37 m (54 inch) diameter duct. The auxiliary fan with a 93 kW (125 bhp) motor located at the surface will supply (blow) air, 23.6 m^3/s (50,000 cfm), to the shaft borer.

7.5.7 Ventilation Raises

The ventilation raises connecting the exhaust main drift and the emplacement drifts or PC drifts will be excavated by raise borer (Reference 5.21). The raise borer will first drill a pilot bore from the emplacement drift. During this operation high pressure air/water mist in the drill stem will cool the cutters and suppress dust at the collar of the hole. Water sprays on the reamer head will likewise cool the head cutters and suppress airborne dust in the raise and on the muck pile at the bottom of the raise. A mobile muck chute as shown in Figure 7.5.7 will be placed at the bottom of the raise during upreaming to capture the falling muck and load it into rail cars. A water spray system and an exhaust tube with a local dust scrubber will be installed to clean the return air from this activity.

7.5.8 Core and Pneumatic Drilling

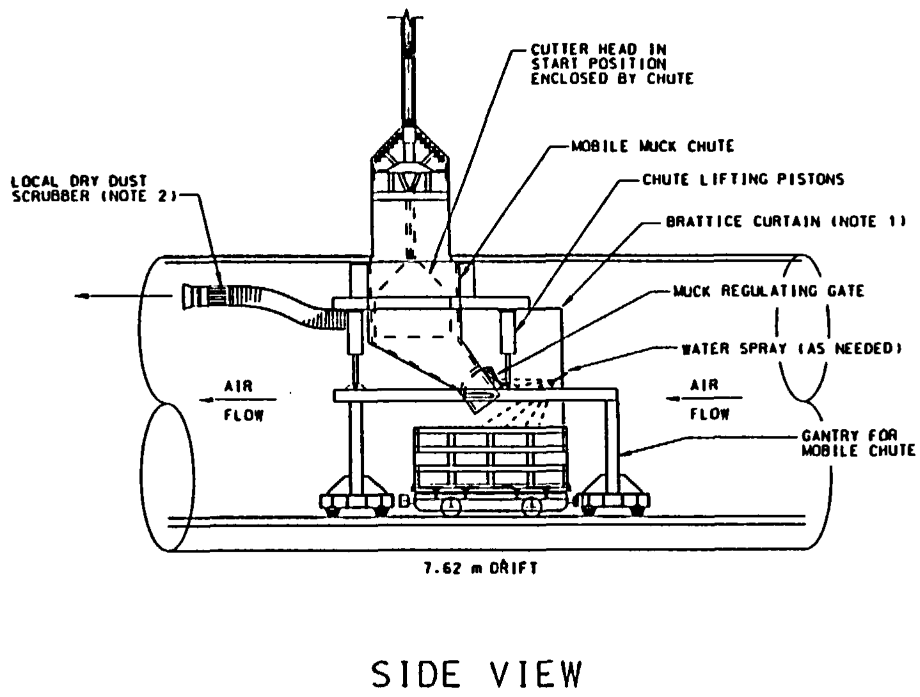
To the extent practical core and pneumatic drilling should use water to minimize dust. Where dry drilling is mandated enclosures and local dust collectors must be used.

7.5.9 Drill and Blast Excavation

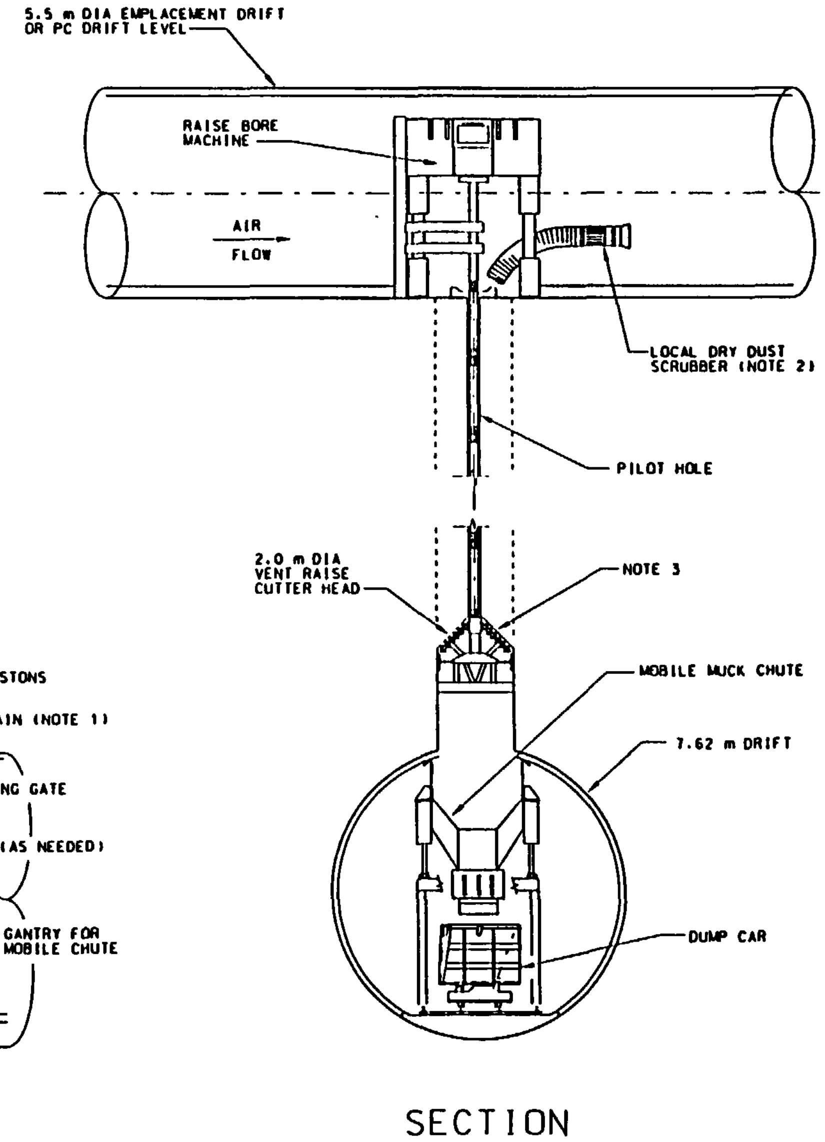
While the repository layout design relies entirely on mechanical excavation, drilling and blasting in some areas cannot be ruled out. Drills use water to suppress dust, and local dust collectors can be provided to contain dust and fumes after the blast. Personnel will be vacated during blasting and kept away from the return path of blasting fumes and dust. Muck piles will be wetted as necessary during mucking operations to minimize creation of fugitive dust. Local dust collectors will be used also if needed.

NOTES:

1. INSTALL BRATTICE CURTAIN AS NEEDED TO DIVERT STRONG AIRFLOW CONTACT FROM MUCK MOVEMENT.
2. LOCAL DUST SCRUBBER ACTIVE ONLY AS NEEDED WITH SUCTION SPIRAL WIRE REINFORCED INLET TUBE NEAR DUST SOURCE.
3. WATER SPRAY ADDED TO MUCK DURING CUTTING IS NOT SHOWN



SIDE VIEW



SECTION

FIGURE 7.5.7
MOBILE CHUTE & DUST CONTROL FOR RAISE UPREAMING

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7.5.10 Muck Conveyors

Muck conveyors are a potential source of airborne dust. Muck from the excavated face, which is usually fairly wet when placed on the conveyor, dries out as it travels on the conveyor through the airstream. Water sprays placed at intervals along the conveyor will minimize dust from the conveyor contaminating the airstream. Conveyor transfer and drop points should be enclosed and provided with water sprays. Scraper and spray wash will wash return belts and idlers.

7.5.11 Airways, Haulage Ways, Mine Cars and Dumping Stations

a) Airways and rail haulage ways

Cleaning the walls and floors of airways and rail haulage ways, by periodically washing down or vacuuming, will remove many potential dust sources. Concrete lined openings facilitate cleaning. Residual dust and dirt should not be allowed to accumulate in the airways and haulage ways as these represent potential dust sources.

b) Mine cars

Keeping the muck in the mine cars wet reduces the potential for creating dust. Overloading cars must be avoided as it can lead to spillage which then becomes another potential dust source. Washing mine cars regularly will keep them free of dirt and dust, and parking a loaded mine car for a long periods should be avoided as this allows the muck to dry out. If feasible, major route of mine cars should not be along primary intake airways.

c) Dumping Stations

Subsurface muck car dumping stations represent major potential dust sources. Enclosure and bypass airways can be installed to avoid high velocity air/dust contact. Water spray at dump activated during dumping will wet the muck and suppress dust. Local dust scrubbers located at the dumps will clean dusty air that escapes from the dump station enclosures. Choice of location and equipment for dump stations must prioritize dust control.

7.5.12 Leakage and Recirculation of Contaminated Air from Exhaust Ducts

Leakage from exhaust ducts containing contaminated air and subsequent recirculation of the leakage contributes to dust problems. Measured leakage during ESF construction

resulted in 32.0 % recirculation (Reference 5.23) over a span of 3,000 m metal duct. If metal duct is to be used, the common solution is to maintain negative pressure to keep the dust inside the duct. Fans can be regulated by either dampers or by fan spacing and blade setting to maintain a negative pressure balance. Ducts should adhere to installation specification for better sealed joints and minimum leakages. These problems may be reduced by using long sections of bagline (Section 7.5.3).

7.5.13 Use of Mobile and Portable Dust Collectors

To assure clean air in primary airways and in selected drifts, mobile and portable dust collectors can be placed at strategic locations. Dust collectors can be obtained as stand-alone portable units or mobile mounted on flat cars. Units can be designed with a range of processing capacities starting from 7.1 m^3/s (15,000 cfm) for small application like the ESF units, 18.9 m^3/s (40,000 cfm) capacity for increased demands, such as emplacement drift construction, and up to 47.2 m^3/s (100,000 cfm) capacity for primary return airway clean-up coming from the 7.62 m diameter airways. Smaller 7.1 to 18.9 m^3/s capacity units may be placed in the tunnel roof while the largest unit, 47.2 m^3/s capacity, may be parked in empty turnouts and alcoves so as not to disturb the haulage ways. Dust collectors are made as automatic self cleaning units, complete with low noise in-line centrifugal fans, starter and automatic dry dust disposal containers. With current standard technology, units with efficiencies of 90% dust removal down to 1.0 micron airborne particulates are available. Mobile and portable dust collectors should be specified as dry units to maintain versatility for subsurface application where water use and disposal could be a factor.

7.5.14 Training and Incentive Plans

Construction personnel should be trained to understand the serious nature of repository dust hazards and the effects of respirable dust on health and safety. Personnel should learn how to identify and report potential dust sources and hazards and the various methods of controlling dust. They should understand the design features and efficiency requirements of dust collectors and scrubbers.

Personnel should be trained so that each can contribute to a successful dust control program by proper work practices, such as good housekeeping, proper use and maintenance of tools and equipment, clean clothing, proper handling of materials, and proper walking in airways. Incentive plans for maintaining clean working places with dust level below a specified allowable goal could be considered. Development of such programs is beyond the scope of this analysis.

7.6 CONSTRUCTION MODE VENTILATION

The VA repository layout is shown in Figure 7.1. The ingress and egress, and muck haulage routes are established by the repository layout and construction analyses (References 5.5 & 5.21), which provide the basis for developing the repository ventilation plan. During initial (early) repository construction the ventilation strategy is constricted by the limited number of headings and possible air routes. As layout construction advances and more openings become available, more efficient ventilation arrangements are possible. Construction of a complex layout, such as the subsurface repository, represents a dynamic situation necessitating continual changes to the overall ventilation system during this period. During the development mode, even though construction of emplacement drift panels moves along the block from north to south, the overall ventilation strategy remains the same from one end of the block to the other. Similarly, the emplacement operations approach does not vary over the life of the repository, although the capacity of the ventilation system must increase as more emplacement drifts are filled. Development mode ventilation is discussed in Section 7.7, and Emplacement ventilation in Section 7.8.

7.6.1 Early Construction Airways

Early construction covers TBM excavation of the perimeter mains (South Main, West Main, North Main, and North Ramp Extension, and East Main North Extension), cross block drifts (between the East and West Mains), the Exhaust Main, and the first panel of Emplacement Drifts and associated ventilation raises. It also includes construction of the Development Intake and Emplacement Exhaust Shafts (Reference 5.21). The ventilation flow paths for the early construction phase is discussed below. The strategy for face ventilation and dust control during the early construction phases and normal development are similar. These are discussed in Section 7.5.

7.6.1.1 Return Airway - South Ramp

During early construction (and development) the South Ramp will serve as the muck conveyor route from subsurface construction to surface (Reference 5.21). A muck conveyor represents a potential dust source and fire hazard. Both hazards can be mitigated with engineering features and controls to maintain safe conditions around conveyors. Even so, conveyor haulage should not be located in the primary intake airway, and for this reason the South Ramp will serve as the return airway for construction and development operations. Contaminated return air from conveyor dust and the potential fire hazard exhausts directly to surface and not through the subsurface workings.

7.6.1.2 Intake Airway - North Ramp

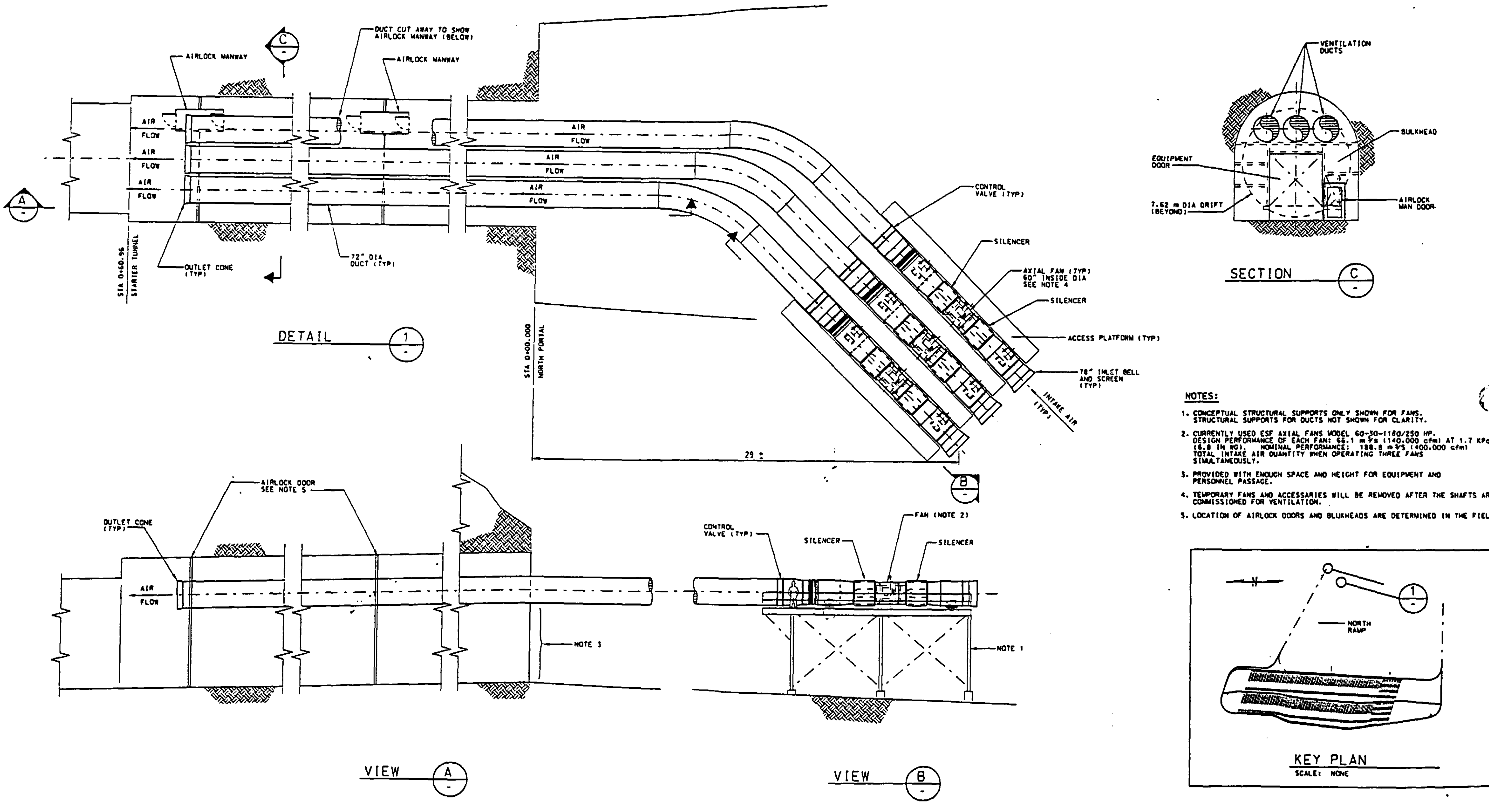
During the pre-emplacement construction period the North Ramp can be utilized as the primary intake airway until the development intake shaft has been completed. Buildings and logistic support are conveniently located on surface near the North Portal (Reference 5.21). During the early period the North Ramp will be used for both personnel and materials supply, although at some point surface construction activities will interfere with subsurface support through this opening.

7.6.1.3 Early Construction Ventilation Flow Path

During early repository construction phase, the openings which have been developed for the ESF loop (the North Ramp, East Main, and South Ramp) provide a flow path for the ventilation air. Fresh air will enter through the North Ramp and exhaust through the South Ramp. This is the same airflow direction as the ESF flow-through ventilation system.

Auxiliary ventilation will be provided for the 7.62 m TBM to drive the South Main, West Main, and North Main perimeter drifts. Another auxiliary ventilation will support the 5.5 m TBM for driving the three cross block drifts, Exhaust Main, and construction of connecting drifts to the development intake and emplacement exhaust shaft bottoms. The early construction phase will end once both emplacement exhaust and development intake shafts are commissioned .

The North Portal will be provided with three temporary intake fans and airlock system for equipment and personnel passage as shown in Figure 7.6.1.3. The choice of locating the fans in the North Portal instead of the South Portal is premised by the presence of the conveyor muck haulage and conveyor magazine in the South Portal (Reference 5.21). The temporary intake fans are Joy Model 60-30-1170/250hp, similar to the ten units used in the ESF construction (Reference 5.20). The three fan units will be activated individually to support the ventilation requirements as needed during early construction phases. Each fan can potentially deliver 66.1 m^3/s (140,000 cfm) of air quantity at 1.7 kPa (6.8 inches wg) static pressure (Reference 5.20). When simultaneously operated in parallel, the three fans will have sufficient power to move a total air quantity of about 188.8 m^3/s (400,000 cfm) along the early construction primary airways.



NOTES:

1. CONCEPTUAL STRUCTURAL SUPPORTS ONLY SHOWN FOR FANS. STRUCTURAL SUPPORTS FOR DUCTS NOT SHOWN FOR CLARITY.
2. CURRENTLY USED ESF AXIAL FANS MODEL 60-30-1180/250 HP. DESIGN PERFORMANCE OF EACH FAN: 66.1 m^3/s (140,000 cfm) AT 1.7 KPa (6.8 IN WG). NOMINAL PERFORMANCE: 188.8 m^3/S (400,000 cfm) TOTAL INTAKE AIR QUANTITY WHEN OPERATING THREE FANS SIMULTANEOUSLY.
3. PROVIDED WITH ENOUGH SPACE AND HEIGHT FOR EQUIPMENT AND PERSONNEL PASSAGE.
4. TEMPORARY FANS AND ACCESSARIES WILL BE REMOVED AFTER THE SHAFTS ARE COMMISSIONED FOR VENTILATION.
5. LOCATION OF AIRLOCK DOORS AND BLUKHEADS ARE DETERMINED IN THE FIELD.

FIGURE 7.6.1.3
NORTH PORTAL TEMPORARY
INTAKE FANS AND AIRLOCK

7.6.2 Early Construction Ventilation Phases

To effectively support early construction ventilation system, four phases are shown. These are described below:

7.6.2.1 Phase 1 - Initial Cross Block and West Main Perimeter Drifts

Phase 1 covers driving, with the 5.5 m TBM, the cross block drifts from the East Main to explore the Solitario Canyon Fault and confirm the position of the West Main (Reference 5.21). The southern most cross block drift will be excavated first followed by the middle and the northern most cross block drift. Simultaneously, the 7.62 m TBM will be launched at the bottom of the South Ramp curve to drive the South Main and West Main. The cross block drifts also provide a flow-through ventilation path from the East Main to the West Main.

Figure 7.6.2.1 shows the airflow pattern during Phase 1 for the 7.62 m TBM. The 1.83 m (72-inch) diameter bagline will have a design capacity of about 36.5 m^3/s (77,300 cfm), consistent with Table 7.4.2.

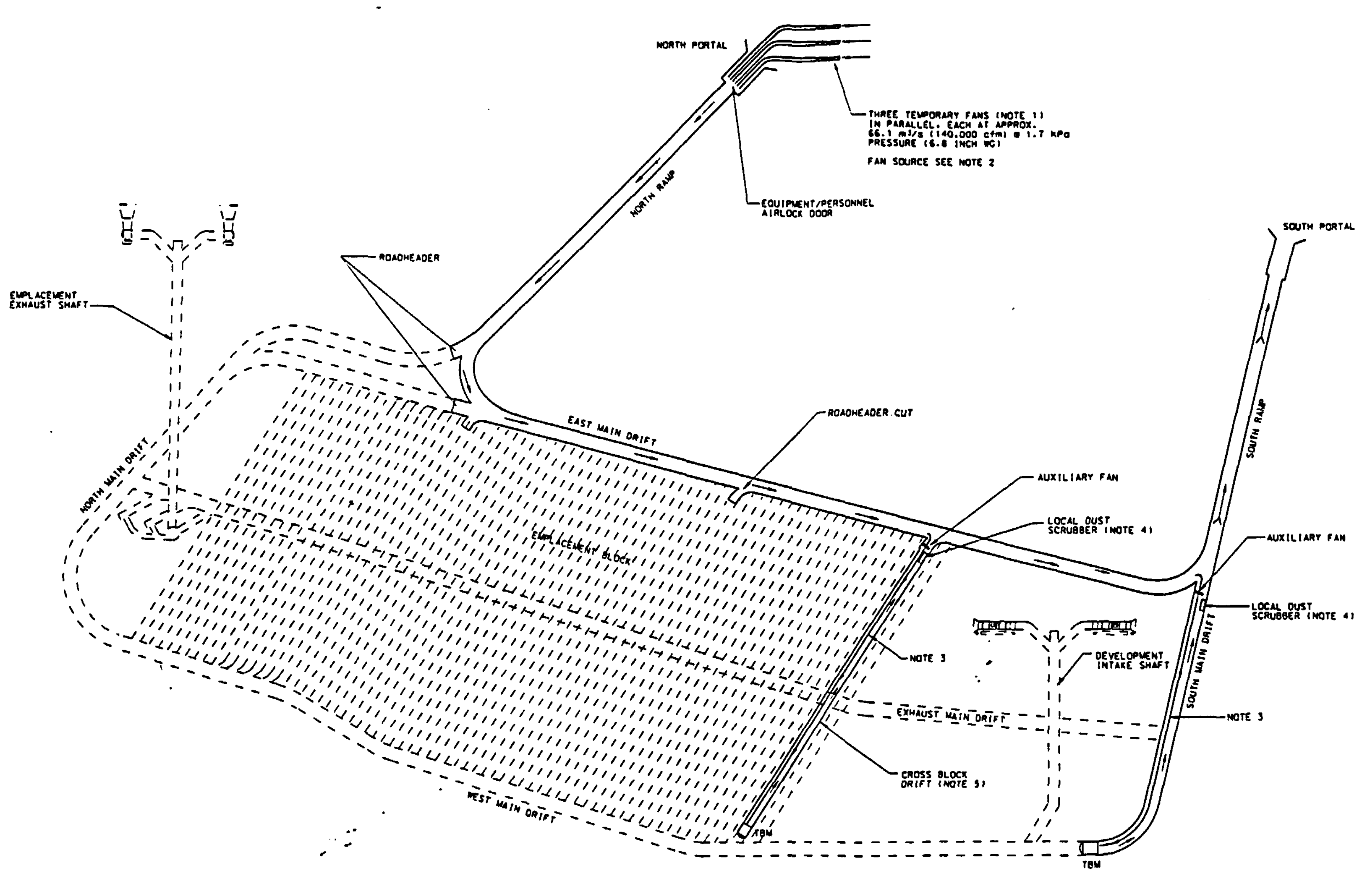
The 5.5 m TBM driving the cross block drifts will require air delivery of 19.0 m^3/s (40,300 cfm) blowing through a 1.37 m (54-inch) diameter bagline.

The roadheaders working in the North Ramp and East Main will have a local auxiliary air supply of about 34.3 m^3/s (72,700 cfm) each.

7.6.2.2 Phase 2 - Flow-Through Cross Block and West Main Drifts

Figure 7.6.2.2 shows flow-through the three completed cross block drifts just prior to breakout of the 7.62 m TBM at the East Main drift and North Ramp Extension. After establishing flow through ventilation in the first (southern most) cross block drift, this arrangement can supply air for construction of the connecting drift from the west main to the bottom of the development shaft, shaft construction, and excavation of the Exhaust Main starter drift.

As in Phase 1 and succeeding phases , the airflow requirements for typical TBM and roadheaders are the same air quantities, consistent with Table 7.4.2.



PRIMARY VENTILATION BALANCE:

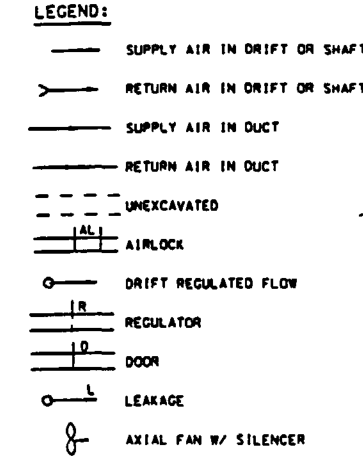
TOTAL POTENTIAL MAXIMUM INTAKE AIR 188.8 m^3/s (400,000 cfm)
NORTH RAMP 188.8 m^3/s (400,000 cfm)

TOTAL POTENTIAL MAXIMUM RETURN AIR 188.8 m^3/s (400,000 cfm)
SOUTH RAMP 188.8 m^3/s (400,000 cfm)

AUXILIARY SYSTEM:

TBM (7.62 m) PERIMETER DRIFTS 36.5 m^3/s (77,300 cfm)
TBM (5.5 m) CROSS BLOCK OR PC DRIFTS 19.0 m^3/s (40,300 cfm)
ROADHEADER TURNOUTS 34.3 m^3/s (72,700 cfm)

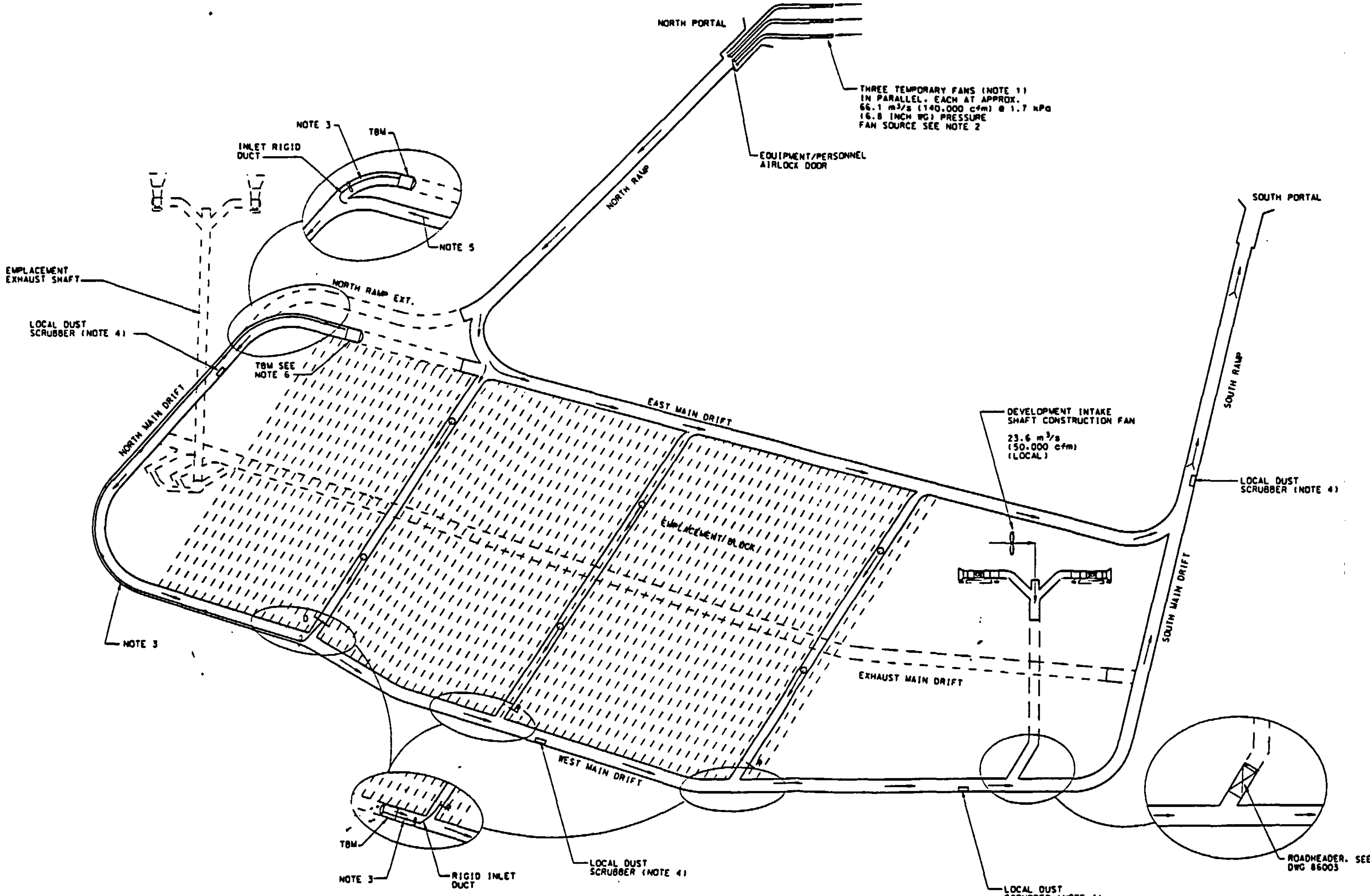
LEGEND:



NOTES:

1. THE THREE TEMPORARY AXIAL FANS IN THE NORTH PORTAL ARE OPERATED INDEPENDENTLY, UP TO A TOTAL OF ABOUT 188.8 m^3/s (400 000 cfm) WHEN THE THREE FANS ARE RUNNING SIMULTANEOUSLY.
2. CURRENTLY USED ESF STANDARD AXIAL FANS, MODEL 60-30-1180/250 HP.
3. FLEXIBLE TUBE FROM TBM CASSETTE DISPENSER IS INSTALLED FOLLOWING THE ADVANCING TBM. FLEXIBLE TUBE WILL BE REMOVED AS SOON AS FLOW THROUGH VENTILATION IS ESTABLISHED.
4. LOCAL DUST SCRUBBERS INSTALLED ALONG DRIFT AS NEEDED.
5. TBM VENTILATION ARRANGEMENT IS TYPICAL TO THE THREE CROSS BLOCK DRIFTS PLANNED.

FIGURE 7.6.2.1
PHASE 1
EARLY CONSTRUCTION VENTILATION



PRIMARY VENTILATION BALANCE:

TOTAL POTENTIAL MAXIMUM INTAKE AIR 188.8 m³/s (400,000 cfm)
NORTH RAMP 188.8 m³/s (400,000 cfm)

TOTAL POTENTIAL MAXIMUM RETURN AIR 188.8 m³/s (400,000 cfm)
SOUTH RAMP 188.8 m³/s (400,000 cfm)

AUXILIARY SYSTEM:

TBM (7.62 m) PERIMETER DRIFTS 36.5 m³/s (77,300 cfm)
TBM (5.5 m) CROSS BLOCK OR PC DRIFTS 19.0 m³/s (40,300 cfm)
ROADHEADER TURNOUTS 34.3 m³/s (72,700 cfm)

LEGEND:

- SUPPLY AIR IN DRIFT OR SHAFT
- RETURN AIR IN DRIFT OR SHAFT
- SUPPLY AIR IN DUCT
- RETURN AIR IN DUCT
- UNEXCAVATED
- AL — AIRLOCK
- DRIFT REGULATED FLOW
- R — REGULATOR
- D — DOOR
- L — LEAKAGE
- AXIAL FAN W/ SILENCER

NOTES:

1. THE THREE TEMPORARY AXIAL FANS IN THE NORTH PORTAL ARE OPERATED INDEPENDENTLY, UP TO A TOTAL OF ABOUT 188.8 m³/s (400 000 cfm) WHEN THE THREE FANS ARE RUNNING SIMULTANEOUSLY.
2. CURRENTLY USED ESF STANDARD AXIAL FANS. MODEL 60-30-1180/250 HP.
3. FLEXIBLE TUBE FROM TBM CASSETTE DISPENSER IS INSTALLED FOLLOWING THE ADVANCING TBM. FLEXIBLE TUBE WILL BE REMOVED AS SOON AS FLOW THROUGH VENTILATION IS ESTABLISHED.
4. LOCAL DUST SCRUBBERS INSTALLED ALONG THE DRIFT AS NEEDED.
5. AIRFLOW DIRECTION ALONG EAST MAIN EXTENSION AFTER CONNECTION TO EAST MAIN DRIFT. AIR SUPPLY FROM NORTH RAMP.
6. TBM AFTER BREAKING THROUGH THE EAST MAIN DRIFT WILL BE MOVED BACK TO DRIVE NORTH RAMP EXTENSION.

FIGURE 7.6.2.2
PHASE 2
CONSTRUCTION VENTILATION

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7.6.2.3 Phase 3 - Ventilation for Exhaust Main, and Flow-through North Main and West Main Drifts

Figure 7.6.2.3 shows development of the Exhaust Main drift, and the raise connection to the Cross Block drift for flow-through ventilation. Another flow-through ventilation loop consists of the primary air going through the North Ramp/North Ramp Extension and splitting to the North Main/West Main and East Main North Extension. This phase will allow construction of the connecting drift to the emplacement exhaust shaft bottom and subsequently for the boring of the emplacement exhaust shaft. This phase also supports construction of the first few emplacement drifts.

7.6.2.4 Phase 4 - First Panel Emplacement and Development

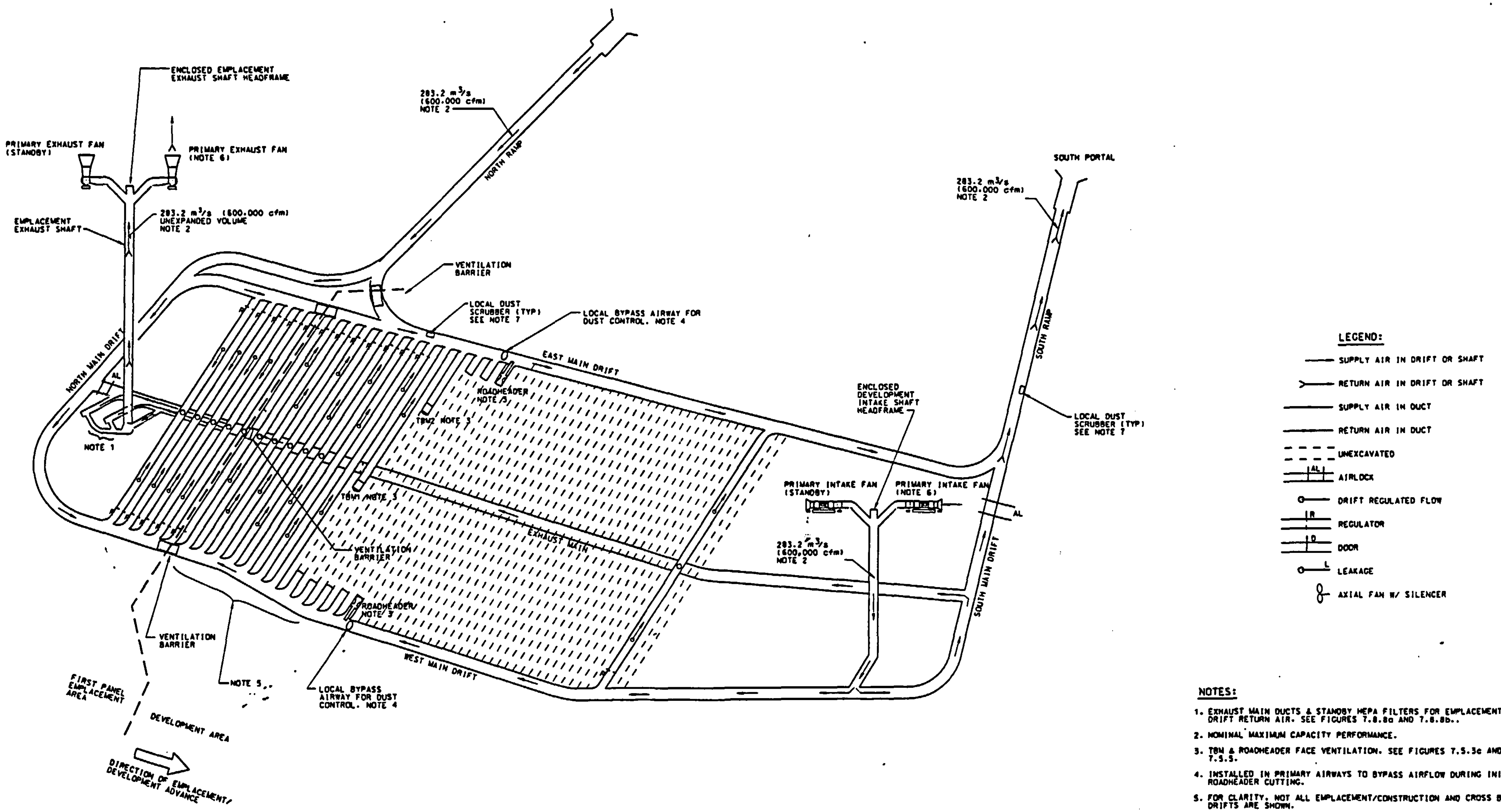
This phase covers the completion of early construction up to the turn-over of the first panel for emplacement of waste packages. During phase 4, the construction of the Exhaust Main drift is complete, the Emplacement Exhaust and Development Intake Shafts with surface primary fans and back-up units are commissioned, the auxiliary exhaust fans and the 1.83 m (72 inches) exhaust ducts for emplacement drift return are installed, and the first panel of emplacement drifts are completed. Figure 7.6.2.4 shows the beginning of simultaneous ventilation for the early emplacement and early development activity.

7.7 DEVELOPMENT MODE VENTILATION

The development mode commences after installation of the isolation barriers between the emplacement and construction sides. At this point both development intake and emplacement exhaust shafts will be in place and operating.

7.7.1. Return/Exhaust Airway - South Ramp.

The development activities will continue to use the South Ramp (References 5.5 & 5.21) for conveyor haulage and return airway as described in Section 7.6. The South Ramp provides a convenient route for personnel and materials access from the South Pad area for development construction. To alleviate dust problems for personnel traveling in the South Ramp, the potential dust sources from dry muck on the conveyor can be mitigated with enclosed drop points and water sprays.



NOTES:

1. EXHAUST MAIN DUCTS & STANDBY HEPA FILTERS FOR EMPLACEMENT DRIFT RETURN AIR. SEE FIGURES 7.8.8a AND 7.8.8b..
2. NOMINAL MAXIMUM CAPACITY PERFORMANCE.
3. TBM & ROADHEADER FACE VENTILATION. SEE FIGURES 7.5.3c AND 7.5.5.
4. INSTALLED IN PRIMARY AIRWAYS TO BYPASS AIRFLOW DURING INITIAL ROADHEADER CUTTING.
5. FOR CLARITY, NOT ALL EMPLACEMENT/CONSTRUCTION AND CROSS BLOCK DRIFTS ARE SHOWN.
6. PRIMARY EMPLACEMENT AND DEVELOPMENT FAN ARRANGEMENT. SEE FIGURES 7.11.1.2 AND 7-11.2.2.
7. LOCAL DUST SCRUBBERS INSTALLED ALONG DRIFTS AS NEEDED.

FIGURE 7.6.2.4
PHASE 4 - FIRST PANEL EMPLACEMENT VENTILATION

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PRIMARY VENTILATION BALANCE:

TOTAL POTENTIAL MAXIMUM INTAKE AIR 188.8 m^3/s (400.000 cfm)

NORTH RAMP 188.8 m^3/s (400.000 cfm)

TOTAL POTENTIAL MAXIMUM RETURN AIR 188.8 m^3/s (400.000 cfm)

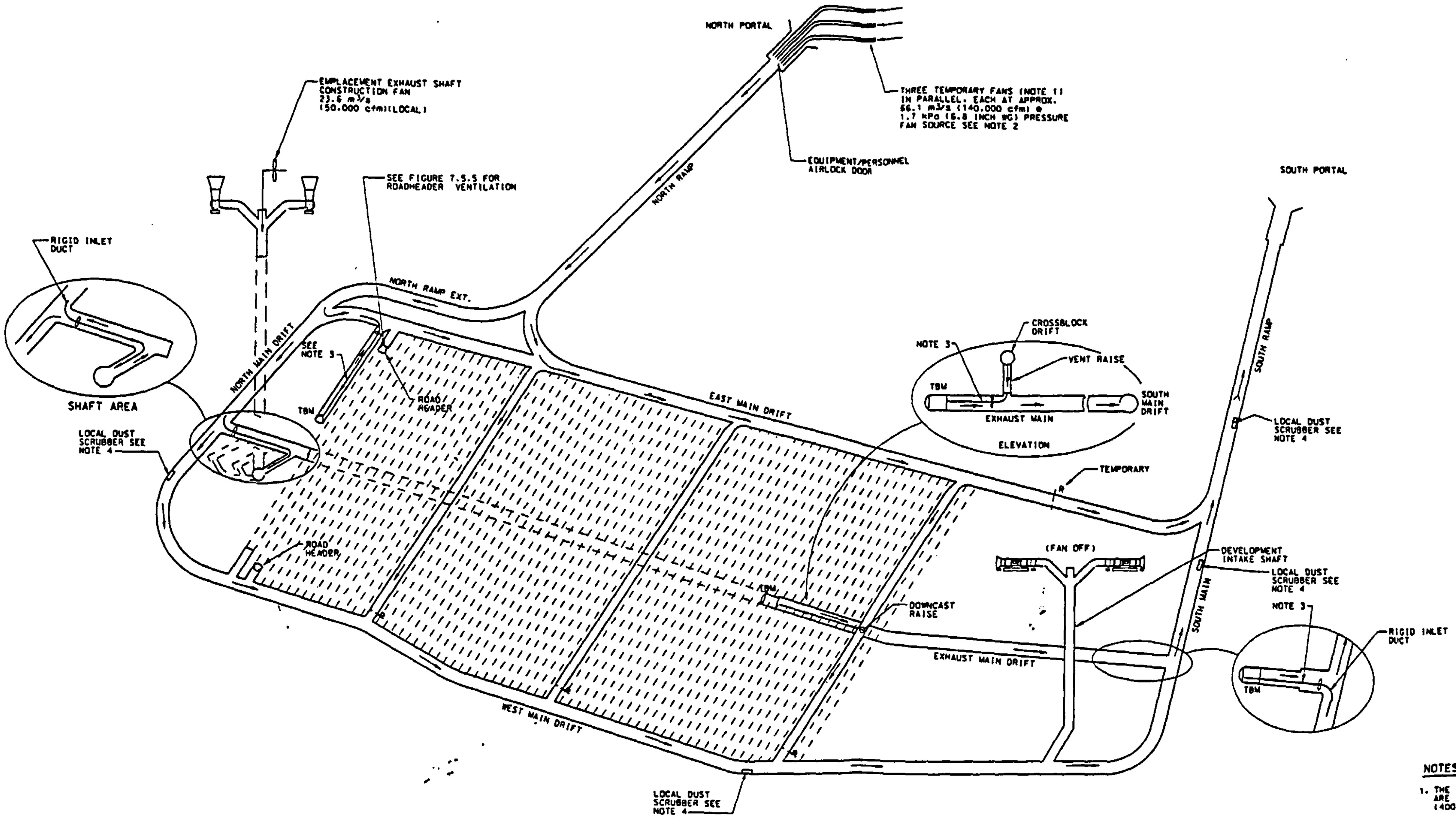
SOUTH RAMP 188.8 m^3/s (400.000 cfm)

AUXILIARY SYSTEM:

TBM (7.62 m) PERIMETER DRIFTS 36.5 m^3/s (77.300 cfm)

TBM (5.5 m) CROSS BLOCK OR PC DRIFTS 19.0 m^3/s (40.300 cfm)

ROADHEADER TURNOUTS 34.3 m^3/s (72.700 cfm)



LEGEND:

- SUPPLY AIR IN DRIFT OR SHAFT
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- AIRLOCK
- DRIFT REGULATED FLOW
- REGULATOR
- DOOR
- LEAKAGE
- AXIAL FAN W/ SILENCER

NOTES:

1. THE THREE TEMPORARY PARALLEL AXIAL FANS IN THE NORTH PORTAL ARE OPERATED INDEPENDENTLY. UP TO A TOTAL OF ABOUT 188.8 m^3/s (400 000 cfm) WHEN THE THREE FANS ARE RUNNING SIMULTANEOUSLY.
2. CURRENTLY USED ESF STANDARD AXIAL FANS. MODEL 60-30-1180/250 HP.
3. FLEXIBLE TUBE FROM TBM CASSETTE DISPENSER IS INSTALLED FOLLOWING THE ADVANCING TBM. FLEXIBLE TUBE WILL BE REMOVED AS SOON AS FLOW THROUGH VENTILATION IS ESTABLISHED.
4. LOCAL DUST SCRUBBERS INSTALLED ALONG DRIFT AS NEEDED.

FIGURE 7.6.2.3
PHASE 3
EARLY CONSTRUCTION VENTILATION

Mobile dust collectors strategically parked at various locations in the South Ramp can be used to reduce dust levels as necessary. Personnel carriers can be enclosed and equipped with dust filters and scrubbers if necessary.

7.7.2. Intake Airway - Development Intake Shaft

The second entry to the development area will be the vertical Development Intake Shaft located in the southwest section of the repository block. As the only other entry to the development construction area, the Development Intake Shaft is designated as the primary intake airway. The shaft can also be used for personnel and materials access if needed, although this would require transportation of men and materials to the top of Yucca Mountain. For normal men and materials access, the shaft would be more expensive and time consuming than using the ramp.

The shaft will be lined with concrete and sized at 6.1 m internal (clear) diameter. This configuration is used in the computer model. The size of the shaft is adequate and will be large enough to operate at a low energy (fan horsepower) level over the operating range of the repository development requirement (Attachment I, II and III, Computer Models).

7.7.3. Primary Flow Path - Development Area

The ventilation flow path for the development area starts at the collar of the Development Intake Shaft which downcasts intake air to the shaft connection drift on the repository level. From here the air splits along the West Main and Exhaust Main. The air then continues through the emplacement drift construction area and exhausts through the East Main to the South Ramp and from there to surface at the South Pad area.

7.7.4. Primary Fan Location - Development Area

The primary fan is located at the surface near the Development Intake Shaft Collar and forces the intake air into the development network. This arrangement will create a continuous positive pressure in the development area. This system coupled with the negative pressure emplacement system described in Section 7.8 assures compliance with criteria requirements under Section 4.2.1.4.

The location of the primary fan on surface is preferred and is a standard mining practice where such location is feasible. This type installation will enhance access for maintenance and provide better control of the primary fan operation in case of underground fire or radiation releases. The features for back-up power, type of primary fan and reversibility options are described in Section 7.11.

7.7.5 Configuration of Development Plan

The configuration, size and length of the primary airways in the development area shown in the repository layout have been used in computer models to determine the overall viability of the repository development ventilation. The data and results are discussed in Section 7.10 of this analysis.

7.7.6 Ventilation Approaches for Development Area Construction

For the development activities, three ventilation approaches are considered.

1) Ducted exhaust air
2) Ducted intake and exhaust air
3) Flow-through ventilation.

The three options are evaluated for ventilation along the primary airways. The minimum drift air velocity rate of 0.51 m/s (100 fpm) needed to assure non-stratification of particulates (Section 7.4.1.1) in the airways is considered. Detailed face ventilation arrangement for TBM and roadheader excavations are the same for the three options and are discussed separately in Sections 7.5.4 and 7.5.5. Concurrent with rock excavation by TBM and roadheader, a number of other construction activities will take place, including finishing the mains, boring ventilation raises between the emplacement drifts and the Exhaust Main, removing construction track, equipping the emplacement drifts with gantry track, electric power supply, ventilation doors and valves, monitoring and control systems, and performing commissioning tests and checks. These activities will spread throughout several emplacement drifts and the mains and will all require ventilation air. Advantages and disadvantages of each option in relation to the primary airways are discussed in the analysis to reach a more effective solution for repository construction.

All options are evaluated with the primary development fans (primary and back up units) installed at the Development intake shaft collar. Trolley wires are installed in the haulage drift below the ventilation ducts (Reference 5.21).

7.7.6.1 Ducted Exhaust Air [Base Air Velocity at 0.51 m/s (100 fpm)]

The ducted exhaust air option delivers the primary air supply to the nearest intersection of the TBM or Roadheader construction face by using the drift airways. From this intersection return air from the TBM or roadheader face is exhausted through ventilation duct to the surface by means of a series mechanical fans in the duct line. A simple schematic and spreadsheet calculation of equipment requirements are shown in Attachment IV. This option has the following ventilation performance and equipment requirements:

a) System total air quantity, 264.3 m^3/s (560,000 cfm)
b) Total energy for primary and auxiliary fans, 7,550 kW (10,130 bhp)
c) Total number of auxiliary fans, 26 units
d) Total number of primary fan, 1 unit
e) Total length of ventilation ducts, 17,520 m (57,470 ft)

7.7.6.1.1 Advantages of Ducted Exhaust Air

The main advantage of ducted exhaust air is the containment of contaminated exhaust air inside the duct for discharge to surface. Personnel in the return drift will be exposed to less dust contamination provided exhaust duct leakage is minimized.

7.7.6.1.2 Disadvantages of Ducted Exhaust Air

a) Requires energy for fans to move the return air through ducts to surface. Fan power consumption will reach a maximum of 7,550 kW (10,130 bhp) during early construction and diminish as development advances towards the South Ramp in the late development stage.

b) Requires installation and maintenance of 26 auxiliary fans and one primary fan, and 17,520 m (57,470 ft) of 1.68 to 1.83 m (66 to 72 inches) diameter duct. Auxiliary fan motors are between 112 to 373 kW (150 to 500 hp), and spread evenly along the primary development airways if rigid metal duct is used. As the development face moves along the block from north to south, duct and fans would be removed as necessary. Flexible duct will not be viable because fans must be clustered closer to the intake end of the duct to generate high positive pressure in excess of potential capability of the flexible tube. In addition, these fans would create a concentrated noise hazard in a busy area, and must be repeatedly removed and set up again in step with the advancing development face. For these reasons flexible duct is not considered further in this analysis for a ducted exhaust system.

c) Elevated noise levels from fans in traffic areas necessitate the need for silencer sets on all duct fans.

d) Uncontrolled recirculation of contaminated air from leakages of large exhaust ducts.

e) May require dust scrubbers in the return airways to minimize personnel dust exposure and air cleaning at the TBM. The dust sources may come from leakage of exhaust ducts, and conveyor and other haulage activities.

f) Large ducts in the Mains will result in ventilation interruption every time the trolley wires and ducts are taken down for maintenance and movement of the TBM and roadheader along the East or West Mains. Trolley wires must be disabled and removed when changing ducts and fans.

g) Dust particulates in the duct will potentially exceed the surface emission limits set by EPA (Section 4.2.7), and will therefore require processing for dust removal.

h) Containing return air inside ducts loses the function of that air to increase airflow velocity in drifts thus minimizing potential for stratification of respirable dust.

I) Limits potential to expand airflow quantities because fans and ducts are selected for a particular output. Increasing the system capacity could necessitate changing fans and/or duct.

j) Ventilation balance on ducted exhaust air is relatively difficult to manage and monitor compared to drift airflows. Special instruments and equipment are needed to monitor quality and quantity of air through ducts.

7.7.6.2 Ducted Intake and Exhaust Air [Base Air Velocity at 0.51 m/s (100 fpm)]

In this option air is supplied in large ducts from the bottom of the Development intake shaft to the intersection of the primary airway and the drift construction face. The quantity of air delivered in the duct must be sufficient for the construction face, drift ventilation, and exhausting return air in an exhaust air duct. The fresh air supply is delivered to the TBM or roadheader. Return air from construction activities splits into two, dust laden exhaust air from excavation is returned through exhaust ducts to surface, and the remainder (the bulk of the supply air) ventilates the drift (see Table 7.4.2) to prevent dust stratification.

A simple schematic and spreadsheet calculation of equipment requirements are shown in Attachment IV. This option has the following ventilation performance and equipment requirements:

a) System total air quantity, 328 m^3/s (695,000 cfm)
b) Total energy for primary and auxiliary fans, 14,700 kW (19,700 bhp)
c) Total number of auxiliary fans, 40 units
d) Total number of primary fan, 1 unit
e) Total length of ventilation ducts, 24,140 m (79,200 ft).

This option requires a series of large fans and ducts to deliver the sufficient air supply. The dust laden air accumulated from exhaust of Roadheaders and TBMs will also require series of large fans and ducts all the way to the surface. The air requirements for the non-excavation activities (i.e. finishing the mains and emplacement drifts) could overcome the capacity of the intake duct to supply the needed air, in which case the air supply through the main would be increased by means of the primary fan on surface. In this situation the intake duct becomes redundant.

7.7.6.2.1 Advantages of Ducted Intake and Exhaust Air

a) Fresh air remains uncontaminated at the construction face, provided the fresh intake source is clean. The intake air in duct under pressure would not be contaminated by exhaust air.

b) Air scrubbers not needed at the construction face area.

c) Personnel in the return drift exposed to less dust contamination provided leakage from exhaust ducts is minimal.

d) Flexible tube may be considered for the intake duct as the fan cluster would be located nearer the intake air shaft with less impact from noise on construction activities, and no need to repeatedly remove and reinstall fans as development moved southwards. Occasionally a fan would be removed or adjusted as the discharge side diminishes in length.

7.7.6.2.2 Disadvantages of Ducted Intake and Exhaust Air

a) Ducted Intake Side

1. Requires energy for fans to move the air through ducts. Fan power consumption will reach a maximum of 10,725 kW (14,380 bhp) during early construction and diminish as development advances towards the South Ramp in the late development stage.

2. Requires installation and maintenance of 22 auxiliary fans and one primary fan, and 9,000 m (29,600 feet) of 1.68 to 1.83 m (66 to 72

inches) diameter ducts. Auxiliary fan motors are between 260 to 520 kW (350 to 700 hp) spread over the repository airways.

3. Disadvantages of elevated noise levels, contamination of airways, removal of duct and fans to accommodate movement of large construction equipment, loss of airflow in the drift, lack of performance flexibility, and difficulty achieving ventilation balance of the system, are the same as for the ducted exhaust system discussed earlier.

b) Ducted Exhaust Side

1. Requires energy for fans to move the return air through ducts to surface. Fan power consumption will reach a maximum 3,950 kW (5,300 bhp) during early construction and diminishes as development advances towards the South Ramp.

2. Requires installation and maintenance of 15,130 m (49,650 feet) of 1.37 to 1.83 m (54 to 72 inches) diameter ducts, and 18 auxiliary fans. Auxiliary fan motors are between 93 to 520 kW (125 to 700 hp) spread over the repository airways.

3. Disadvantages of elevated noise levels, contamination of air ways, removal of ducts and fans to accommodate movement of large construction equipment, loss of airflow in the drift, lack of performance flexibility, and difficulty achieving ventilation balance of the system, are the same as for the ducted exhaust system discussed earlier.

7.7.6.3 Flow-through Ventilation [Base Air Velocity at 0.51 m/s (100 fpm)]

Flow-through ventilation utilizes available drifts as airways. This approach is widely used in underground mines and facilities with high volume air requirements and multiple working places to be ventilated. Drift airways have minimum resistance to airflow and hence ventilation operation costs less and permits rapid increase of airflow to areas in need. The TBM and roadheader are supplied with air by an auxiliary fan and duct system from the primary airways. The air supply, if contaminated by recirculation, may need scrubbing before delivery to the face. Dusty return air from the excavation operations must be cleaned for subsequent reuse. A simple schematic and spreadsheet calculation of equipment requirements are shown in Attachment IV. This option has the following ventilation performance and equipment requirements:

a) System total air quantity, 264.3 m^3/s (560,000 cfm)
b) Total energy for primary and auxiliary fans, 1,015 kW (1,360 bhp)
c) Total number of auxiliary fans, None
d) Total number of primary fan, 1 unit
e) Total length of ventilation ducts, None.

7.7.6.3.1 Advantages of Flow-through Ventilation

a) Requires less energy than ducts to move air through large cross sectional area openings. Only a primary fan is needed in the system with a peak power demand of 1015 kW (1,360 bhp) during early construction. Power demand diminishes as development advances towards the South Ramp.

b) No auxiliary fans and ducts needed along primary repository airways.

c) No recirculation of contaminated air from leakage of large exhaust ducts, which are frequent maintenance problems.

d) The absence of ventilation ducts along the mains and ramp allow movement of TBM and Roadheader without interference to the normal airflow.

e) No excessive dust particulates in the return airways to exceed surface emission limits set by EPA requirements.

f) Higher airflow velocity in the drift lessens probability of respirable dust stratification, and increased rate of dust removal lessens dwell time and consequent effect on personnel health and safety.

g) Has flexibility to decrease or increase airflow quantities if needed by means of adjusting the primary fan on the surface.

7.7.6.3.2 Disadvantages of Flow-through Ventilation

a) Requires effective dust control program, including installation of dust collector in the supply air to TBM and roadheader.

b) Requires installation of dust collectors in return air from TBM and Roadheader before returning air to the primary airways.

c) Requires installation of dust collectors to keep air clean in the primary return airways.

7.7.6.4 Comparative Evaluation of Options to Satisfy OSHA Based Minimum Air Velocity at 0.15 m/s (30 fpm) for Drift Construction

The three options discussed in Sections 7.7.6.1, 7.7.6.2 and 7.7.6.3 were evaluated using the recommended minimum drift air velocity of 0.51 m/s (100 fpm). For comparative purposes the OSHA based minimum drift construction air velocity of 0.15 m/s (30 fpm) was also evaluated. This OSHA evaluation will not be the basis for recommendation nor will it be discussed further after this section. It is for information only to demonstrate how the three ventilation options would perform if OSHA base minimum air velocity requirement were used for design. It has been previously demonstrated that this is inadequate for working areas.

For delivery of air quantity to work areas, the drift air velocity is subjected to the same 15% fluctuation and 25% leakage allowances (Section 7.4.1.1). This will have a net delivery on air velocity at 0.24 m/s (47 fpm) for construction drifts. Using the same cross sectional area of drifts given in Table 7.4.2, the volume delivery of air to satisfy OSHA requirements are 21,800 cfm for roadheaders and 10,300 cfm for emplacement drift TBMs.

The general advantages and disadvantages of the three options as applied to repository construction are the same as mentioned in Sections 7.7.6.1, 7.7.6.2 and 7.7.6.3. The comparative sizes of the ventilation equipment would be relatively smaller and are summarized as follows:

7.7.6.4.1 Ducted Exhaust Air - [Base air velocity at 0.15 m/s (30 fpm)]

a) System total air quantity, 104.5 m^3/s (221,400 cfm)
b) Total energy for primary and auxiliary fans, 1,775 kW (2,380 bhp)
c) Total number of auxiliary fans, 20 units
d) Total number of primary fan, 1 unit
e) Total length of ventilation ducts, 15,135 m (49,650 ft)

This option is shown in Attachment IV with a simplified schematic and a spreadsheet calculation of the required equipment.

7.7.6.4.2 Ducted Intake and Exhaust Air - [Base minimum drift air velocity at 0.15 m/s (30 fpm)]

a) System total air quantity, 154.1 m^3/s (326,500 cfm)
b) Total energy for primary and auxiliary fans, 3,220 kW (4,320 bhp)
c) Total number of auxiliary fans, 33 units
d) Total number of primary fan, 1 unit

e) Total length of ventilation ducts, 28,280 m (92,770 ft)

This option is shown in Attachment IV with a simplified schematic and a spreadsheet calculation of the required equipment.

7.7.6.4.3 Flow-through - [Base minimum drift air velocity at 0.15 m/s (30 fpm)]

a) System total air quantity, 104.5 m^3/s (221,400 cfm)
b) Total energy for primary fan, 56 kW (75 bhp)
c) Total number of auxiliary fans, None
d) Total number of primary fan, 1 unit
e) Total length of ventilation ducts, None

This option is shown in Attachment IV with a simplified schematic and a spreadsheet calculation of the required equipment.

7.7.7 Construction Development Ventilation Recommendation

Flow-through ventilation has advantages over ducted systems with respect to lower energy needs, less equipment needed and hence less maintenance, greater flexibility to operate over a wider range of airflows, and less impact on construction activities and less ventilation interruptions. The three disadvantages cited for flow-through ventilation (Section 7.7.6.3) all relate to the need for dust collectors and scrubbers. Considering the serious dust hazards and the very restrictive TLVs for cristobalite and quartz in the repository construction, these dust collectors and scrubbers are likely to be needed regardless of which of the three options are chosen. Air cleaners require far less power to operate than using long ducts and multiple fans. For these reasons the flow-through ventilation approach is recommended for primary air delivery during the development mode. Figure 7.7.7 is a simplified schematic of development flow-through ventilation.

Flow-through ventilation system with efficient variable speed primary fan has flexibility to accommodate over a wide range of airflow requirements to satisfy repository minimum drift air velocity of 0.51 m/s (100 fpm).

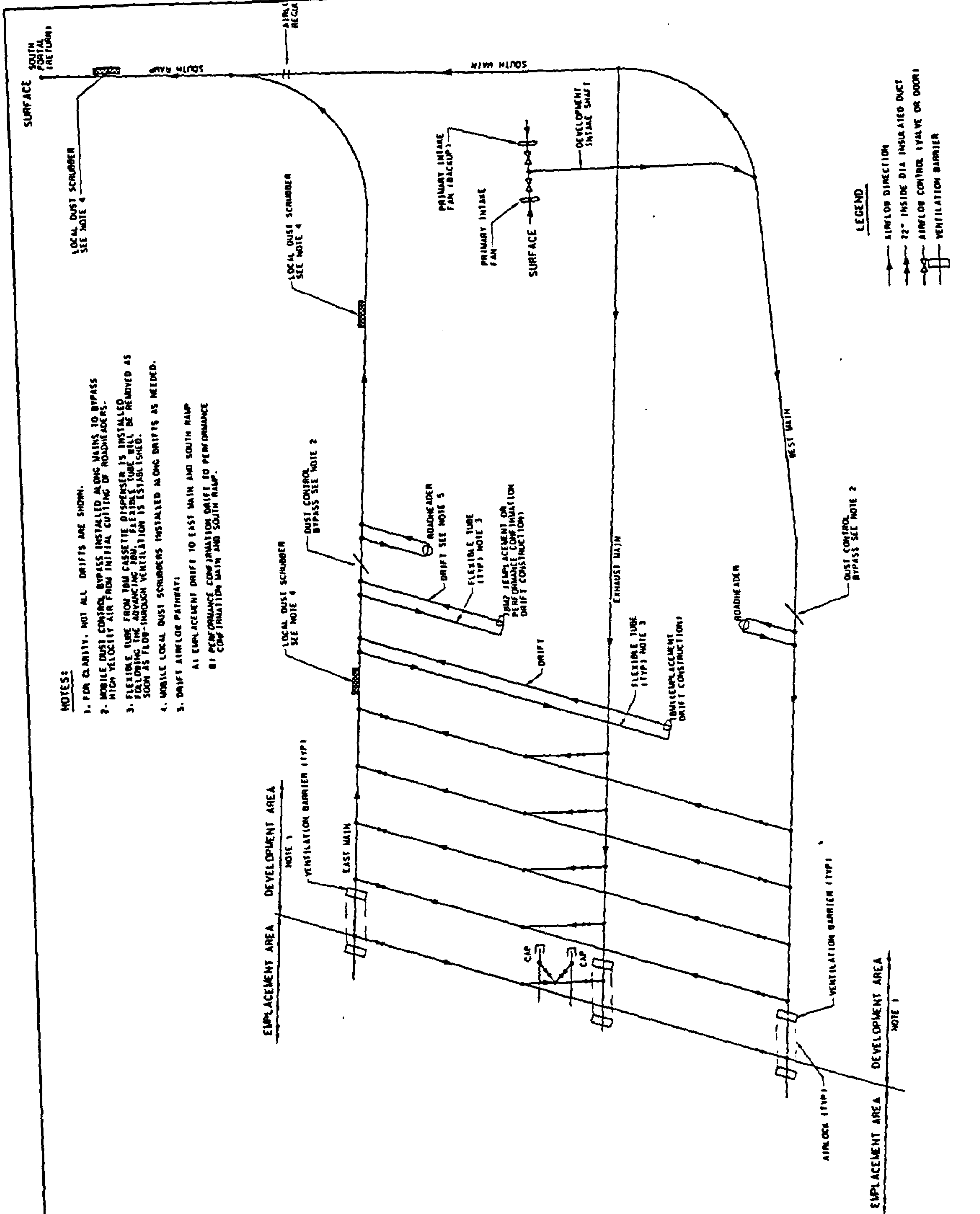

FIGURE 7.7.7
DEVELOPMENT FLOW THROUGH
VENTILATION SCHEMATIC

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7.8 EMPLACEMENT VENTILATION

At commencement of waste emplacement operations, construction of the first panel of emplacement drifts will have been completed. Emplacement activities in the first panel will run concurrent with the ongoing development (construction) of the next drift panels. Emplacement operations start at the north end of the repository block and move southwards as emplacement panels are finished.

7.8.1. Intake Airway - North Ramp

The North Ramp will serve as the access for transportation of waste packages from the waste handling facilities building located on the surface near the North Portal to the subsurface emplacement area, and as egress and ingress of emplacement area personnel. The North Ramp will also serve as primary intake airway for the emplacement operations area. The North Ramp, excavated by TBM as part of the ESF, has a 7.62 m excavated diameter. Ground support and concrete liner will reduce the clear cross section to 7.02 m (Reference 5.21). This obstruction including the invert is used for airway calculations.

During repository operations, there will be no potential dust sources in the North Ramp (from construction activities) other than ambient surface dust and pollens. Surface dust and other particulates can be minimized by filtering the intake air through a coarse filtration system at the North Portal. The filtration is similar to the performance of a typical household air-conditioning filter.

7.8.2 Return/Exhaust Airway - Emplacement Exhaust Shaft

The emplacement exhaust shaft at the north end of the repository block will serve as the exhaust airway for repository emplacement operations. The emplacement exhaust shaft collar will be located approximately 3,700 m from the north pad and portal area, where the surface waste handling facilities and emplacement side air intake air are located, and ensures a reasonable isolation from these facilities. (Reference 5.5)

The shaft will be concrete lined with a smooth finish 6.1 m inside diameter. This configuration is used in the computer model to simulate the overall ventilation network. The size of the shaft is adequate and will be large enough to operate at a low energy (fan horsepower) level over the operating range of the repository ventilation system (Refer Attachment I, II and III, Computer Models).

7.8.3 Primary Flow Path - Emplacement Area

Figure 7.8.3 shows the emplacement operations air supply. The ventilation flow paths for the emplacement area start at the surface intake, through the North Ramp/North Ramp Extension, splits into the North Main/West Main and East Main Extension, through an Emplacement drifts, Cross Block drifts, or Performance Confirmation drifts, downcasts through a ventilation raise to the Exhaust Main, and then exhausts up the Emplacement Shaft to surface. Air from active emplacement drifts (i.e. with waste packages) flows into auxiliary ducts in the Exhaust Main to contain heat and control potential radioactive leakage. Air from the ducts can be diverted through HEPA filters and adsorption units in event of leakage. Fans for the auxiliary ducts will be located near the shaft bottom and will pull air through the duct to create a negative pressure in the ducts and emplacement drifts. Negative pressure will ensure that potential leakage flows into the ducts and not out to contaminate the Exhaust Main Airway, and that emplacement drift air as it heats and expands does not flow back out into the East or West Mains. Both return air from the Exhaust main and auxiliary ducts will be directed into the emplacement exhaust air shaft.

The arrangement of exhaust duct system is a total application of negative pressure by installing the centrifugal fan near the bottom of the shaft. Features of this auxiliary fan are discussed in Section 7.11 of this analysis. The rationale for locating the primary fans on surface are the same for the development fans discussed in Section 7.7.

7.8.4 Primary Fan Location - Emplacement Area

The primary fan, and back up unit, for the emplacement operation air supply will be located on surface near the emplacement exhaust shaft Collar and will exhaust the return air from the subsurface area. The rational for locating the fans on the surface is the same as for the development fans.

7.8.5 Configuration of Emplacement Plan

The repository layout provides the basis for computer models to determine the overall air requirements and balance of the repository emplacement ventilation. The data and results are discussed in Section 7.10 of this analysis.

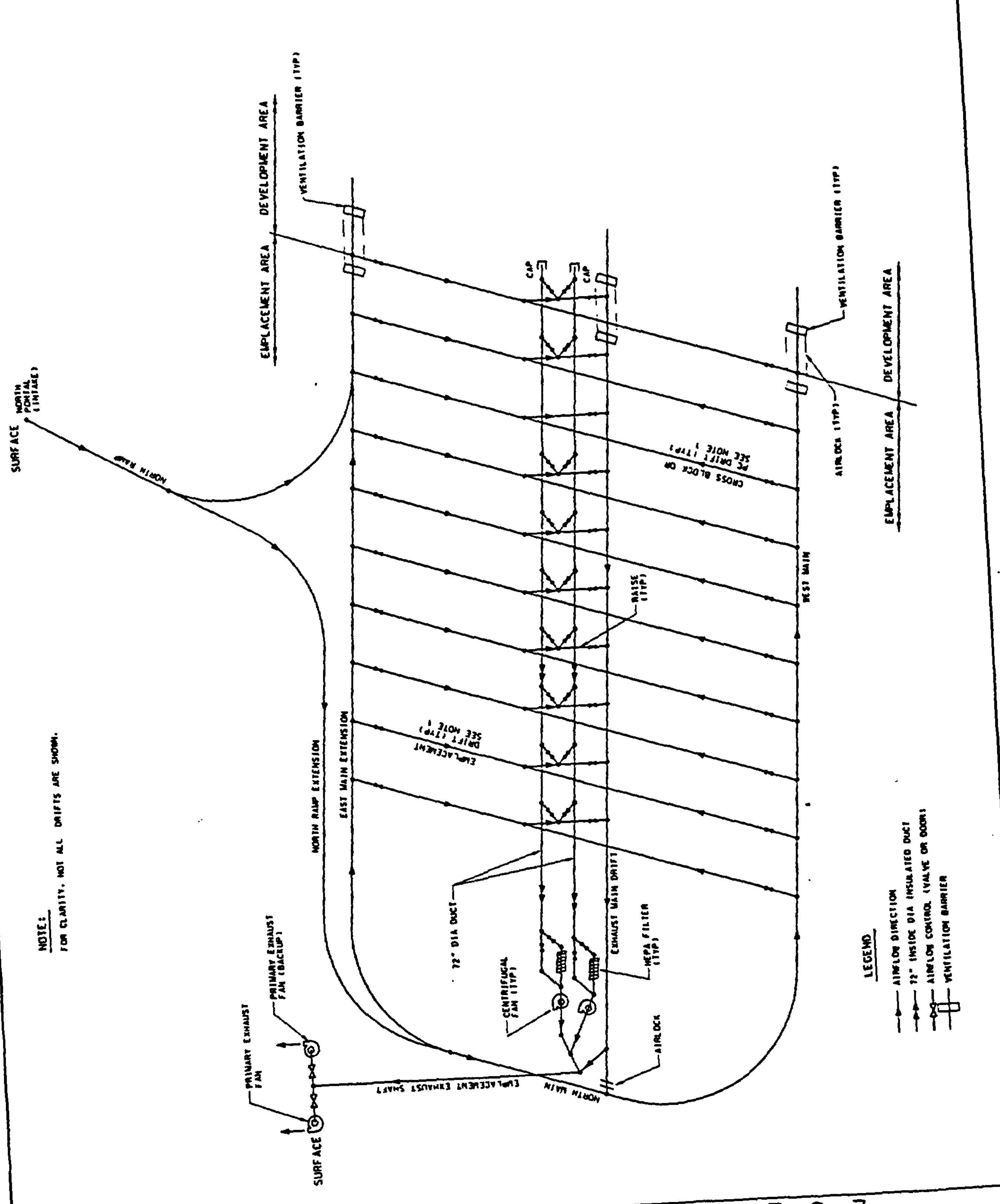

FIGURE 7.8.3
EMPLACEMENT
VENTILATION SCHEMATIC

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7.8.6 Emplacement Ventilation Concurrent with Development Ventilation

Figure 7.6.2.4 shows the two separate ventilation systems between emplacement and development areas during the early emplacement phase, when the first panel is being emplaced with waste packages. Ventilation barriers are installed to separate the emplacement and development areas, and are moved southward as shown in Figure 7.8.6 as panels are completed and turned over to emplacement operations. Features to assure separation of ventilation between the two areas were described in Section 7.4.8.

7.8.7 Emplacement Exhaust Duct

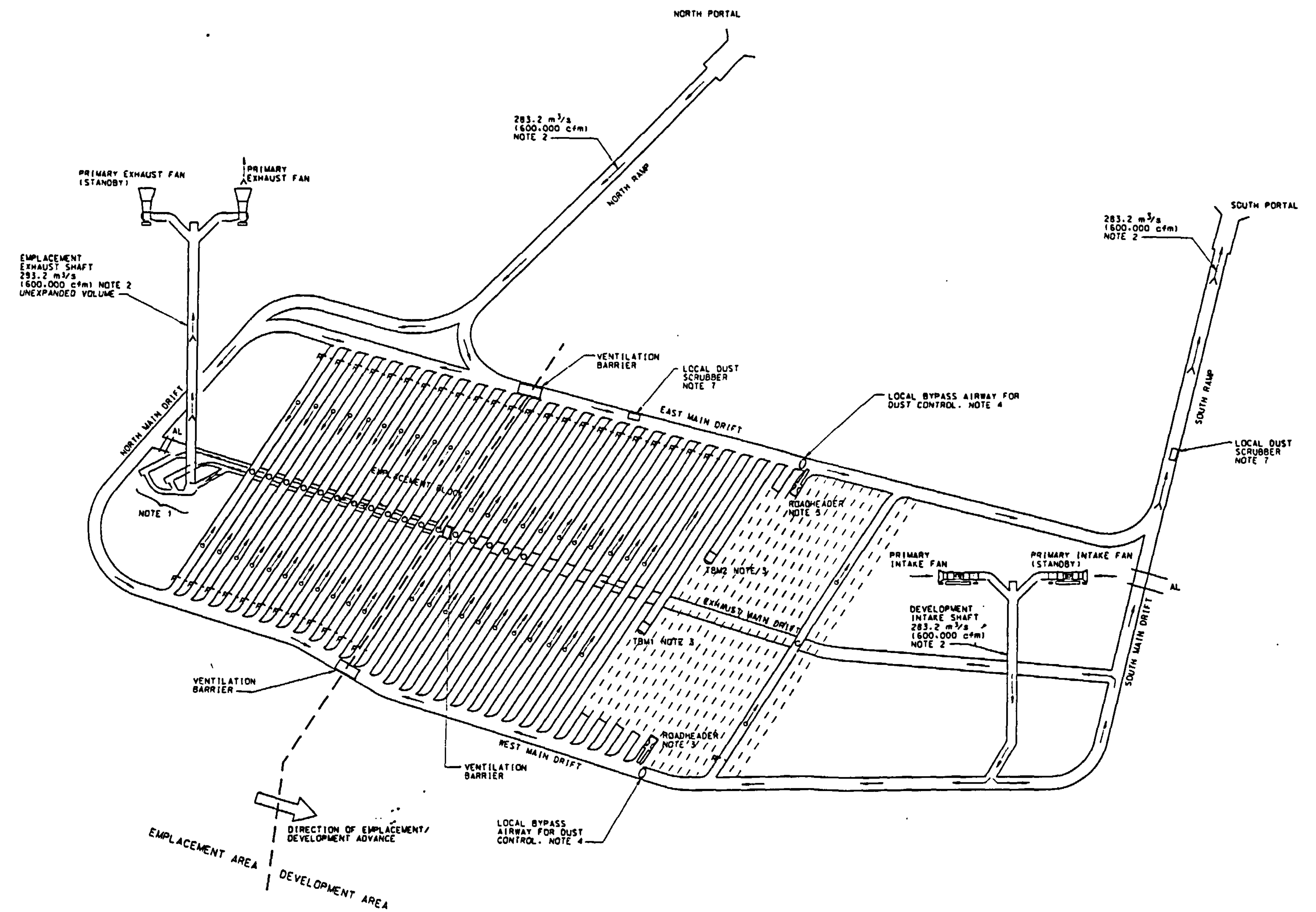
The 1.83 m (72 inch) diameter exhaust duct is sized for an airflow of 47.2 m^3/s (100,000 cfm) at the farthest (southernmost) emplacement drift from the fan. With an estimated 25% leakage allowance (into the duct) from about a hundred emplacement valves, the emplacement auxiliary fan must have a capability of moving an estimated 61.4 m^3/s (130,000 cfm) of air. The recommendation to use the 1.83 m (72 inch) diameter exhaust duct is based on the evaluation in Attachment VI, page 3.

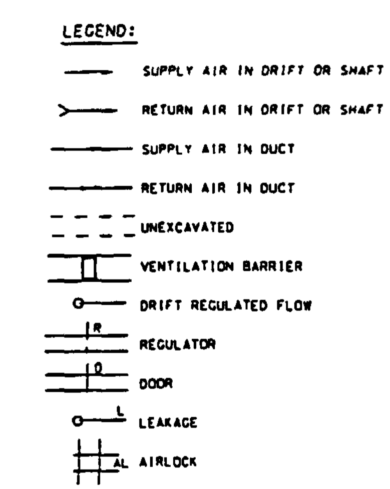
The installation of the emplacement exhaust duct along the exhaust main drift and the structural support of the exhaust ducts as connected to the raise liners are covered by a separate analysis.

7.8.8 Drift Arrangement for Auxiliary Emplacement Exhaust Fan

Figures 7.8.8a and 7.8.8b show the location and conceptual drift arrangement for two sets of underground auxiliary emplacement exhaust fan. From the exhaust main drift, the two 1.83 m (72 inches) diameter exhaust ducts are each connected to a fan through streamlined drifts. The drift layout is configured for convenience to maintain the auxiliary fans, and the HEPA filters if needed at this location.

The final selection of location and use of HEPA filters, and related maintenance and test procedures are addressed in another analysis.





NOTES:

1. FOR EXHAUST MAIN DUCTS & STANDBY HEPA FILTERS FOR EMPLACEMENT DRIFT RETURN AIR. SEE FIGURES 7.8.8a AND 7.8.8b.
2. NOMINAL MAXIMUM CAPACITY PERFORMANCE.
3. TBM & ROADHEADER FACE VENTILATION. SEE FIGURES 7.5.3c AND 7.5.5.
4. INSTALLED IN PRIMARY AIRWAYS TO BYPASS AIRFLOW DURING INITIAL ROADHEADER CUTTING.
5. FOR AIRFLOW SCHEMATIC OF EMPLACEMENT AND DEVELOPMENT.
6. FOR CLARITY, NOT ALL EMPLACEMENT AND CROSS BLOCK DRIFTS ARE SHOWN. PERFORMANCE CONFIRMATION DRIFT IS SHOWN ON DRAWING 86021.
7. LOCAL DUST SCRUBBERS WILL BE INSTALLED ALONG DRIFTS, AS REQUIRED.

FIGURE 7.8.6
TYPICAL EMPLACEMENT AND DEVELOPMENT VENTILATION PHASE

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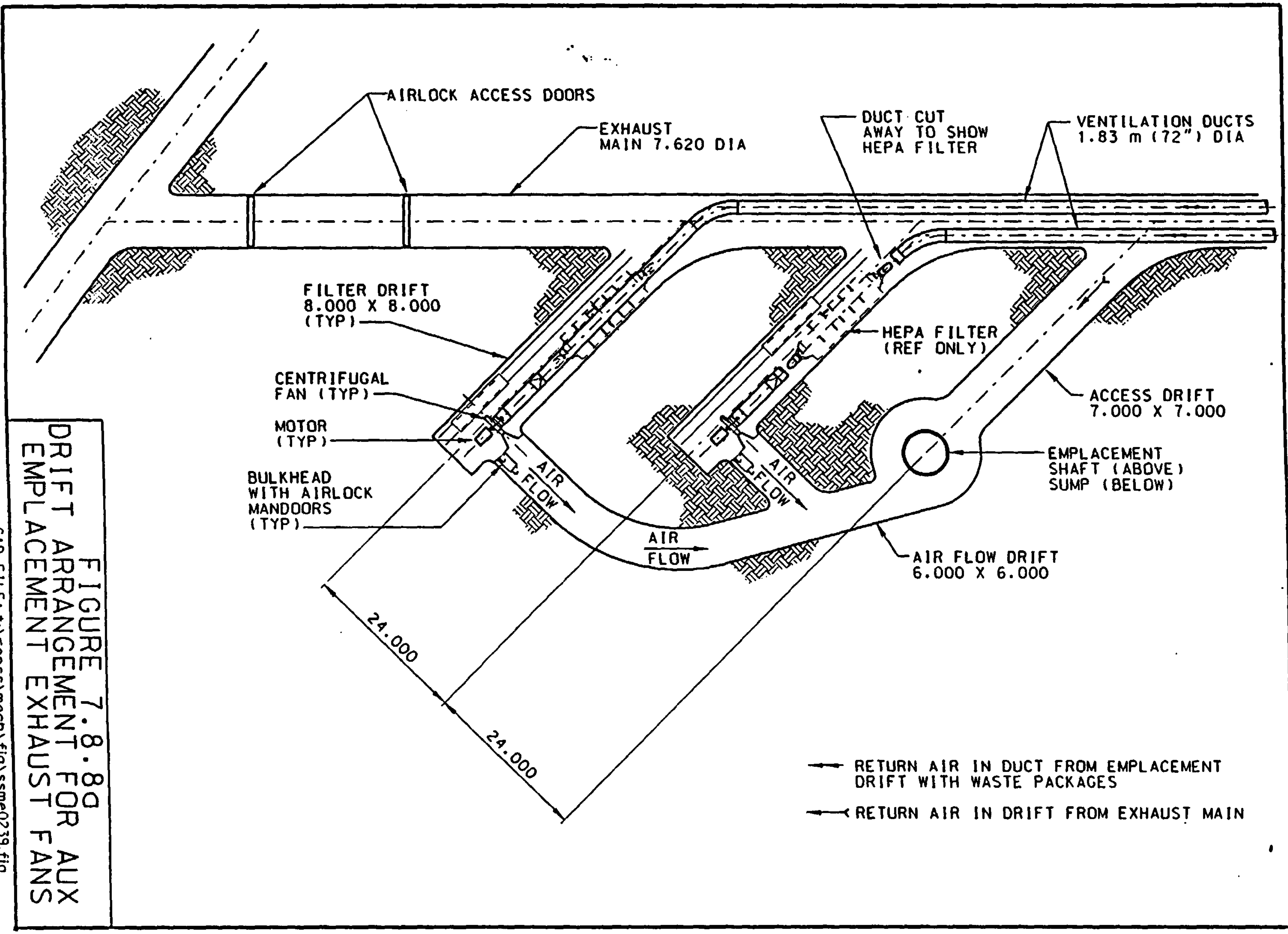

FIGURE 7.8.8a
DRIFT ARRANGEMENT FOR AUX
EMPLACEMENT EXHAUST FANS

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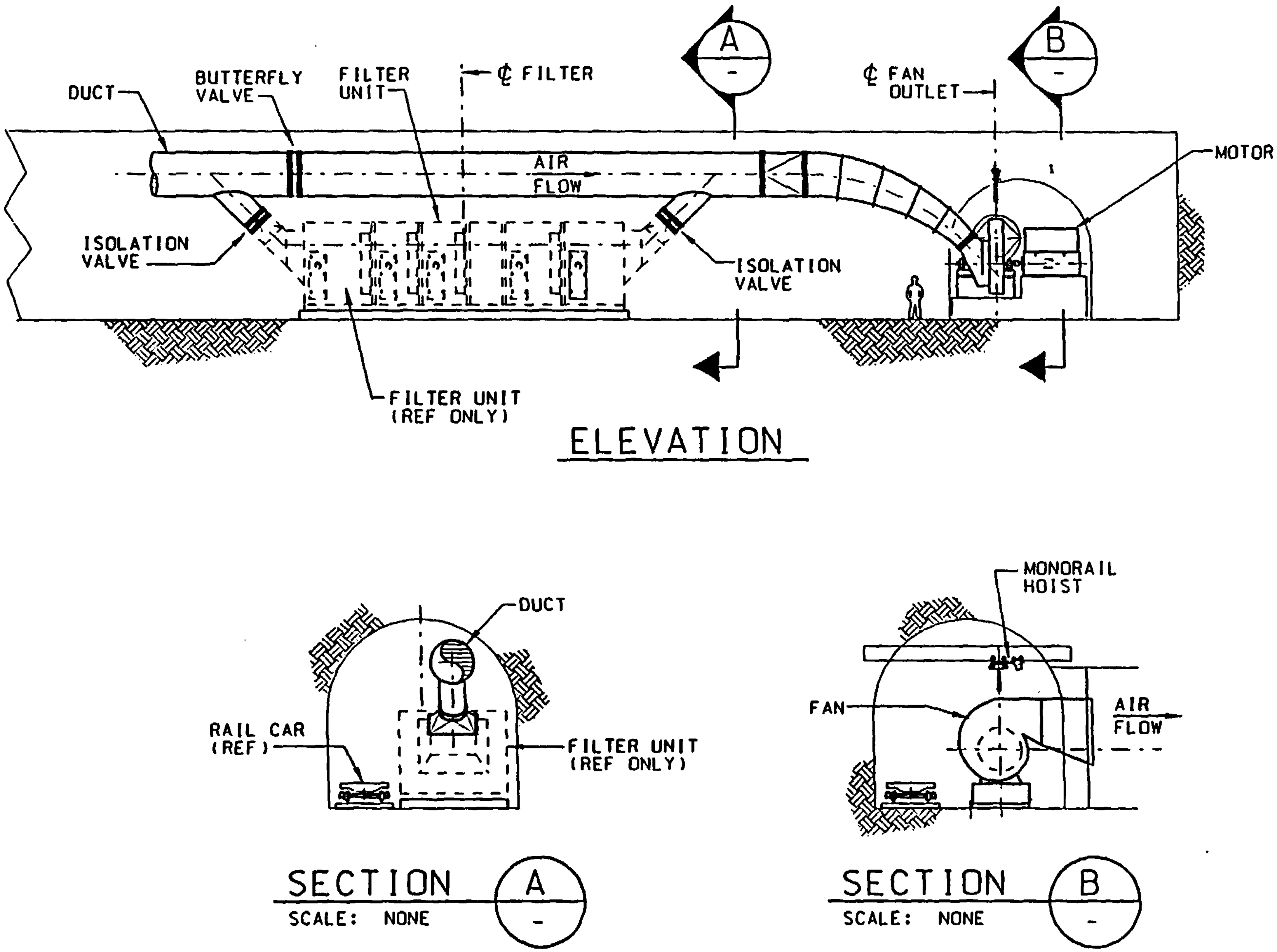

FIGURE 7.8.8b
AUXILIARY EMPLACEMENT EXHAUST
FAN ELEVATION ARRANGEMENT

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7.9 CARETAKER MODE VENTILATION

Caretaker phase begins after completion of waste emplacement. The purpose of the ventilation system at this time is to support subsurface personnel in the maintenance of airways, environmental monitoring and performance confirmation, and keeping the repository ready for retrieval (if mandated), backfill, and closure.

7.9.1 Return/Exhaust Airway - Emplacement Exhaust Shaft with Converted Development Shaft as Back-up

The ventilation mode during the final emplacement phase utilizes the Emplacement Shaft as a return/exhaust airway. This status will be maintained for the caretaker phase. During the caretaker period the Development Shaft becomes idle (as all development has been completed) and can be converted if needed to a back-up exhaust shaft for the subsurface emplacement area. Converting the Development Shaft to this role would be covered by a separate analysis.

7.9.2 Intake Airway - North Ramp with Converted South Ramp as Back-up

The final emplacement phase involves the North Ramp as intake airway. This status will be maintained for caretaker phase. During caretaker period, the South Ramp will be idle and can be converted to become a back-up emplacement intake airway. Converting the South Ramp to become the emplacement intake airway will be covered by a separate analysis.

7.9.3 Primary Caretaker Airflow Path

Air intakes through the North Ramp or South Ramp and splits into West and East Mains, then continues through the emplacement drifts. The air downcasts through raises and into the exhaust main drift or exhaust main auxiliary ducts with HEPA filter and adsorption units. Both return air from the exhaust main and exhaust main auxiliary ducts are directed into the Emplacement or the back-up Development Shaft to surface.

7.9.4 Primary Fan Location - Caretaker Phase

For the caretaker mode the Emplacement Shaft will utilize the same primary surface fan as used during the emplacement mode. The fans at the Development Shaft, if required, will be changed to operate in an exhaust mode.

7.9.5 Configuration of Caretaker Plan

The repository layout during caretaker will use the same ventilation equipment and primary airways needed for emplacement operations. Airflow during caretaker is shown in Figure 7.9.5.

7.10 COMPUTER NETWORK MODELS

The features and air balance calculations for the recommended ventilation approaches discussed in Sections 7.7, 7.8 and 7.9 were performed with the VNETPC software, and are discussed below.

7.10.1 Computer Model for Early Emplacement/Early Development Operation

A computer model is designed to simulate emplacement ventilation for the first five emplacement drifts turned over for emplacement, concurrent with the development and construction of the next panel consisting of 16 to 22 emplacement drifts with TBMs and roadheaders (Reference 5.22).

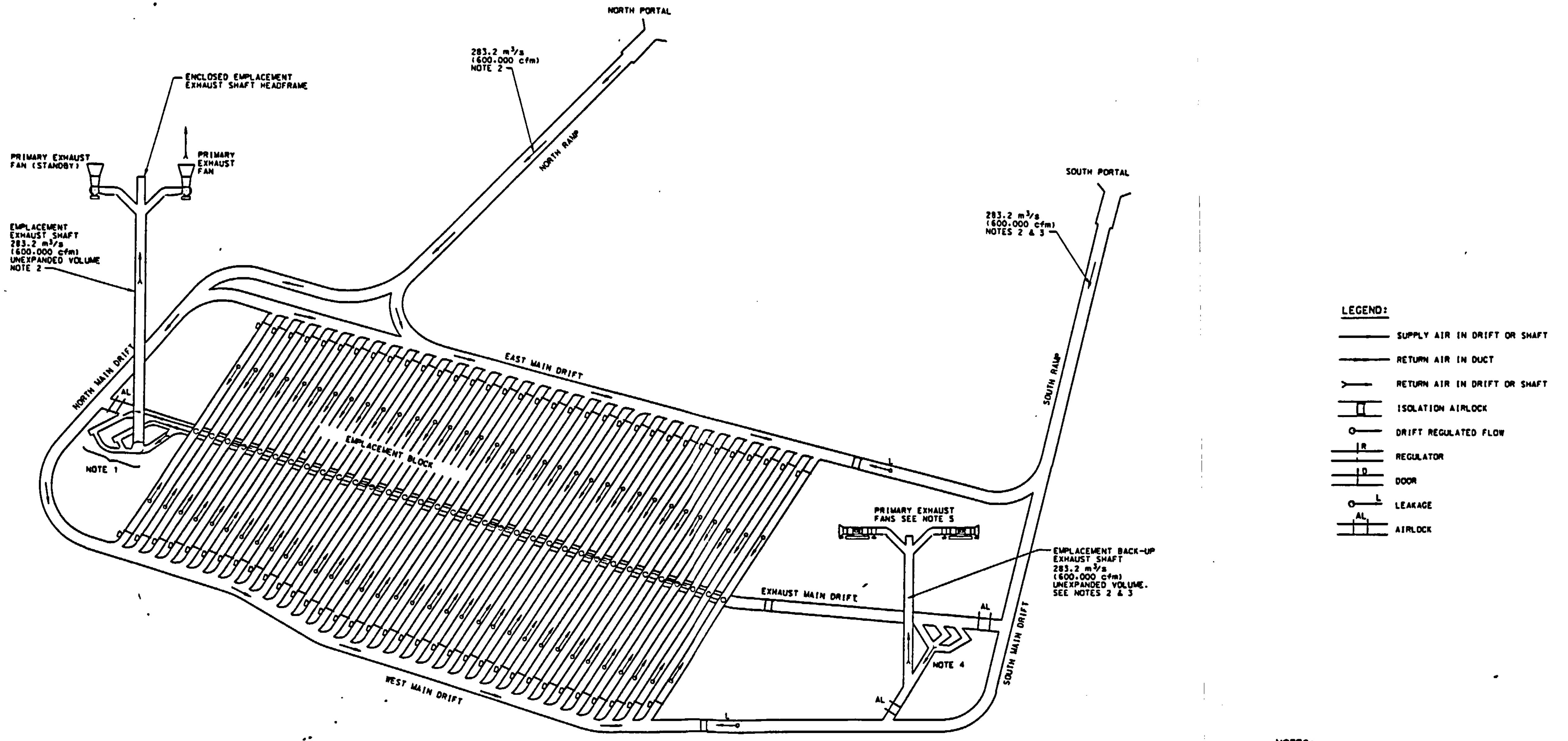
During early emplacement, the ventilation system in the emplacement area is at minimum operation compared to its potential during the later stage of emplacement. Concurrently, the early development area ventilation system is at potential maximum operation providing the farthest construction ventilation to areas away from the intake Development Shaft and the exhaust South Ramp.

Attachment 1, page 2 has a repository layout showing the simplified branch network and distances of nodes used in the model. Attachment I, pages 3-5 has spreadsheets showing the calculation of network resistances. Figure 7.10.1 shows the airflow circuit of the model.

The computer simulation output for the ventilation during early emplacement and development is also shown in Attachment I. The computer model generates the following output information:

7.10.1.1 Airflow During Early Emplacement/Early Development

a) The emplacement area has a total air supply of about 160.2 m^3/s (339,400 cfm) through the North Ramp intake.



NOTES:

1. EXHAUST DUCTS AND HEPA FILTER ARRANGEMENT ARE SHOWN ON FIGURES 7.8.8a AND 7.8.8b..
2. NOMINAL MAXIMUM CAPACITY.
3. THE USE OF DEVELOPMENT AIRWAYS AS EMPLACEMENT AIRWAYS IS AN OPTION AFTER COMPLETION OF EMPLACEMENT.
4. NEEDED CONFIGURATION TO BECOME BACK-UP EMPLACEMENT EXHAUST SYSTEM.
5. AXIAL FAN MAY BE CHANGED TO CENTRIFUGAL FAN.

FIGURE 7.9.5
CARETAKER AIRFLOW CONFIGURATION

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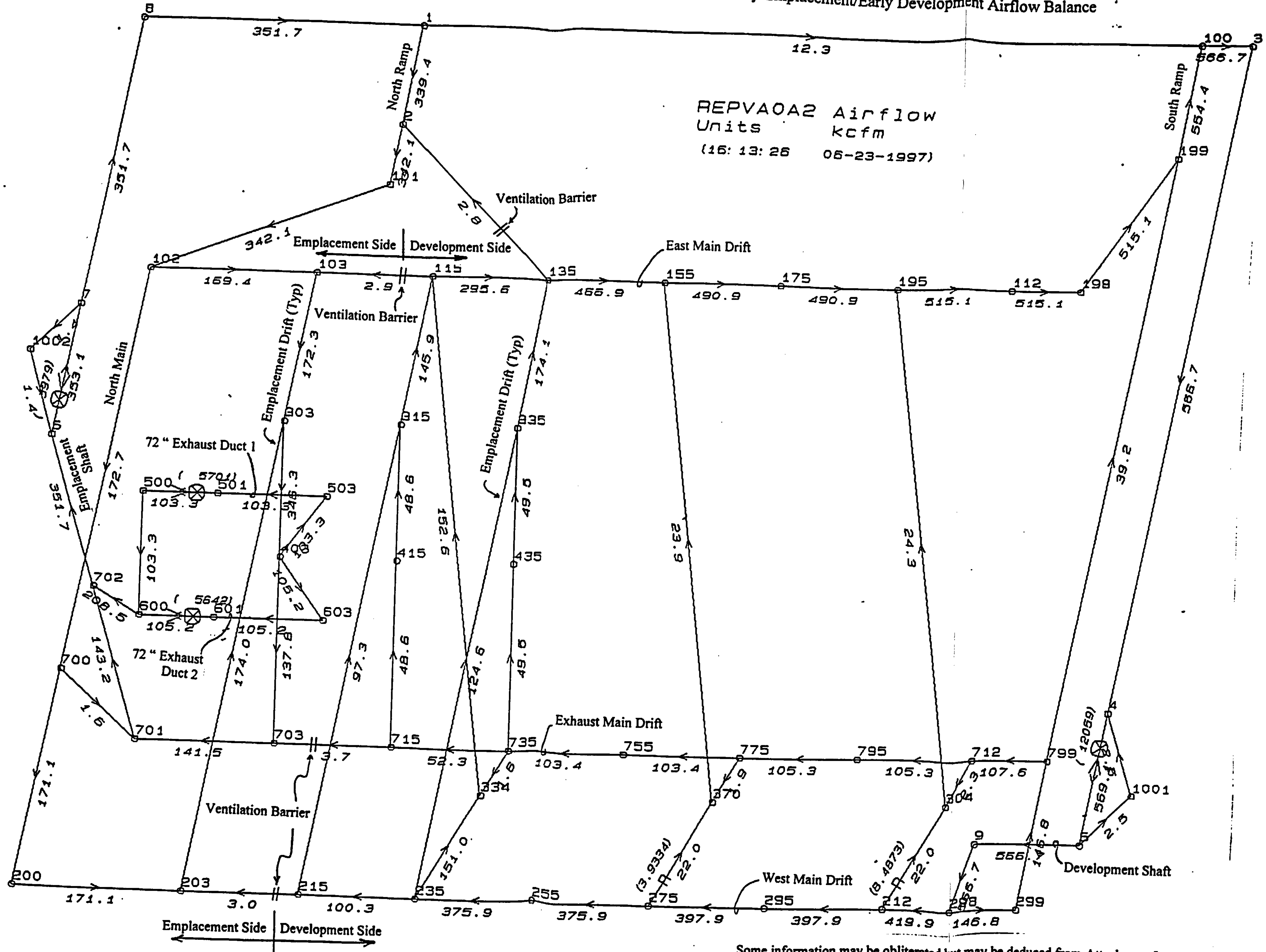
Figure 7.10.1 - Early Emplacement/Early Development Airflow Balance



Some information may be obliterated but may be deduced from Attachment I, pages 6 thru 11.

b) The development area has a total air supply of about 267.5 m^3/s (566,700 cfm) through the Development Intake Shaft intake. The total air available for emplacement and PC drift construction is about 198.2 m^3/s (420,000 cfm) coming from the development intake shaft/West Main drift air supply. About 50.8 m^3/s (107,600 cfm) is going through the Exhaust Main drift for related construction of the raises and exhaust main drift.

c) The model shows a viable airflow to support emplacement ventilation concurrent with development ventilation. Variation of ventilation performance related to the primary output of this model may be done by specific adjustments of local regulators and auxiliary systems to direct air quantities to specific drifts. These are usually field adjustments of several alterations for which detail is not shown in the computer model.

7.10.1.2 Differential Pressures on Ventilation Barriers During Early Emplacement/Early Development Operations

The computer model during early emplacement/early development shows a trend of pressure differential on the ventilation barriers (Attachment I, pages 11 and 14). The pressure differential at the barrier has a total effective range from 1.89 to 3.38 kPa (7.6 to 13.6 inches wg). The emplacement side has negative pressure near the barrier at about -0.15 to -0.92 kPa (- 0.61 to - 3.7 inches wg) (below atmospheric pressure) while the development side near the barrier has about +1.72 to +2.46 kPa (+ 6.9 to + 9.9 inches wg) (above atmospheric pressure).

7.10.1.3 Fan Performances

Operating points of each fan are shown on Attachment I, page 9.

a) Primary Emplacement Fan: 166.65 m^3/s (353,090 cfm) at 1.0 kPa (4.0 inches wg) with 165 kW of air power (221 air horsepower). At 75% fan efficiency, this is about 220 kW (295 bhp) of fan motor operation. As noted this may be the minimum point of the emplacement operation because emplacement activities has the least area during this time.

b) Primary Development Fan: 268.6 m^3/s (569,110 cfm) at 3.01 kPa (12.1 inches wg) with 806 kW of air power (1081 air horsepower). At 75% fan efficiency, this is about 1074 kW (1,440 bhp) of fan motor operation. Without flexibility and contingency allowance, this may be the maximum operating point of the development operation because development activities has the largest area during this time.

c) Auxiliary Exhaust Duct Fan # 1 (East Side): 48.74 m^3/s (103,270 cfm) at 1.42 kPa (5.7 inches wg) with 69.35 kW of air power (93 air horsepower). At 75% fan efficiency, this is about 92.46 kW (124 bhp) of fan motor operation. As noted this may be the minimum point of the exhaust main auxiliary operation because emplacement activities has the least area during this time.

d) Auxiliary Exhaust Duct Fan # 2 (West Side): 49.67 m^3/s (105,240 cfm) at 1.39 kPa (5.6 inches wg) of 70 kW air power (94 air horsepower). At 75% fan efficiency, this is about 93.21 kW (125 bhp) of fan motor operation. As noted this may be the minimum point of the exhaust main auxiliary operation because emplacement activities has the least area during this time. Note also that operation of the second auxiliary duct is optional and is shown in the computer model to predict potential pressure differential for barrier design when pressures are higher than a single auxiliary fan operation.

7.10.2 Computer Model for Late Emplacement/Late Development Operation

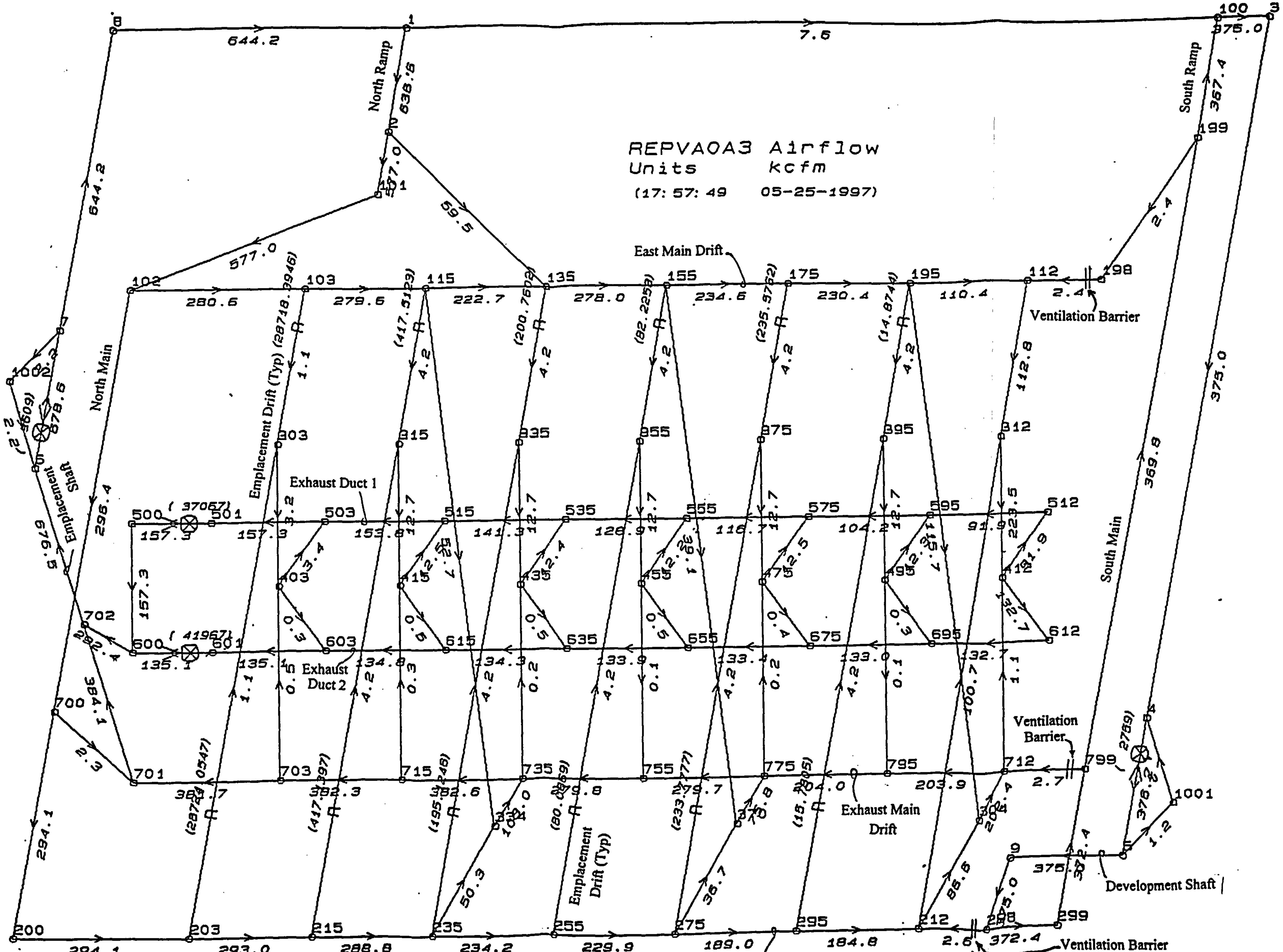
A computer model is designed to simulate emplacement ventilation of the last few emplacement drifts turned over for emplacement, concurrent with a phasing out development area.

At this stage, the ventilation system has to support the widest emplacement area, at maximum potential operation. The exhaust Emplacement Shaft and intake North Ramp are on the farthest side of the emplacement activities. Concurrently, the development area is phasing out and potentially constructing conversion of the Development Shaft and South Ramp as back-up primary airways for caretaker phase.

Attachment II, page 2 has a repository layout showing the simplified branch network and distances of nodes used in the model. Attachment II, pages 3-6 has spreadsheets showing the calculation of network resistances. Figure 7.10.2 shows the airflow circuit of the model.

The computer simulation output for the ventilation during late emplacement and development is also shown in Attachment II. The computer model generates the following output information:

Figure 7.10.2 - Late Emplacement/Late Development Airflow Balance



Some information may be obliterated but may be deduced from Attachment II, pages 7 thru 14.

7.10.2.1 Airflow During Late Emplacement/Late Development

a) The emplacement area has a total air supply of about 300.47 m^3/s (636,600 cfm) through the North Ramp intake. Range of air quantities along the mains are the following: East Main, 51.92 to 132.16 m^3/s (110,000 to 280,000 cfm); West Main, 87.22 to 138.81 m^3/s (184,800 to 294,100 cfm); and Exhaust Main, 96.24 to 180.16 m^3/s (203,900 to 381,700 cfm).

b) The return air from emplacement drifts through auxiliary exhaust ducts ranges from 43.4 to 74.2 m^3/s (91,900 to 157,300 cfm). The airflow balance inside the exhaust duct # 1 (East Side) includes an injected airflow of about 15.23 m^3/s (32,260 cfm) to simulate expanded return air caused by waste package heating.

c) The development phase out area has a total air supply of about 177 m^3/s (375,000 cfm) through the Development Shaft intake.

d) The model shows a viable airflow to support late emplacement ventilation concurrent with late development/phase out ventilation. Variation of ventilation performance related to the primary output of this model may be done by specific adjustments of local regulators and auxiliary systems to direct air quantities to specific drifts. These are usually field adjustments of several alterations for which detail is not shown in the computer model.

7.10.2.2 Differential Pressure on Ventilation Barriers During Late Emplacement/Late Development Operation

Attachment II, pages 14 and 17 show the pressure differential at the barrier between the emplacement and development areas. The total effective pressure range is 1.39 to 1.77 kPa (5.6 to 7.1 inches wg). The emplacement side has negative pressure near the barrier at about -1.12 to - 1.32 kPa (- 4.5 to - 5.3 inches wg) (below atmospheric pressure) while the development side near the barrier has about +0.3 to +0.5 kPa (+ 1.2 to + 2.0 inches wg) (above atmospheric pressure).

7.10.2.3 Fan Performances

Operating points of each fan are shown on Attachment II, pages 10 and 11.

a) Primary Emplacement Fan: 320.3 m^3/s (678,630 cfm) at 2.39 kPa (9.6 inches wg) with 765.8 kW of air power (1027 air horsepower). At 75% fan efficiency, this is about 1021.6 kW (1370 bhp) of fan motor operation.

Without flexibility and contingency allowances, this may be the maximum point of the emplacement operation because emplacement activities have the widest area during this time.

b) Primary Development Fan: 177.54 m^3/s (376,160 cfm) at 0.696 kPa (2.8 inches wg) at 122.29 kW of air power (164 air horsepower). At 75% fan efficiency, this is about 163.3 kW (219 bhp) of fan motor operation. At this stage, this may be the minimum operation because development operation has the least area of activities during this time.

c) Auxiliary Exhaust Duct Fan # 1 (East Side): 74.22 m^3/s (157,250 cfm) at 9.2 kPa (37 inches wg) with 684.5 kW of air power (918 air horsepower). At 75% fan efficiency, this is about 912.7 kW (1224 bhp) of fan motor operation. As noted this may be the maximum point including maximum flexibility of the exhaust main auxiliary operation because emplacement activities has the widest area during this time. The airflow balance inside the exhaust duct includes an injected airflow of about 15.23 m^3/s (32,260 cfm) to simulate expanded return air caused by waste package heating.

d) Auxiliary Exhaust Duct Fan # 2 (West Side): 63.78 m^3/s (135,130 cfm) at 10.45 kPa (42 inches wg) with 666.65 kW of air power (894 air horsepower). At 75% fan efficiency, this is about 888.87 kW (1192 bhp) of fan motor operation. As noted this may be also a maximum point including maximum flexibility of the exhaust main auxiliary operation because emplacement activities has the widest area during this time.

7.10.3 Computer Model for Caretaker Phase

A computer model is designed to simulate the caretaker phase after completion of emplacement ventilation. At this stage, the ventilation system has no more boundary or required barrier to separate development and emplacement areas. Ventilation is one system with the Development Shaft and South Ramp as standby airways.

The last set of barriers installed during emplacement are temporarily used as airlocks to isolate the South Ramp and Development Shaft back-up airways. The primary fan on the Development Shaft is shut off. Fan # 2 of the Auxiliary Exhaust Main is also shut off. The objective is to provide the least air to the repository ventilation while maintaining complete access to all areas needed for subsurface monitoring and performance confirmation during caretaker phase. Only the primary Emplacement Shaft fan and the Auxiliary Exhaust Duct Fan # 1 (East Side) are on.

Attachment III, page 2 has a repository layout showing the simplified branch network and

distances of nodes used in the model. Attachment III, pages 3-6 has spreadsheets showing the calculation of network resistances. Figure 7.10.3 shows the airflow circuit of the model.

The computer simulation output for the ventilation during caretaker phase is also shown in Attachment III. The computer output generates the following information:

7.10.3.1 Airflow During Caretaker Phase

a) The caretaker phase has a total air supply of about 192.58 m^3/s (408,000 cfm) through the North Ramp intake. Range of air quantities along the mains are the following: East Main, 58.95 to 82.97 m^3/s (124,900 to 175,800 cfm); West Main, 48.56 to 90.86 m^3/s (102,900 to 192,500 cfm); and Exhaust Main, 94.68 to 160.19 m^3/s (200,600 to 338,200 cfm).

b) The return air from the emplacement drifts through the auxiliary exhaust duct is about 49.37 m^3/s (104,600 cfm). The airflow balance inside the exhaust duct includes an injected airflow of about 15.23 m^3/s (32,260 cfm) to simulate expanded return air caused by waste package heating.

c) The model shows a viable network to support the caretaker ventilation. Variation of ventilation performance related to the primary output of this model may be done by specific adjustments of local regulators and auxiliary systems to direct air quantities to specific drifts. These are usually field adjustments involving several alterations, detail of which is not shown in the computer model.

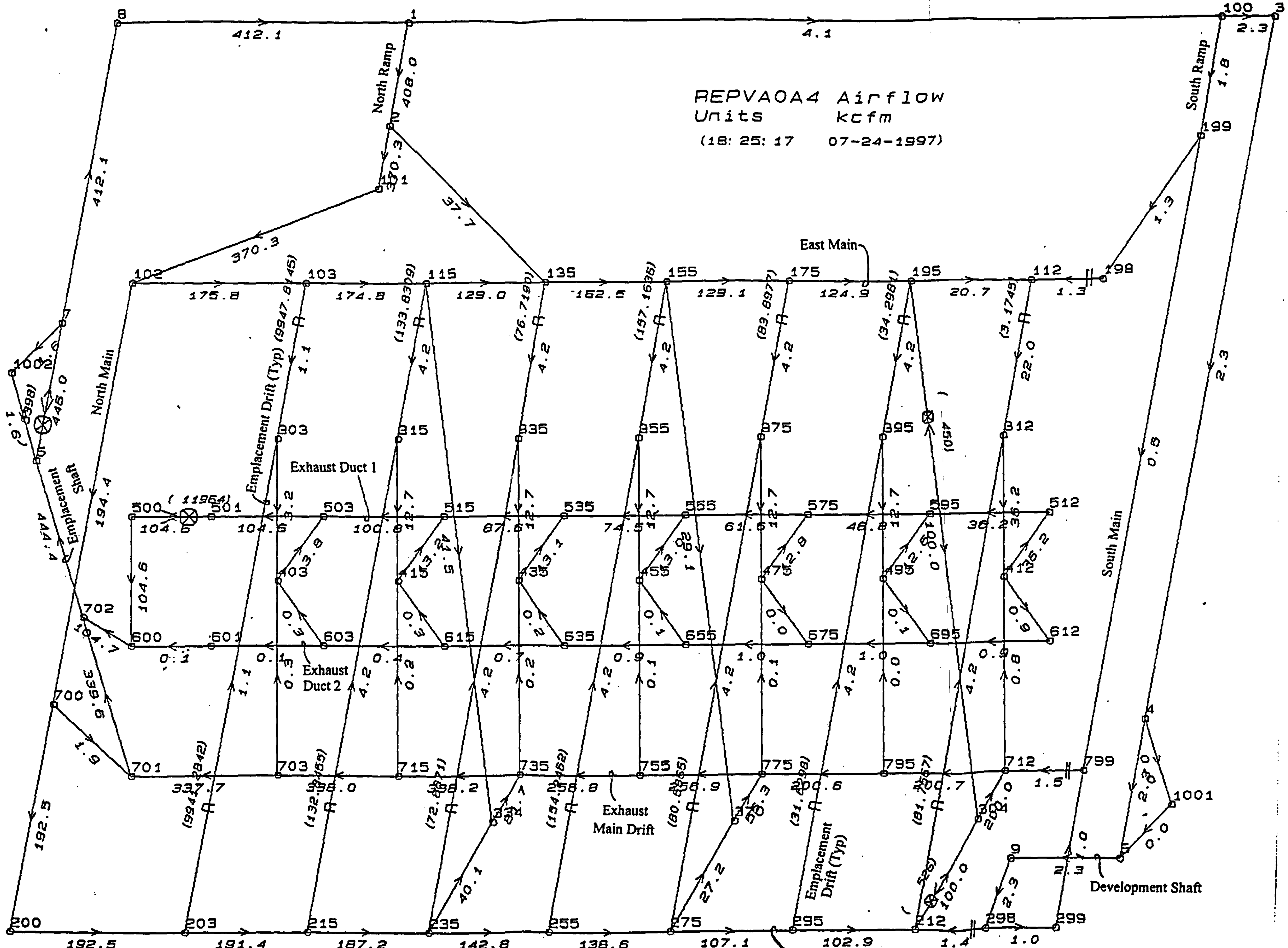
7.10.3.2 Differential Pressure

The differential pressure of the temporary airlock between the caretaker area and the back-up primary airways is shown in Attachment III, pages 14 and 17. The pressure range is between 0.42 to 0.52 kPa (1.7 to 2.1 inches wg).

7.10.3.3 Fan Performance

Operating points of each fan are shown in Attachment III, page 10.

Figure 7.10.3 - Caretaker Airflow Balance



Some information may be obliterated but may be deduced from Attachment III, pages 7 thru 14.

a) Primary Caretaker Fan: 210.45 m^3/s (445,880 cfm) at 1.34 kPa (5.4 inches wg) with 283.36 kW of air power (380 air horsepower). At 75% fan efficiency, this is about 377.32 kW (506 bhp) of fan motor operation. Without flexibility and contingency allowances, this may be the minimum point of the caretaker ventilation to support human access to non-restricted subsurface areas.

b) Auxiliary Exhaust Duct Fan # 1 (East Side): 48.52 m^3/s (102,810 cfm) at 3.01 kPa (12.1 inches wg) with 146.15 kW of air power (196 air horsepower). At 75% fan efficiency, this is about 194.62 kW (261 bhp) of fan motor operation. As noted this may be the minimum point of the exhaust main auxiliary operation to control airflow monitor of emplacement drifts.

7.10.4 Ventilation Barrier Pressure Summary

From the computer output discussed in Sections 7.10.1.2 and 7.10.2.2, the effective pressure differential on the ventilation barrier between the emplacement and development areas ranges from 1.39 to 3.38 kPa (5.6 to 13.6 inches wg). It is preferable to standardize a single barrier design to at least 4.97 kPa (20 inches wg) of effective pressure differential to cover system fluctuation and occasional pressure spikes.

7.11 VENTILATION FANS

This section discusses the primary and auxiliary fans need to operate the repository ventilation systems from construction start up to the end of the pre-closure activities.

7.11.1 Primary Emplacement Fan

The primary emplacement fan and back up fan are located on surface near the emplacement exhaust shaft collar and are connected to the shaft by means of duct work.

7.11.1.1 Recommended Performance

From the computer models, the following operating ranges of the primary emplacement fans are established:

a) Early Emplacement: 166.65 m^3/s (353,090 cfm) at 1.0 kPa (4.0 inches wg) with 220 kW (295 bhp) of fan motor operation at 75% fan efficiency.

b) Late Emplacement: 320.3 m^3/s (678,630 cfm) at 2.39 kPa (9.6 inches wg) with

1021.6 kW (1370 bhp) of fan motor operation at 75% fan efficiency.

It is recommended that an allowance for flexibility (Attachment VI, page 2) and contingency be provided. For VA design, the primary emplacement fan should be sized to deliver (770,000 cfm) at (12.4 inches wg) with 2000 hp variable speed motor. The fan motor has to have a variable frequency (variable speed) to cover the operating ranges needed during the preclosure life of the repository.

7.11.1.2 Fan Design Features and Emplacement Exhaust Shaft Collar Arrangement

a) Centrifugal Fan - The primary fan on the emplacement exhaust shaft collar is in exhausting mode, discharging the return air to the surface. Considering the potential elevated temperatures of the return air from emplacement operation, the primary fan arrangement should be set-up preferably with the motor and bearings outside the airstream. This can be satisfied by a centrifugal fan arrangement to take advantage of the motor and bearings outside the airstream.

b) Standard Industry Fan - Standard industry centrifugal fan will be used. An option to utilize stainless steel blades and housing may be evaluated in the future for potential longer life of the fan assembly to support repository ventilation operation for the next 100 years.

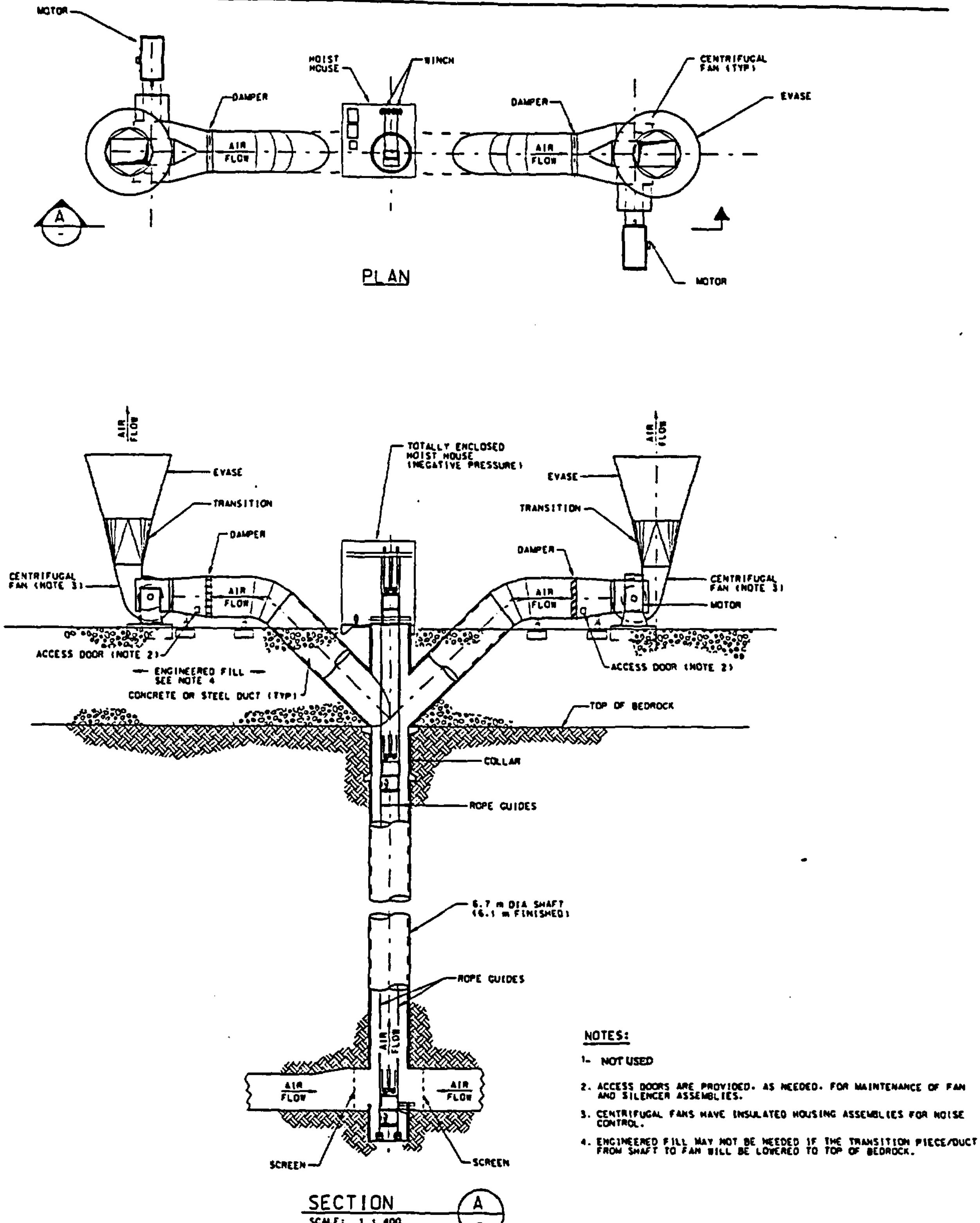
c) 100% Back-up Unit and Back-up Power Supply - The fan needs to operate continuously as required by criteria 4.2.1.2. Two fans will be installed on the emplacement exhaust shaft collar, one in operation and the other identical fan as back-up. Back-up power supply should also be provided in case of power failure from the main power source.

d) Non-Reversible Airflow - The elevated air temperatures and continuous low airflow in the emplacement drifts are controlled in one way direction and isolated from human contact through the isolation of auxiliary exhaust ducts. To maintain this safety feature, the primary emplacement fan should not be reversed. This feature will require the primary fans be non-reversible.

e) Silencer - The fan will be provided with silencers to keep the noise below 85 dBA, 10 ft away from fan.

f) Monitoring Fan Performance - The fan should be provided with a standard monitoring package to monitor performance of the fan.

Figure 7.11.1.2 shows the general arrangement of the primary emplacement fan as installed in the emplacement exhaust shaft collar.



NOTES:

1- NOT USED

2. ACCESS DOORS ARE PROVIDED, AS NEEDED, FOR MAINTENANCE OF FAN AND SILENCER ASSEMBLIES.

3. CENTRIFUGAL FANS HAVE INSULATED HOUSING ASSEMBLIES FOR NOISE CONTROL.

4. ENGINEERED FILL MAY NOT BE NEEDED IF THE TRANSITION PIECE/DUCT FROM SHAFT TO FAN WILL BE LOWERED TO TOP OF BEDROCK.

FIGURE 7.11.1.2
PRIMARY EMPLACEMENT
FAN ARRANGEMENT

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7.11.2 Primary Development Fan

The primary development fan and back up fan located on surface near the development intake shaft. The fans are connected to the shaft collar by means of duct work.

7.11.2.1 Recommended Performance

From the computer models, the following operating points of the primary development fan are established:

a) Early Development: 268.6 m^3/s (569,110 cfm) at 3.01 kPa (12.1 inches wg) with 1074 kW (1,440 bhp) of fan motor operation at 75% fan efficiency.

b) Late Development: 177.54 m^3/s (376,160 cfm) at 0.696 kPa (2.8 inches wg) with 163.3 kW (219 bhp) of fan motor operation at 75% fan efficiency.

It is recommended that an allowance for flexibility (Attachment VI, page 2) and contingency be provided. For VA design, the primary development fan be size to deliver (635,000 cfm) at (15 inches wg) with 2000 hp variable speed motor. The fan motor has to have a variable frequency (variable speed) to cover the operating ranges needed during the preclosure life of the repository.

7.11.2.2 Fan Design Features and Development Intake Shaft Collar Arrangement

a) Axial Fan - The primary fan on the development intake shaft collar is normally in blowing mode. Air supply is blown into the shaft for subsurface development activities. It is not critical if the fan motor and bearings are in the intake airstream. It is in fact more beneficial if the motor is in the airstream during winter when the fan motor heat can be added to the airstream to help minimize potential ice built-up in the shaft airway. More so, in the absence of a shaft heater which is not recommended in VA ventilation design.

b) Standard Industry Fan - Standard industry axial fan will be used. An option to utilize stainless steel blades and housing may be evaluated in the future for potential longer life of the fan assembly to support the construction phase for at least 25 years.

c) 100% Back-up Unit and Back-up Power Supply - The fan needs to operate continuously as required by criteria 4.2.1.2. Two fans will be installed on the development intake shaft collar, one in operation and the other identical fan as back-up. Back-up power supply is also be provided in case of power failure from the main power source. The need for full redundancy needs to be

evaluated further as design progresses.

d) Reversible Airflow - When needed and in case of emergency, an option to reverse the primary airflow of the development area is available. This is an additional ventilation feature that has to be justified further by Emergency and Evacuation Plan to be covered by a separate report. A slight reversing airflow caused by reversing the primary fan of the development area will still maintain the required pressure differential between the development and emplacement area, that is, as long as the emplacement primary fan is in normal operation. In this case, the leakage will still flow from low negative pressure in the development area to the high negative pressure in the emplacement area. If the Design Base Accidents analysis identifies a more complex chain of accident events, further analysis will be necessary to address this situation.

e) Silencer - The fan will be provided with silencers to keep the noise below 85 dBA, 10 ft away from fan.

f) Monitoring Fan Performance - The fan should be provided with standard monitoring package to monitor performance of the fan.

Figure 7.11.2.2 shows the general arrangement of the primary development fan as installed in the development intake shaft collar.

7.11.3 Auxiliary Fans for Return Air from Emplacement Drifts Through Exhaust Ducts

Auxiliary fans are located at the exhaust end of the exhaust ducts in the Exhaust Main to induce a negative pressure in the ducts.

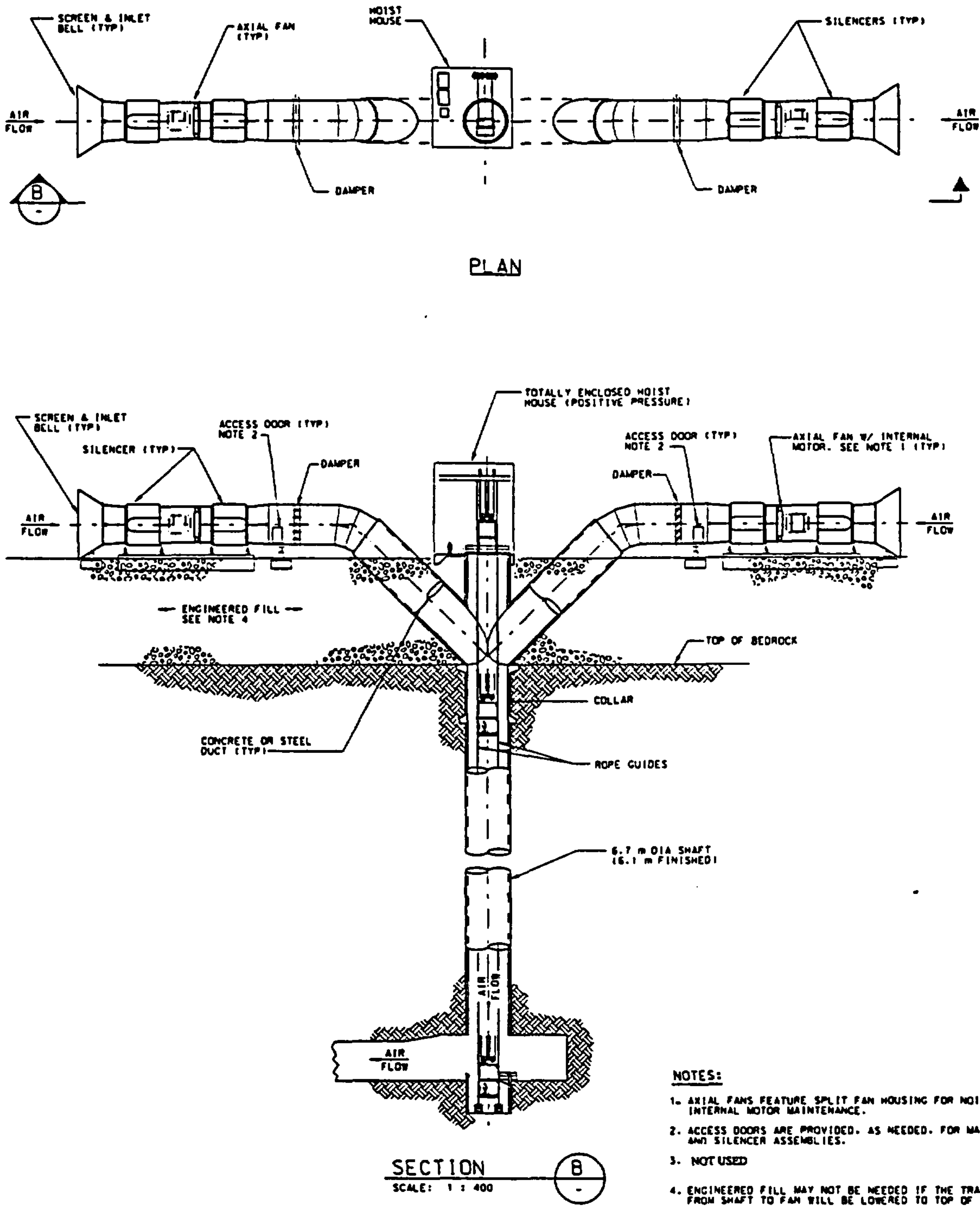
7.11.3.1 Recommended Performance

From the computer models, the following operating ranges of the auxiliary fans are established:

a) Early Emplacement: Auxiliary Fan # 1 (East Side): 48.74 m^3/s (103,270 cfm) at 1.42 kPa (5.7 inches wg) with 92.46 kW (124 bhp) of fan motor operation at 75% fan efficiency.

b) Early Emplacement: Auxiliary Fan # 2 (West Side): 49.67 m^3/s (105,240 cfm) with 93.21 kW (125 bhp) of fan motor operation at 75% fan efficiency.

c) Late Emplacement: Auxiliary Fan # 1 (East Side): 74.22 m^3/s (157,250 cfm) at 9.2 kPa (37 inches wg) with 912.7 kW (1224 bhp) of fan motor operation at 75% fan efficiency.



NOTES:

1. AXIAL FANS FEATURE SPLIT FAN HOUSING FOR NOISE CONTROL AND INTERNAL MOTOR MAINTENANCE.
2. ACCESS DOORS ARE PROVIDED, AS NEEDED, FOR MAINTENANCE OF FAN AND SILENCER ASSEMBLIES.
3. NOT USED
4. ENGINEERED FILL MAY NOT BE NEEDED IF THE TRANSITION PIECE/DUCT FROM SHAFT TO FAN WILL BE LOWERED TO TOP OF BEDROCK.

FIGURE 7.11.2.2
PRIMARY DEVELOPMENT
FAN ARRANGEMENT

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d) Late Emplacement: Auxiliary Fan # 2 (West Side): 63.78 m^3/s (135,130 cfm) at 10.45 kPa (42 inches wg) with 888.87 kW (1192 bhp) of fan motor operation at 75% fan efficiency.

It is recommended that an allowance for flexibility (Attachment VI, page 2) and contingency be provided. For VA design, the auxiliary fan should be sized to deliver 64.67 m^3/s (137,000 cfm) at 10.7 kPa (43 inches wg) with 932 kW (1250 bhp) variable speed motor. The fan motor has to have a variable frequency (variable speed) to cover the operating ranges needed during the repository operation.

7.11.3.2 Fan Design Features and Installation Arrangement

a) Centrifugal Fan - The auxiliary fan for the return air from emplacement drifts is in exhausting mode. The high negative pressure requirement and volume stability at various ranges of operation is better met by a centrifugal fan. Considering the heat of the return air, the fan should be an external drive fan.
b) Standard Industry Fan - Standard industry centrifugal fan will be used. An option to utilize stainless steel blades and housing may be evaluated in the future for potential longer life of the fan assembly to support repository ventilation operation for the next 100 years.
c) 100% Back-up Unit and Back-up Power Supply - The fan needs to operate continuously as required by criteria 4.2.1.2. Two fans will be installed, one in operation and the other identical fan as back-up unit. Back-up power supply should also be provided in case of power failure from the main power source.
d) Non-Reversible Airflow - The elevated air temperatures and continuous low airflow in the emplacement drifts are controlled in one direction and isolated from human contact through this auxiliary exhaust duct system. To maintain this safety feature, the auxiliary exhaust duct fan should not be reversed.
e) Silencer - The fan shall be provided with silencers to keep the noise below 85 dBA, 10 ft away from fan.
f) Monitoring Fan Performance - The fan should be provided with standard monitoring package to monitor performance of the fan.

Figures 7.8.8a and 7.8.8b show the general arrangement of the auxiliary exhaust fan typically installed near the emplacement exhaust shaft bottom.

8. CONCLUSIONS

The following conclusions are drawn from the analysis.

8.1 The concurrent emplacement and construction (development) operations will be separated by ventilation barriers as discussed in Section 7.4.8. Each side will have independent ventilation systems. The emplacement ventilation system will operate at an induced negative pressure, and development system at a higher pressure. The set-up assures direction of potential leakages from development to emplacement areas to comply with project requirements.

8.2 The emplacement ventilation system will operate throughout the subsurface at a negative pressure in emplacement drifts and exhaust ducts relative to the access and travelways so as to protect subsurface personnel from potential exposure to leakage of radioactive particulates and gasses. This arrangement is shown in Section 7.8.

8.3 Heating and cooling will not be required to maintain a comfortable ambient temperature in the subsurface. These are addressed in Section 7.4.9. For retrieval purposes, blast cooling may be used to accelerate the cooling of emplacement drift. This will be the subject of other analyses.

8.4 The flow-through ventilation approach is recommended for the primary airways during the development period. This approach allows much higher airflows at lower power consumption than alternative ducted systems, and eliminates the need for long ducts and multiple fans in the main travelways. Flow-through ventilation provides flexibility to adjust airflow volumes to demand, and can meet the minimum flow rates required by OSHA and/or much higher rates up to 0.51 m/s minimum air velocity near the construction face to eliminate dust stratification. Emplacement drift construction activities subsequent to completion of the excavation will also be ventilated by flow-through air. TBM excavation will be ventilated with flexible tubes and auxiliary fans. Comparative study of options are shown in Section 7.7.6.

8.5 Measures will be taken to actively deal with potential cristobalite and other silica-based dusts created by excavation, drilling and mucking during construction. These measures include use of water to suppress dust during drilling, excavation and muck removal, air cleaners to remove dust from active headings and travelways, maintaining a minimum airflow of 0.51 m/s (100 fpm) in construction drifts to dilute and remove dust and prevent dust stratification in the airways, use of 152 to 305 m (500 and 1000 ft) sections of flexible tube (in cassettes) instead of the 6 m (20 ft) sections of corrugated duct to reduce number of joints and consequently the potential for dust recirculation, good housekeeping measures, and employment of strategically located dust collectors in mains as needed.

These are addressed in Section 7.5.

8.6 Muck on conveyors will be kept wet with water, transfer and dump points will be covered and dusty air drawn off and cleaned. If necessary, covers will be placed over the conveyor in the South Ramp to reduce dust creation, the conveyor belt and idlers will be washed as necessary to remove dust. These are discussed in Section 7.5.

8.7 The emplacement exhaust shaft will serve as the exhaust airway and the North Main as the intake airway for emplacement operations. Primary emplacement fan in exhaust mode will be located near the emplacement exhaust shaft collar as shown in Figure 7.11.1.2. Centrifugal fans will be utilized for emplacement operations primary and auxiliary exhaust main ventilation. The centrifugal fan arrangement keeps the electric motor out of the hot air stream. Emplacement fans will be non-reversible; otherwise, hot air and potential radioactive leakage from inside the emplacement drifts would be reversed into emplacement side travelways and potentially into the construction side. The fans will be specified as stated in Sections 7.11.1.1 and 7.11.1.2 .

8.8 The Development Shaft will serve as the intake airway and the South Ramp as the exhaust airway for the development activities. Primary development fan in blowing mode will be located near the development intake shaft collar as shown in Figure 7.11.2.2. The primary development fans will be reversible if needed to deal with emergency situations. If fans are reversed, the pressures will be controlled to maintain a slight positive pressure over the emplacement side. The fans will be specified as stated in Sections 7.11.2.1 and 7.11.2.2 .

8.9 During the early construction period (pre-emplacement phase) the North Ramp will serve as the intake airway and the South Ramp as exhaust airway. The North Portal will be provided with temporary intake fans and airlock systems for equipment, rail haulage, and personnel. This arrangement is discussed in Section 7.6.1.

8.10 The ventilation layout as detailed in Section 7 complies with the criteria in Section 4.2 and is consistent with the VA design inputs.

8.11 The emplacement drift ventilation system has doors and regulators to support control of airflow along emplacement drifts. The control will satisfy the ventilation phases during emplacement, caretaker, retrieval, backfill and environmental monitoring as needed. These are discussed in Sections 7.4.1.3 and 7.4.1.4.

8.12 The TBVs identified in Section 4 are carried through to the outputs of this analysis. Therefore, the outputs with the TBVs may not be used for construction, procurement, or fabrication without being controlled in accordance with NLP-3-15.

9. ATTACHMENTS

9.1 ATTACHMENT I

COMPUTER NETWORK MODEL - EARLY EMPLACEMENT / EARLY DEVELOPMENT PHASE

1. Outline of Repository VA Layout and Node Distances
2. Calculation Spreadsheet for airway resistances
3. VNETPC File (Repvaoa2) input and output
4. VNETPC File (Repvaoa2) output - Branch Number Plot
5. VNETPC File (Repvaoa2) output - Resistance Plot
6. VNETPC File (Repvaoa2) output - Pressure Plot
7. VNETPC File (Repvaoa2) output - Air Power Plot
8. VNETPC File (Repvaoa2) output - Airflow Plot
9. VNETPC File (Repvaoa2) Fan Curves Used

9.2 ATTACHMENT II

COMPUTER NETWORK MODEL - LATE EMPLACEMENT / LATE DEVELOPMENT PHASE

1. Outline of Repository VA Layout and Node Distances
2. Calculation Spreadsheet for airway resistances
3. VNETPC File (Repvaoa3) input and output
4. VNETPC File (Repvaoa3) output - Branch Number Plot
5. VNETPC File (Repvaoa3) output - Resistance Plot
6. VNETPC File (Repvaoa3) output - Pressure Plot
7. VNETPC File (Repvaoa3) output - Air Power Plot
8. VNETPC File (Repvaoa3) output - Airflow Plot
9. VNETPC File (Repvaoa3) Fan Curves Used

9.3 ATTACHMENT III

COMPUTER NETWORK MODEL - CARETAKER PHASE

1. Outline of Repository VA Layout and Node Distances
2. Calculation Spreadsheet for airway resistances
3. VNETPC File (Repvaoa4) input and output
4. VNETPC File (Repvaoa4) output - Branch Number Plot

5. VNETPC File (Repvaoa4) output - Resistance Plot
6. VNETPC File (Repvaoa4) output - Pressure Plot
7. VNETPC File (Repvaoa4) output - Air Power Plot
8. VNETPC File (Repvaoa4) output - Airflow Plot
9. VNETPC File (Repvaoa4) Fan Curves Used

9.4 ATTACHMENT IV

VENTILATION APPROACHES FOR DEVELOPMENT AREA CONSTRUCTION

1. Ducted Exhaust Air (Base minimum air velocity at 0.51 m/s (100 fpm)
2. Ducted Intake and Exhaust Air (Base minimum air velocity at 0.51 m/s (100 fpm)
3. Flow-through Ventilation (Base minimum air velocity at 0.51 m/s (100 fpm)
4. Ducted Exhaust Air (Base minimum air velocity at 0.15 m/s (30 fpm)
5. Ducted Intake and Exhaust Air (Base minimum air velocity at 0.15 m/s (30 fpm)
6. Flow-through Ventilation (Base minimum air velocity at 0.15 m/s (30 fpm)

9.5 ATTACHMENT V

HYPOTHETICAL AIR PSYCHROMETRY OF REPOSITORY ENVIRONMENT

1. General psychrometry of air supply (inlet side) for typical emplacement drift at temperature dry bulb, td = 10 to 26.7 °C (50 to 80 °F), relative humidity at 20, 25, 30, 35 & 40 %.

2. Air psychrometry of exhaust air from emplacement drift after heating it to temperature dry bulb, td = 35 to 200 °C (95 to 392 °F) and moisture content of air, G = 26 & 30 grains of moisture/lb dry air.

3. Air psychrometry of exhaust air from emplacement drift after heating it to temperature dry bulb, td =35 to 200 °C (95 to 392 °F) and moisture content of air, G = 35 & 40 grains of moisture/lb dry air.

4. Air psychrometry of exhaust air from emplacement drift after heating it to temperature dry bulb, td =35 to 200 °C (95 to 392 °F) and moisture content of air, G = 50 & 60 grains of moisture/lb dry air.

5. Air psychrometry of exhaust air from emplacement drift after heating it to temperature dry bulb, td =35 to 200 °C (95 to 392 °F) and moisture content of air, G = 70 & 80 grains of moisture/lb dry air.

6. Air psychrometry of exhaust air from emplacement drift after heating it to

temperature dry bulb, td =35 to 200 °C (95 to 392 °F) and moisture content of air, G = 100 & 120 grains of moisture/lb dry air.

7. Air psychrometry of exhaust air from emplacement drift after heating it to temperature dry bulb, td =35 to 200 °C (95 to 392 °F) and moisture content of air, G = 140 & 160 grains of moisture/lb dry air.

8. Air psychrometry of exhaust air from emplacement drift after heating it to temperature dry bulb, td =35 to 200 °C (95 to 392 °F) and moisture content of air, G = 180 & 200 grains of moisture/lb dry air.

9. Air psychrometry of ambient air at effective temperature of 27 °C (81 °F).

9.6 ATTACHMENT VI

1. Flexibility and Sizing of Repository Major Fans

2. Comparative Performances of the 1.52, 1.67 and 1.83 m (60", 66", and 72") Diameter Ventilation Pipes for Emplacement Exhaust Ducts

COMPUTER MODEL - EARLY EMPLACEMENT / EARLY DEVELOPMENT PHASE

Input values on Tables are shaded.

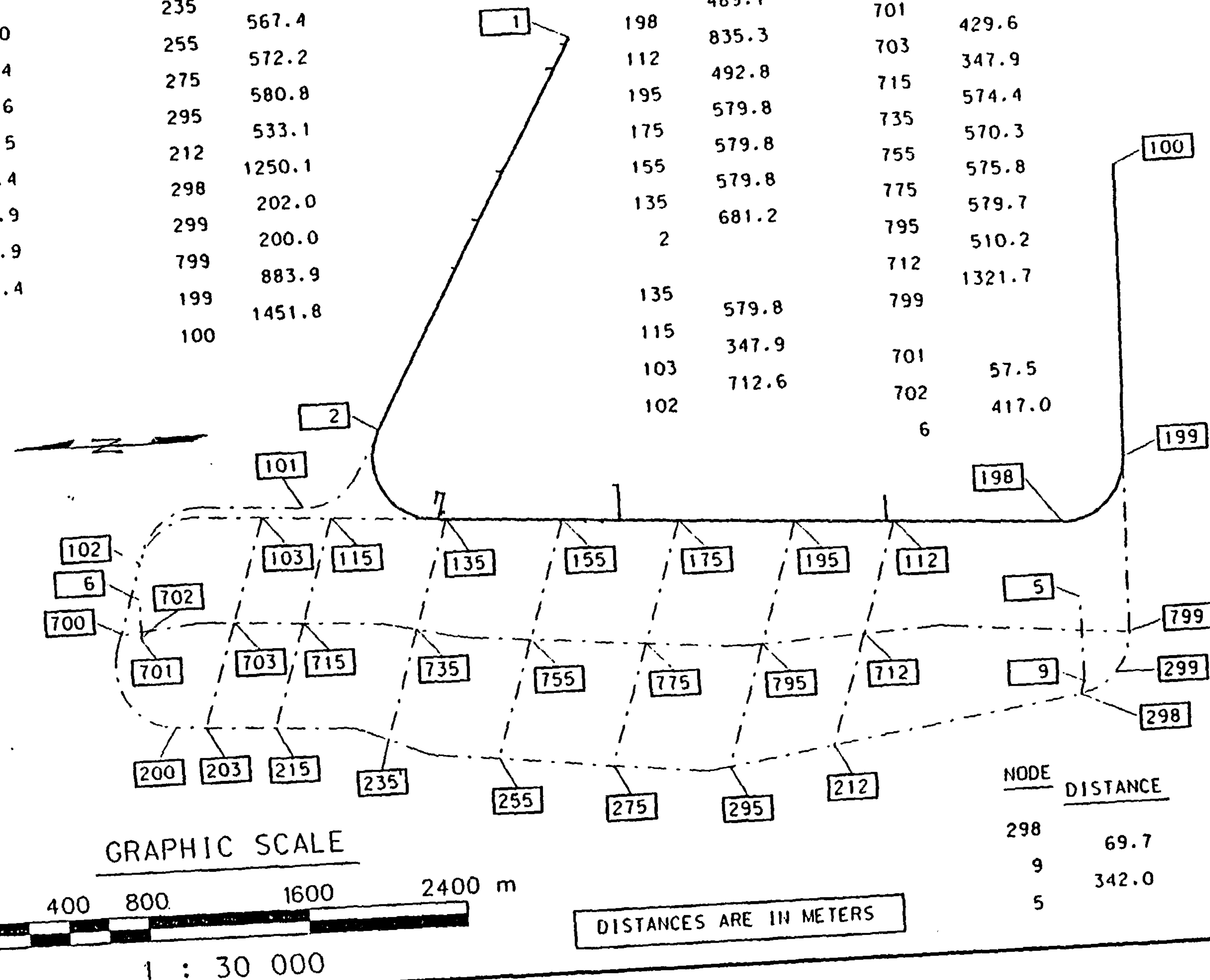
VENTILATION NODES

NODE	DISTANCE
1	2187.0
2	582.4
101	960.6
102	361.5
700	632.4
200	149.9
203	347.9
215	573.4
235	

NODE	DISTANCE
235	567.4
255	572.2
275	580.8
295	533.1
212	1250.1
298	202.0
299	200.0
799	883.9
199	1451.8
100	

NODE	DISTANCE
199	489.7
198	835.3
112	492.8
195	579.8
175	579.8
155	579.8
135	681.2
2	
135	579.8
115	347.9
103	712.6
102	

NODE	DISTANCE
700	138.3
701	429.6
703	347.9
715	574.4
735	570.3
755	575.8
775	579.7
795	510.2
712	1321.7
799	
701	57.5
702	417.0
6	



NODE	DISTANCE
298	69.7
9	342.0
5	

DISTANCES ARE IN METERS

CAD FILE: t:\repss\mech\fig\ssme0200.fig

ILE # Repva0A2, VNETPC INPUT, Viability Assessment Report, Early Emplacement/Early Development Phase

alculation of airway potential resistances during early emplacement/development phase.

Line No.	BRANCH From	BRANCH To	RESISTANCE in PU VNETPC INPUT RPUa+RPUb	REGULATOR RESISTANCE in PU (Field Installed RPUb	RESISTANCE in PU From R RPUa = R/10	AIRWAY RESISTANCE R = KPL/(5.2A^3) in.min^2/ft^6	FRICTION FACTOR K (x10^-10)	CROSS AREA A (Ft)	PERIMETER P (Ft)	ACTUAL LENGTH meter ÷ (m)	ACTUAL LENGTH L' (Ft)	EQUIV. LENGTH L=L'+10% (Ft)	NOTES FOR BRANCH DESCRIPTION	LINE NO.
1	1	2	0.0053		0.0053	0.0533	30	395.1000	72.2600	2187	7175	7893	North Ramp	1
2	2	101	0.0014		0.0014	0.0142	30	395.1000	72.2600	582	1911	2102	North Ramp Ext. (1)	2
3	101	102	0.0023		0.0023	0.0234	30	395.1000	72.2600	961	3152	3467	North Ramp Ext. (2)	3
4	102	103	0.0035		0.0035	0.0348	60	395.1000	72.2600	713	2338	2572	East Main Drift, empl. drift 1 to 5 + drift connection	4
5	103	115	1000.0020	1000.0003	0.0017	0.0170	60	395.1000	72.2600	348	1141	1256	East Main Drift, empl drift 6 to 25/Barrier	5
6	115	135	0.0028		0.0028	0.0283	60	395.1000	72.2600	580	1902	2092	East Main Drift, empl drift 26 to 45	6
7	2	135	1000.0020	1000.0003	0.0017	0.0166	30	395.1000	72.2600	681	2235	2458	North Ramp curve to East Main/Barrier	7
8	135	155	0.0028		0.0028	0.0283	60	395.1000	72.2600	580	1902	2092	East Main Drift, empl drift 46 to 65	8
9	155	175	0.0028		0.0028	0.0283	60	395.1000	72.2600	580	1902	2092	East Main Drift, empl drift 66 to 85	9
10	175	195	0.0028		0.0028	0.0283	60	395.1000	72.2600	580	1902	2092	East Main Drift, empl drift 86 to 104	10
11	195	112	0.0024		0.0024	0.0240	60	395.1000	72.2600	493	1617	1778	East Main Drift, empl drift 105 to 120	11
12	112	198	0.0039	-0.0002	0.0041	0.0408	60	395.1000	72.2600	835	2740	3015	East Main Drift, south end	12
13	198	199	0.0024		0.0024	0.0239	60	395.1000	72.2600	490	1607	1767	East Main Drift curve to South Ramp	13
14	199	100	0.0087		0.0087	0.0865	70	389.1000	72.2600	1452	4763	5239	South Ramp	14
15	102	700	0.0009		0.0009	0.0088	30	395.1000	72.2600	362	1186	1305	North Main - East loop	15
16	700	200	0.0015		0.0015	0.0154	30	395.1000	72.2600	632	2075	2282	North Main - West loop	16
17	200	203	0.0007		0.0007	0.0073	60	395.1000	72.2600	150	492	541	West Main Drift, empl. drift 1 to 5	17
18	203	215	1000.0020	1000.0003	0.0017	0.0170	60	395.1000	72.2600	348	1141	1256	West Main Drift, empl drift 6 to 25/Barrier	18
19	215	235	0.0028		0.0028	0.0280	60	395.1000	72.2600	573	1881	2069	West Main Drift, empl drift 26 to 45	19
20	235	255	0.0028		0.0028	0.0277	60	395.1000	72.2600	567	1862	2048	West Main Drift, empl drift 46 to 65	20
21	275	255	0.0028		0.0028	0.0279	60	395.1000	72.2600	572	1877	2065	West Main Drift, empl drift 66 to 85	21
22	295	275	0.0028		0.0028	0.0283	60	395.1000	72.2600	581	1906	2096	West Main Drift, empl drift 86 to 104	22
23	212	295	0.0026		0.0026	0.0260	60	395.1000	72.2600	533	1749	1924	West Main Drift, empl drift 105 to 120	23
24	298	212	0.0061		0.0061	0.0610	60	395.1000	72.2600	1250	4101	4512	West Main Drift, empl drift 120 to Dev. Shaft	24
25	298	299	0.0010		0.0010	0.0098	60	395.1000	72.2600	200	656	722	West Main Drift, south end	25
26	299	799	0.0010		0.0010	0.0099	60	395.1000	72.2600	202	663	729	West Main Drift curve to South Ramp Ext/Exh Main	26
27	799	199	5.0043	5.0000	0.0043	0.0431	60	395.1000	72.2600	884	2900	3190	South Ramp Ext/Reg Door	27
28	103	303	0.0156		0.0156	0.1555	85	219.8900	52.5700	533	1749	1924	Emplacement Drifts, empl. drift 1 to 5, Fix 1.06kcfm	28
29	115	315	0.0156		0.0156	0.1555	85	219.8900	52.5700	533	1749	1924	Emplacement Drifts, empl drift 6 to 25, Fix 4.24 kcfm	29
30	135	335	0.0164		0.0164	0.1639	85	219.8900	52.5700	562	1843	2028	Emplacement Drifts, empl drift 26 to 45, Fix 4.24 kcfm	30
31	203	303	0.0156		0.0156	0.1555	85	219.8900	52.5700	533	1749	1924	Emplacement Drifts, empl. drift 1 to 5, Fix 1.06 kcfm	31
32	215	315	0.0156		0.0156	0.1555	85	219.8900	52.5700	533	1749	1924	Emplacement Drifts, empl drift 6 to 25, Fix 4.24 kcfm	32
33	235	335	0.0164		0.0164	0.1639	85	219.8900	52.5700	562	1843	2028	Emplacement Drifts, empl drift 26 to 45, Fix 4.24 kcfm	33
34	303	403	0.0167		0.0167	0.1668	20	24.4300	17.5200	10	33	36	Raises, empl. drift 1 to 5	34
35	315	415	0.0167		0.0167	0.1668	20	24.4300	17.5200	10	33	36	Raises, empl drift 6 to 25	35
36	335	435	0.0167		0.0167	0.1668	20	24.4300	17.5200	10	33	36	Raises, empl drift 26 to 45	36
37	403	703	0.005		0.0050	0.0500	20	24.4300	17.5200	3	10	11	Raise Door to Exhaust Main, empl. drift 1 to 5	37
38	415	715	1.005	1.000	0.0050	0.0500	20	24.4300	17.5200	3	10	11	Raise Door to Exhaust Main, empl drift 6 to 25/Reg	38
39	435	735	1.005	1.000	0.0050	0.0500	20	24.4300	17.5200	3	10	11	Raise Door to Exhaust Main, empl drift 26 to 45/Reg	39
40	403	503	0.2141		0.2141	2.1412	11	4.2800	7.3300	3	10	11	Gate valve, raise to Duct 1, empl. drift 1 to 5	40

FILE # Repva0A2, VNETPC INPUT, Viability Assessment Report, Early Emplacement/Early Development Phase

Calculation of airway potential resistances during early emplacement/development phase.

Line No.	BRANCH From	BRANCH To	RESISTANCE in PU VNETPC INPUT RPUa+RPUb	REGULATOR RESISTANCE in PU (Field Installed) RPUb	RESISTANCE in PU From R RPUa = R/10	AIRWAY RESISTANCE R = KPL/(5.2A^3) in.min^2/ft^6	FRICTION FACTOR K (x10^-10)	CROSS AREA A (Ft)	PERIMETER P (Ft)	ACTUAL LENGTH meter (m)	ACTUAL LENGTH L' (Ft)	EQUIV. LENGTH L=L'+10% (Ft)	NOTES FOR BRANCH DESCRIPTION	LINE NO.
41	403	603	0.2141		0.2141	2.1412	11	4.2800	7.3300	3	10	11	Gate valve, raise to Duct 2, empl. drift 1 to 5	41
42	503	501	0.2994		0.2994	2.9936	11	28.2700	18.8500	470	1542	1696	Duct 1 from Emplace. Drift 1 to 5 + length to shaft	42
43	501	500	0.0382		0.0382	0.3822	11	28.2700	18.8500	60	197	217	Centrifugal Fan 1	43
44	500	600	0.0003		0.0003	0.0034	60	387.5008	78.7402	60	197	217	Drift connection 6x6 -Duct 1 discharge to Empl Shaft	44
45	603	601	0.2739		0.2739	2.7389	11	28.2700	18.8500	430	1411	1552	Duct 2 from Emplace. Drift 1 to 5 + length to shaft	45
46	601	600	0.0382		0.0382	0.3822	11	28.2700	18.8500	60	197	217	Centrifugal Fan 2	46
47	600	702	0.0002		0.0002	0.0017	60	387.5008	78.7402	30	98	108	Drift connection for duct 1 & 2 discharge to Shaft, 6x6	47
48	799	712	0.0139	-0.0005	0.0144	0.1441	70	318.1400	72.2600	1322	4337	4771	Exhaust Main, South Ramp Ext to Empl Drift	48
49	712	795	0.0056		0.0056	0.0556	70	318.1400	72.2600	510	1673	1841	Exhaust Main from Emplacement Drift 105 to 120	49
50	795	775	0.0063		0.0063	0.0632	70	318.1400	72.2600	580	1903	2093	Exhaust Main from Emplacement Drift 86 to 104	50
51	775	755	0.0063		0.0063	0.0628	70	318.1400	72.2600	576	1890	2079	Exhaust Main from Emplacement Drift 65 to 85	51
52	755	735	0.0062		0.0062	0.0621	70	318.1400	72.2600	570	1870	2057	Exhaust Main from Emplacement Drift 46 to 65	52
53	735	715	0.0063		0.0063	0.0626	70	318.1400	72.2600	574	1885	2073	Exhaust Main from Emplacement Drift 26 to 45	53
54	715	703	1000.0040	1000.0002	0.0038	0.0379	70	318.1400	72.2600	348	1142	1256	Exhaust Main from Emplacement Drift 6 to 25/Barrier	54
55	703	701	0.0047		0.0047	0.0469	70	318.1400	72.2600	430	1411	1552	Exhaust Main from Emplacement Drift 1 to 5	55
56	700	701	1000.0010	999.9995	0.0015	0.0150	70	318.1400	72.2600	138	453	498	Exhaust Main Airlock to North Main	56
57	701	702	0.0002		0.0002	0.0018	70	527.4316	91.8635	58	190	209	Exhaust Main connection to Emplacement Shaft, 7x7	57
58	702	6	0.0012		0.0012	0.0123	20	309.5700	62.8700	417	1368	1505	Emplacement Shaft (Collar Elev. 1455m)	58
59	6	7	0.0002		0.0002	0.0016	11	309.5700	62.8700	100	328	361	Primary Emplacement Fan	59
60	7	1002	1000.0000	1000.0000	0.0000	0.0000	0	0	0	0	0	0	Primary Emplacement Fan leakage leg 1	60
61	1002	6	1000.0000	1000.0000	0.0000	0.0000	0	0	0	0	0	0	Primary Emplacement Fan leakage leg 2	61
62	7	8	0.0000		0.0000	0.0000	0	0	0	0	0	0	Surface dummy, Empl Shaft to North Ramp Portal 1	62
63	8	1	0.0000		0.0000	0.0000	0	0	0	0	0	0	Surface dummy, Empl Shaft to North Ramp Portal 2	63
64	1	100	0.0000		0.0000	0.0000	0	0	0	0	0	0	Surface dummy, North Ramp Portal to South Ramp Po	64
65	100	3	0.0000		0.0000	0.0000	0	0	0	0	0	0	Surface dummy, South Ramp Portal to Dev Shaft leg 1	65
66	3	4	0.0000		0.0000	0.0000	0	0	0	0	0	0	Surface dummy, South Ramp Portal to Dev Shaft leg 2	66
67	4	5	0.0001		0.0001	0.0011	11	309.5700	62.8700	70	230	253	Primary Development Fan	67
68	5	1001	1000.0000	1000.0000	0.0000	0.0000	0	0	0	0	0	0	Primary Development Fan leakage leg 1	68
69	1001	4	1000.0000	1000.0000	0.0000	0.0000	0	0	0	0	0	0	Primary Development Fan leakage leg 1	69
70	5	9	0.0048		0.0048	0.0478	95	309.5700	62.8700	342	1122	1234	Development Shaft (Collar elev. 1452m)	70
71	9	298	0.0002		0.0002	0.0018	60	527.4318	91.8635	70	230	253	Development Shaft connection to West Main	71
72	115	334	0.0110		0.0110	0.1097	60	219.8900	52.5700	533	1749	1924	Vent Drift + PC Bypass Regulator from East Main, 1	72
73	235	334	0.0110		0.0110	0.1097	60	219.8900	52.5700	533	1749	1924	Vent Drift + PC Bypass Regulator from West Main, 1	73
74	334	735	1000.0170	1000.0003	0.0167	0.1668	20	24.4300	17.5200	10	33	36	Raise for Vent Drift + PC Bypass Regulator, 1	74
75	155	370	0.0128		0.0128	0.1279	60	219.8900	52.5700	621	2037	2241	Vent Drift + PC Bypass Regulator from East Main, 2	75
76	275	370		Fix 22k	0.0128	0.1279	60	219.8900	52.5700	621	2037	2241	Vent Drift + PC Bypass Regulator from West Main, 2	76
77	370	775	1000.0170	1000.0003	0.0167	0.1668	20	24.4300	17.5200	10	33	36	Raise for Vent Drift + PC Bypass Regulator, 2	77
78	195	304	0.0123		0.0123	0.1233	60	219.8900	52.5700	599	1965	2162	Vent Drift + PC Bypass Regulator from East Main, 3	78
79	212	304		Fix 22k	0.0123	0.1233	60	219.8900	52.5700	599	1965	2162	Vent Drift + PC Bypass Regulator from West Main, 3	79
80	304	712	1000.0170	1000.0003	0.0167	0.1668	20	24.4300	17.5200	10	33	36	Raise for Vent Drift + PC Bypass Regulator, 3	80

Ref. Line

Calculation of cross areas and perimeters

Ref. Line		K factor assumptions		Calculated Gross Cross Area, ft^2	Less Area of Perm. Items Ft^2	Net Are Used Ft^2	Perimeter Used Ft
1				Calculated	Less Area of	Net Are	Perimeter
2		K factor assum	ptions	Gross Cross	Perm. Items	Used	Used
3		x 10 ^(-10) lb	min^2/ft^4	Area, ft^2	Ft^2	Ft^2	Ft
4							
5	North Ramp / North Main, 7.62m dia	30	DCSS 022	490.88	a, c, u	395.10	72.26
6	East / West Main drifts, 7.62 m dia	60	DCSS 022	490.88	a, c, u	395.10	72.26
7	Emplacement drifts, 5.1 m dia	70	DCSS 022	219.89		219.89	52.57
8	Empl drifts (Loaded), 5.1 m dia	85	DCSS 022	219.89		219.89	52.57
9	Smooth exhaust ducts, 72"ID, 84"OD	11	DCSS 022	28.27		28.27	18.85
10	Exhaust main (raise bottom & duct blockage)	70	DCSS 022	490.88	a, c, 2d,u	318.14	72.26
11	Raises, 1.7 m dia	20		24.43		24.43	17.52
12	Emplacement Shaft, 6.1 m dia	20		314.57	g	309.57	62.87
13	Development Shaft, 6.1 m dia	95	DCSS 022	314.57	g, u	307.57	62.87
14	Regulator valves 28" dia housing	11		4.28		4.28	7.33
15	South Ramp Service Main	70	DCSS 022	490.88	a, b, c, u	389.10	72.26

16

17 Less estimated permanent obstruction in airways:

18 a - main invert (34.34); b - conveyor (6); c - concrete lining above invert (59.44); d - duct 84"OD (38.48); g - guides in shaft (5); s - steel set (42.19); u - utilities & rails (2).

19

20	when "u" has	Water Supply	0.35
21		Water Return	0.35
22		Compressed Air	0.20
23		Power & Hangers	0.60
24		Rail	0.50
25			
26		Net Cross Area	2.00 Ft^2

27

28 Note: Liner in ramps and mains are assumed 12 inches thick for concrete or 8 inches thick for steel.

29

30

VNETPC (Version 3.1)
15:43:26
06-23-1997

Output File Name: OUTPUT.TMP
Network File Name: REPVA0A2
Network Title: REPOSITORY VENTILATION
Mine Name: YUCCA MOUNTAIN PROJECT
Company: M&O/MK/RSJURANI
Comments: EARLY EMPLACEMENT/DEVELOPMENT PHASE

**** DATA SUPPLIED BY USER ****

Fan Data:

	Fan Ref No.	From	To	Operating Pressure in.w.g.	No. Characteristic Pts.
1	13	4	5	10.000	10
2	18	6	7	5.000	10
3	2	501	500	5.000	10
4	2	601	600	5.000	10

Fan Characteristic Points:

Fan 1	Pressure in.w.g.	Airflow kcfm
	28.000	40.00
	24.000	120.00
	20.000	230.00
	18.600	290.00
	19.200	330.00
	20.000	380.00
	18.000	450.00
	14.000	540.00
	10.000	600.00
	4.000	660.00

Fan 2	Pressure in.w.g.	Airflow kcfm
	17.400	10.00
	16.400	40.00
	15.200	70.00
	14.000	110.00
	12.200	180.00
	11.200	220.00
	10.000	260.00
	7.600	300.00
	5.200	330.00
	2.000	355.00

Fan 3	Pressure in.w.g.	Airflow kcfm

2.400	140.00
4.700	120.00
5.500	110.00
6.100	90.00
6.700	80.00
6.000	60.00
5.400	50.00
4.850	30.00
5.000	20.00
6.800	0.00

Fan 4	Pressure in.w.g.	Airflow kcfm
	2.400	140.00
	4.700	120.00
	5.500	110.00
	6.100	90.00
	6.700	80.00
	6.000	60.00
	5.400	50.00
	4.850	30.00
	5.000	20.00
	6.800	0.00

Branch Data:

Branch	From	To	Resistance P.U.	Airflow kcfm	Pressure Dp m.in.wg.	Frict. Factor lbfmin^2/ft^4 X10^10	Len ft	Equiv Len ft	Area ft^2
1	1	2	0.00530						
2	2	101	0.00140						
3	101	102	0.00230						
4	102	103	0.00350						
5	103	115	1000.00201						
6	115	135	0.00280						
7	2	135	1000.00201						
8	135	155	0.00280						
9	155	175	0.00280						
10	175	195	0.00280						
11	195	112	0.00240						
12	112	198	0.00390						
13	198	199	0.00240						
14	199	100	0.00870						
15	102	700	0.00090						
16	700	200	0.00150						
17	200	203	0.00070						
18	203	215	1000.00201						
19	215	235	0.00280						
20	235	255	0.00280						
21	275	255	0.00280						
22	295	275	0.00280						
23	212	295	0.00260						
24	298	212	0.00610						
25	298	299	0.00100						
26	299	799	0.00100						
27	799	199	5.00430						
28	103	303	0.01560						

29	115	315	0.01560	
30	135	335	0.01640	
31	203	303	0.01560	
32	215	315	0.01560	
33	235	335	0.01640	
34	303	403	0.01670	
35	315	415	0.01670	
36	335	435	0.01670	
37	403	703	0.00500	
38	415	715	1.00500	
39	435	735	1.00500	
40	403	503	0.21410	
41	403	603	0.21410	
42	503	501	0.29940	
43	501	500	0.03820	
44	500	600	0.00030	
45	603	601	0.27390	
46	601	600	0.03820	
47	600	702	0.00020	
48	799	712	0.01390	
49	712	795	0.00560	
50	795	775	0.00630	
51	775	755	0.00630	
52	755	735	0.00620	
53	735	715	0.00630	
54	715	703	1000.00403	
55	703	701	0.00470	
56	700	701	1000.00098	
57	701	702	0.00020	
58	702	6	0.00120	
59	6	7	0.00020	
60	7	1002	1000.00000	
61	1002	6	1000.00000	
62	7	8	0.00001	
63	8	1	0.00001	
64	1	100	0.00001	
65	100	3	0.00001	
66	3	4	0.00001	
67	4	5	0.00010	
68	5	1001	1000.00000	
69	1001	4	1000.00000	
70	5	9	0.00480	
71	9	298	0.00020	
72	115	334	0.01100	
73	235	334	0.01100	
74	334	735	1000.01703	
75	155	370	0.01280	
76	275	370	0.50000	22.00 - Fixed
77	370	775	1000.01703	
78	195	304	0.01230	
79	212	304	0.50000	22.00 - Fixed
80	304	712	1000.01703	

**** OUTPUT DATA ****

Annual costs are based on electricity charges of 10.0 cents per kWh and fan efficiencies of 75.0%
Cost given for an NVP represents money saved by natural ventilation

Network File Name - REPVA0A2
Output File Name - OUTPUT.TMP

*** Fan Operating Points ***

Fan	Ref No.	From	To	Pressure in.w.g.	Quantity kcfm	Air Power hp	Op.Cost $/year
1	13	4	5	12.059	569.11	1081.43	941873
2	18	6	7	3.979	353.09	221.38	192815
3	2	501	500	5.701	103.27	92.77	80797
4	2	601	600	5.642	105.24	93.56	81486

Network File Name - REPVA0A2
Output File Name - OUTPUT.TMP

*** Branch Data ***

Branch	From	To	Press.Dp m.in.wg.	Airflow kcfm	Resist. P.U.	AP Loss hp	Op.Cost $/year
1	1	2	610	339.39	0.00530	32.6	28413
2	2	101	163	342.14	0.00140	8.8	7654
3	101	102	269	342.14	0.00230	14.5	12631
4	102	103	100	169.43	0.00350	2.7	2325
5	103	115	-8330	-2.89	1000.00201	3.8	3300
6	115	135	244	295.56	0.00280	11.4	9897
7	2	135	-7552	-2.75	1000.00201	3.3	2848
8	135	155	610	466.92	0.00280	44.9	39090
9	155	175	674	490.86	0.00280	52.1	45405
10	175	195	674	490.86	0.00280	52.1	45405
11	195	112	636	515.14	0.00240	51.6	44965
12	112	198	1034	515.14	0.00390	83.9	73103
13	198	199	636	515.14	0.00240	51.6	44965
14	199	100	2673	554.36	0.00870	233.5	203366
15	102	700	26	172.71	0.00090	0.7	616
16	700	200	43	171.06	0.00150	1.2	1009
17	200	203	20	171.06	0.00070	0.5	470
18	203	215	-8799	-2.97	1000.00201	4.1	3582
19	215	235	-28	-100.25	0.00280	0.4	385
20	235	255	-395	-375.85	0.00280	23.4	20375
21	275	255	395	375.85	0.00280	23.4	20375
22	295	275	443	397.85	0.00280	27.8	24188
23	212	295	411	397.85	0.00260	25.8	22441
24	298	212	1075	419.85	0.00610	71.1	61942
25	298	299	21	146.81	0.00100	0.5	423
26	299	799	21	146.81	0.00100	0.5	423
27	799	199	7697	39.22	5.00430	47.6	41430
28	103	303	463	172.31	0.01560	12.6	10949
29	115	315	-331	-145.85	0.01560	7.6	6626
30	135	335	-497	-174.11	0.01640	13.6	11876
31	203	303	472	174.02	0.01560	12.9	11273

32	215	315	147	97.28	0.01560	2.3	1963	
33	235	335	254	124.58	0.01640	5.0	4343	
34	303	403	2003	346.34	0.01670	109.3	95206	
35	315	415	-39	-48.57	0.01670	0.3	260	
36	335	435	-40	-49.53	0.01670	0.3	272	
37	403	703	94	137.83	0.00500	2.0	1778	
38	415	715	-2370	-48.57	1.00500	18.1	15797	
39	435	735	-2465	-49.53	1.00500	19.2	16755	
40	403	503	2283	103.27	0.21410	37.2	32356	
41	403	603	2371	105.24	0.21410	39.3	34244	
42	503	501	3192	103.27	0.29940	51.9	45239	
43	501	500	407	103.27	0.03820	6.6	5768	
44	500	600	3	103.27	0.00030	0.0	43	
45	603	601	3033	105.24	0.27390	50.3	43805	
46	601	600	423	105.24	0.03820	7.0	6109	
47	600	702	8	208.50	0.00020	0.3	229	
48	799	712	160	107.59	0.01390	2.7	2362	
49	712	795	62	105.30	0.00560	1.0	896	
50	795	775	69	105.30	0.00630	1.1	997	
51	775	755	67	103.37	0.00630	1.1	950	
52	755	735	66	103.37	0.00620	1.1	936	
53	735	715	17	52.26	0.00630	0.1	122	
54	715	703	13633	3.69	1000.00403	7.9	6908	
55	703	701	94	141.53	0.00470	2.1	1826	
56	700	701	2729	1.65	1000.00098	0.7	619	
57	701	702	4	143.18	0.00020	0.1	79	
58	702	6	148	351.68	0.00120	8.2	7143	
59	6	7	24	353.09	0.00020	1.3	1163	
60	7	1002	1977	1.41	1000.00000	0.4	382	
61	1002	6	1977	1.41	1000.00000	0.4	382	
62	7	8	1	351.68	0.00001	0.1	48	
63	8	1	1	351.68	0.00001	0.1	48	
64	1	100	0	12.29	0.00001	0.0	0	
65	100	3	3	566.66	0.00001	0.3	233	
66	3	4	3	566.66	0.00001	0.3	233	
67	4	5	32	569.11	0.00010	2.9	2499	
68	5	1001	6013	2.45	1000.00000	2.3	2024	
69	1001	4	6013	2.45	1000.00000	2.3	2024	
70	5	9	1541	566.66	0.00480	137.6	119842	
71	9	298	64	566.66	0.00020	5.7	4977	
72	115	334	-256	-152.60	0.01100	6.2	5361	
73	235	334	250	151.02	0.01100	5.9	5181	
74	334	735	-2502	-1.58	1000.01703	0.6	543	
75	155	370	-7	-23.93	0.01280	0.0	23	
76*	275	370	2145	22.00	4.43343	7.4	6476	-Regulator Required
77	370	775	-3739	-1.93	1000.01703	1.1	992	
78	195	304	-7	-24.28	0.01230	0.0	23	
79*	212	304	4349	22.00	8.98733	15.1	13131	-Regulator Required
80	304	712	-5221	-2.28	1000.01703	1.9	1637	

Number of Iterations = 2

Network File Name - REPVA0A2

Output File Name - OUTPUT.TMP

*** Regulator List ***

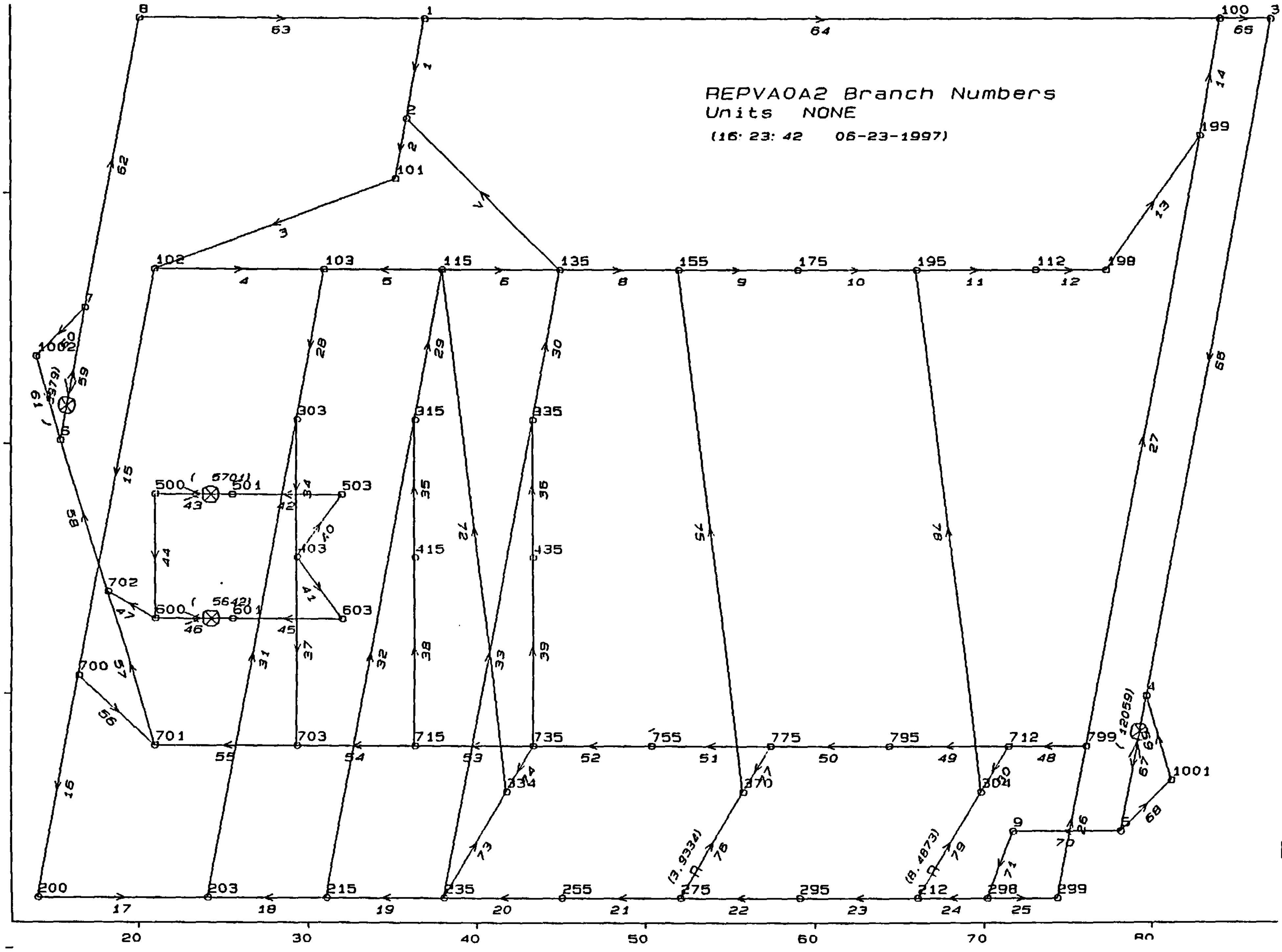
Branch	From	To	Fixed Quantity (kcfm)	Regulator Resistance (P.U.)
76	275	370	22.0	3.93340
79	212	304	22.0	8.48730

The following table gives the frictional pressure relative to 0 m.in.wg. at junction No. 1
The table may be used to find neutral points and the pressure difference available to produce flow between any two junctions in the network.
** The value 99999 indicates an inaccessible junction **

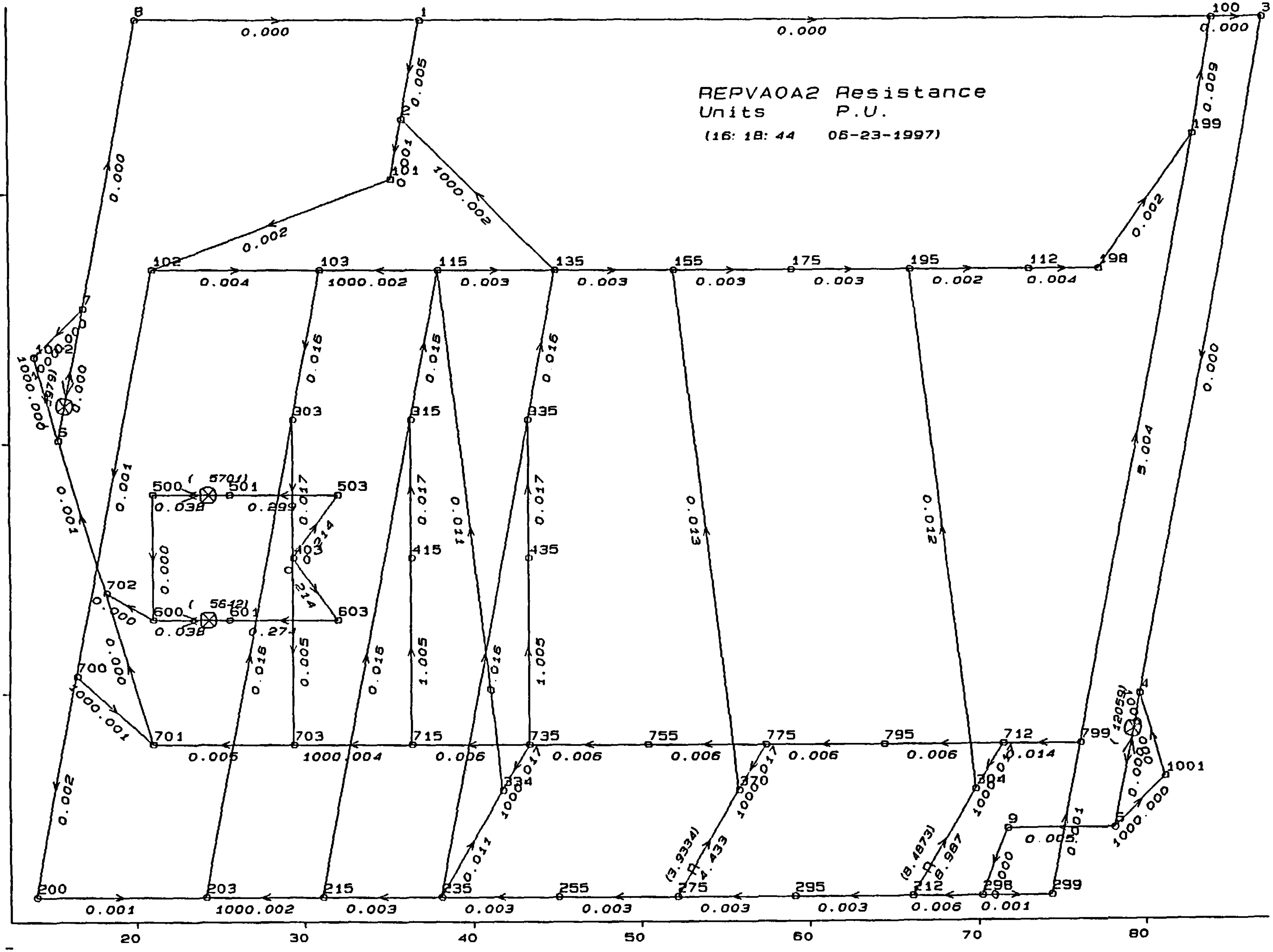
Junction	Pressure	Junction	Pressure	Junction	Pressure	Junction	Pressure
1	0	2	-610	3	4	4	1
5	12028	6	-3948	7	7	8	6
9	10487	100	7	101	-773	102	-1042
103	-1142	112	4350	115	7188	135	6944
155	6334	175	5660	195	4986	198	3316
199	2680	200	-1111	203	-1131	212	9340
215	7668	235	7696	255	8091	275	8486
295	8929	298	10415	299	10394	303	-1605
304	4993	315	7519	334	7444	335	7441
370	6341	403	-3608	415	7558	435	7481
500	-3789	501	-9083	503	-5891	600	-3792
601	-9012	603	-5979	700	-1068	701	-3796
702	-3800	703	-3702	712	10213	715	9928
735	9946	755	10015	775	10082	795	10151
799	10373	1001	6015	1002	-1970		

**** NETWORK EXERCISE COMPLETE ****

Some information may be obliterated but may be deduced from Attachment I, pages 6 thru 11.



Some information may be obliterated but may be deduced from Attachment I, pages 6 thru 11.



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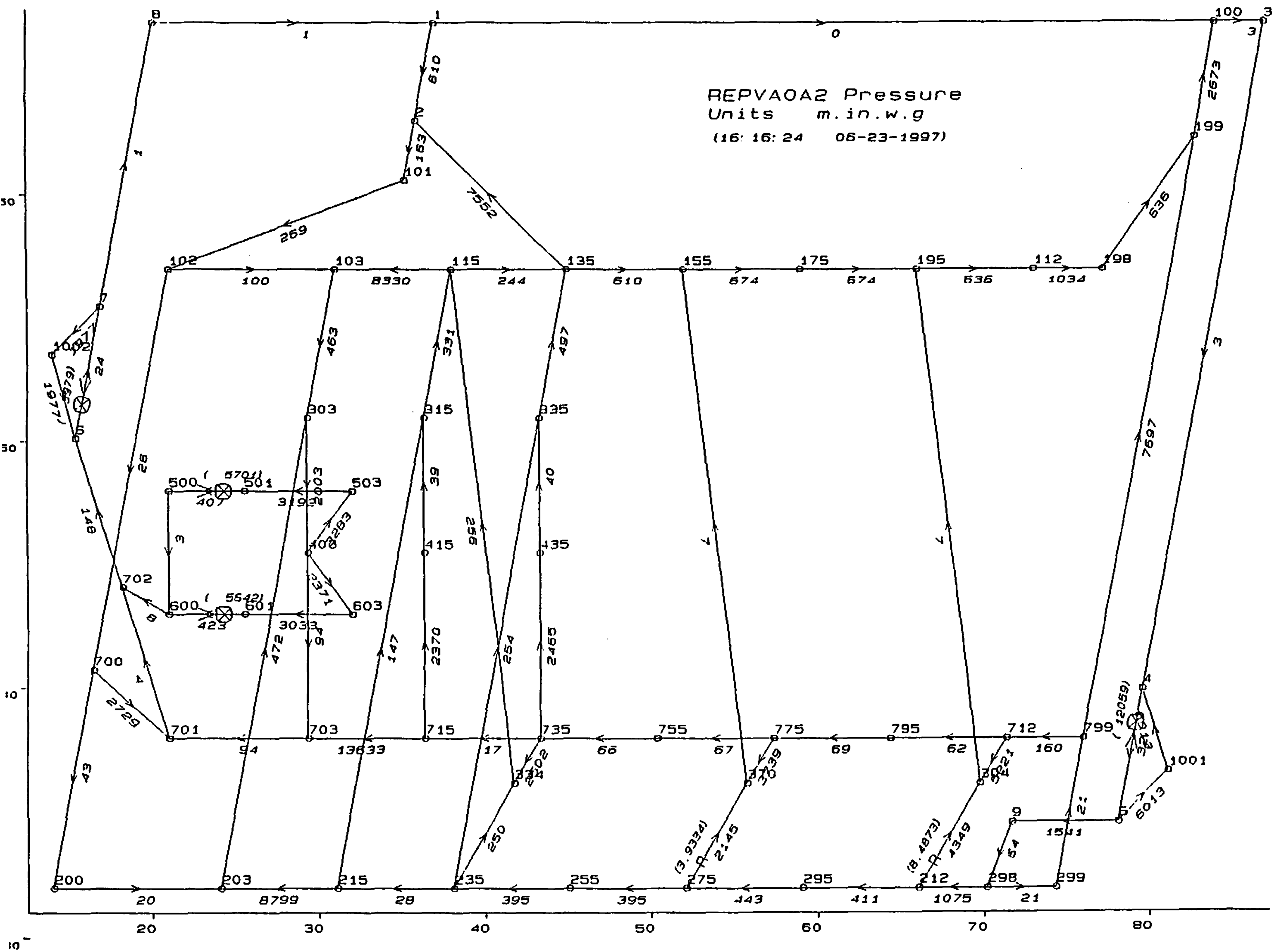
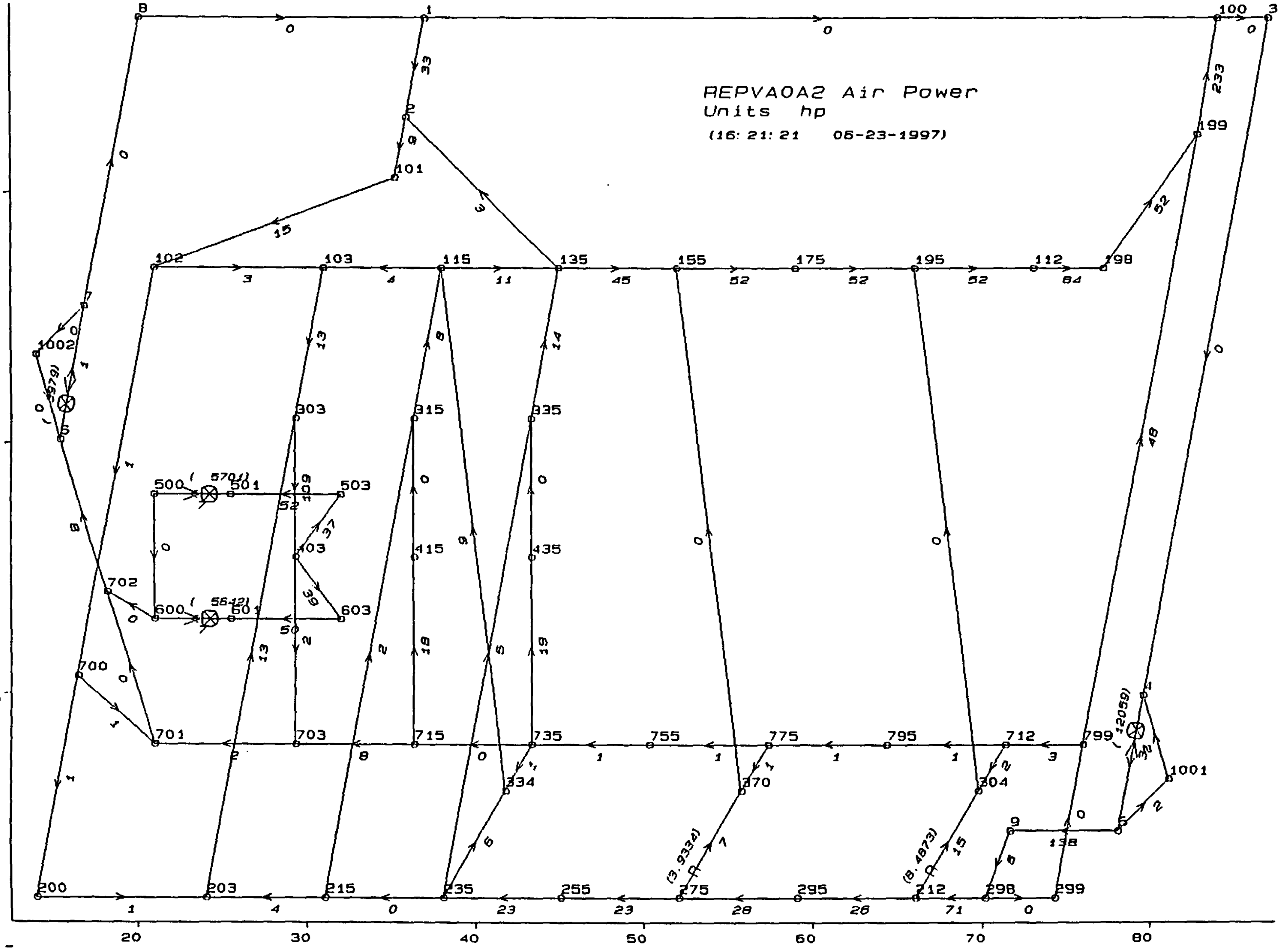


Overall Development and Emplacement Ventilation Systems
BCA000000-01717-0200-00015 REV 00

ATTACHMENT I
Page I- 14 of I-19

Some information may be obliterated but may be deduced from Attachment I, pages 6 thru 11.



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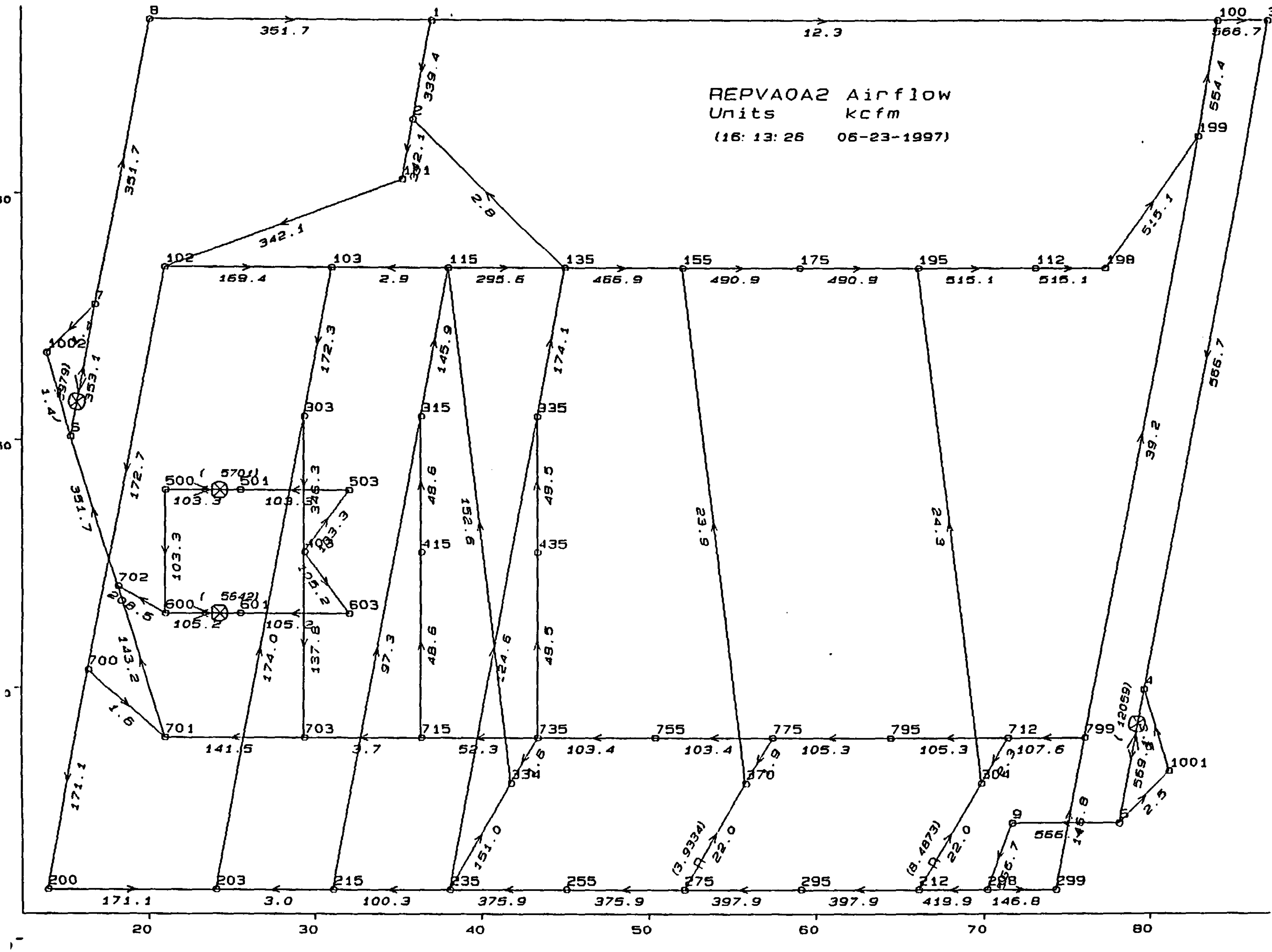
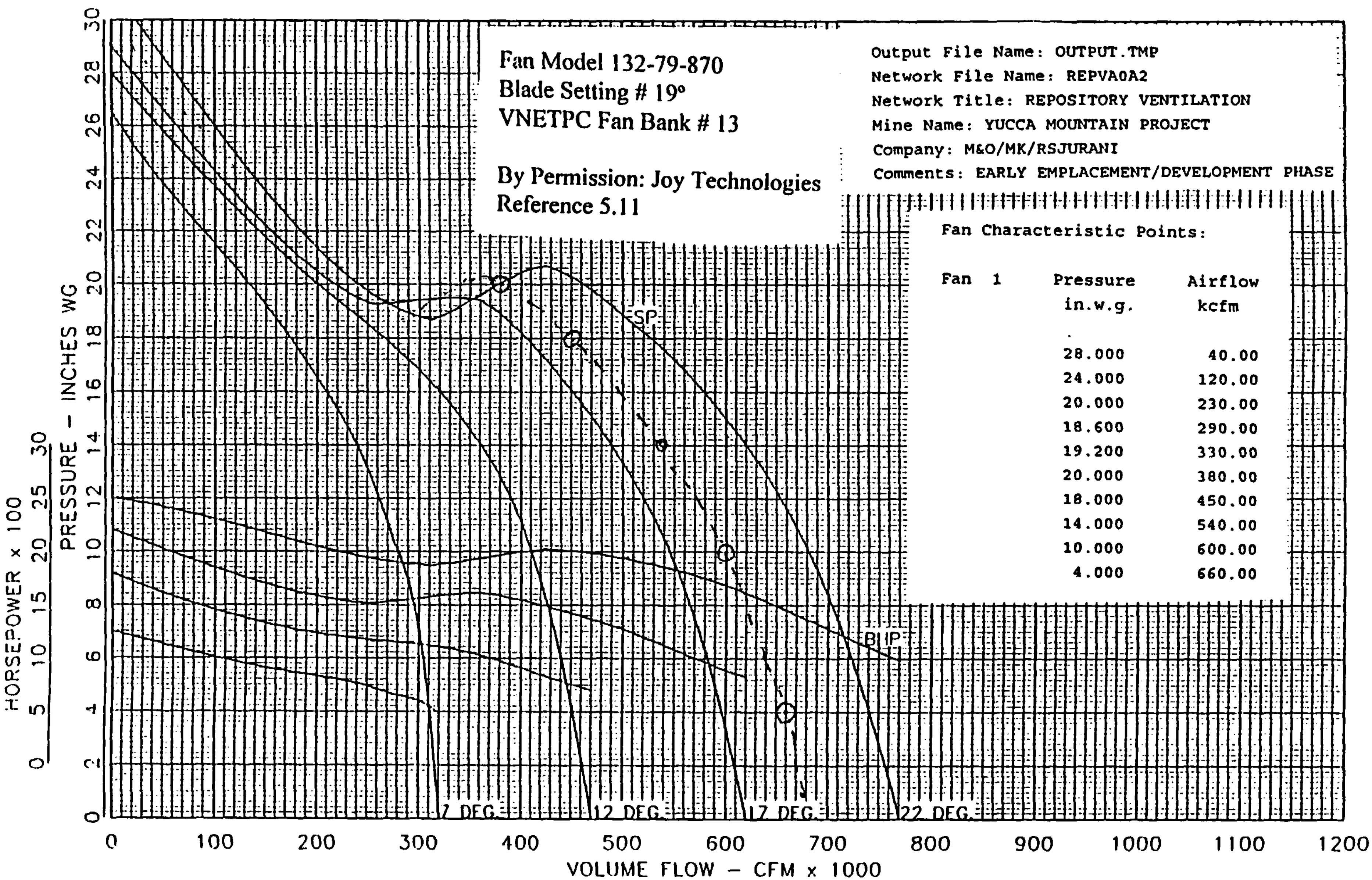
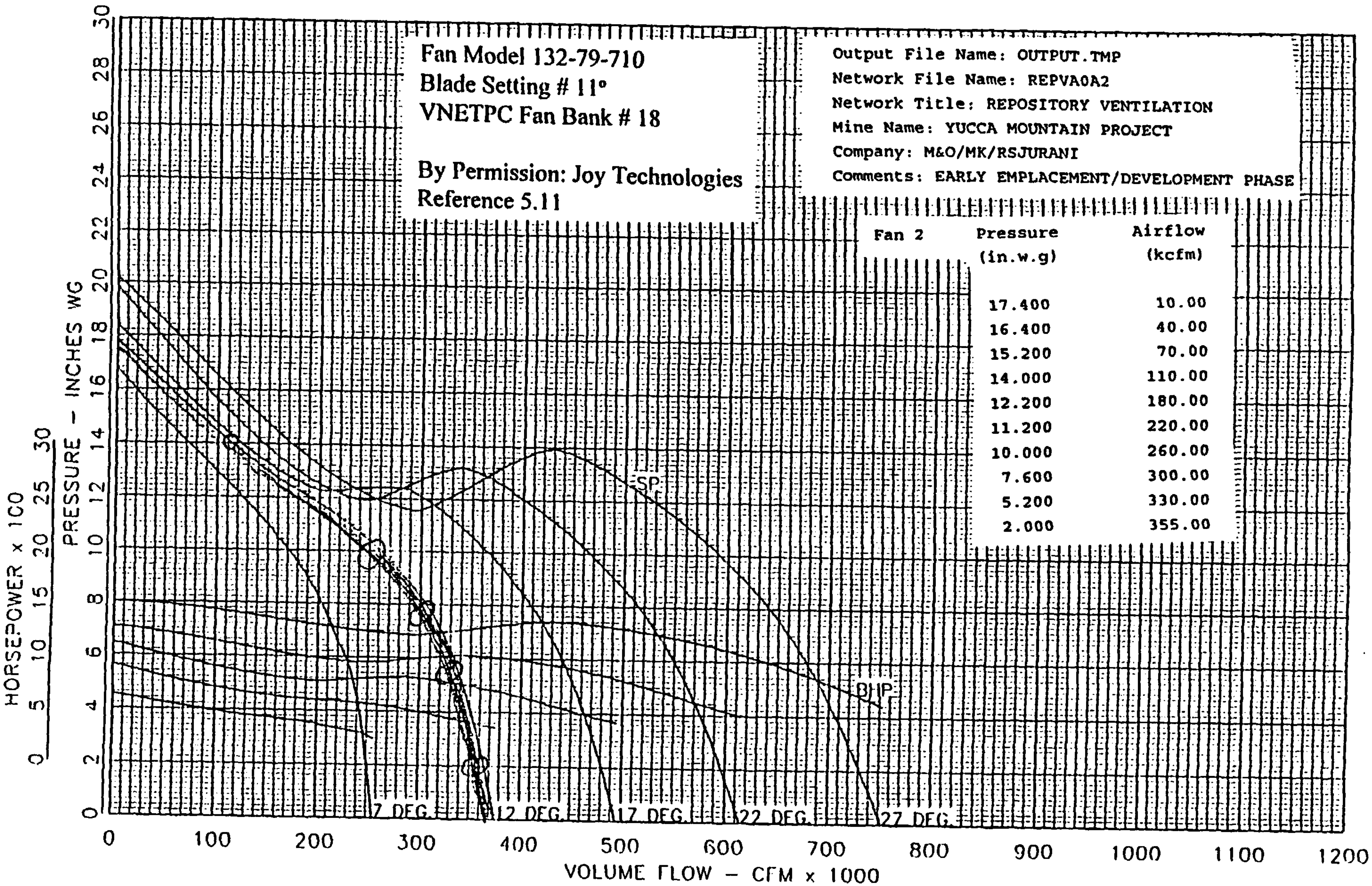
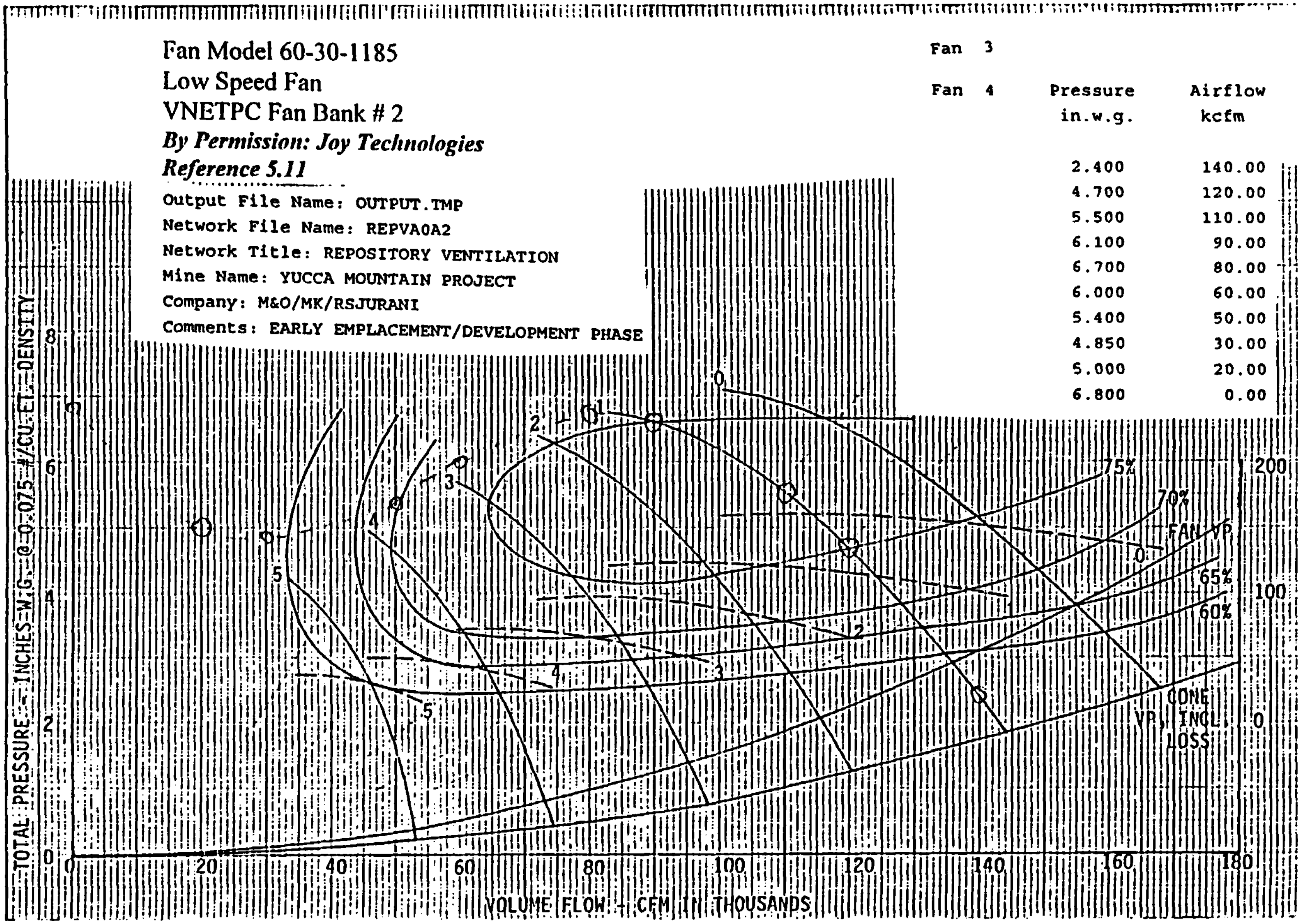




Fan 1	Pressure in.w.g.	Airflow kcfm
	28.000	40.00
	24.000	120.00
	20.000	230.00
	18.600	290.00
	19.200	330.00
	20.000	380.00
	18.000	450.00
	14.000	540.00
	10.000	600.00
	4.000	660.00


Fan Model 132-79-710
Blade Setting # 11°
VNETPC Fan Bank # 18
By Permission: Joy Technologies
Reference 5.11
Output File Name: OUTPUT.TMP
Network File Name: REPVA0A2
Network Title: REPOSITORY VENTILATION
Mine Name: YUCCA MOUNTAIN PROJECT
Company: M&O/MK/RSJURANI
Comments: EARLY EMPLACEMENT/DEVELOPMENT PHASE
Fan 2
Pressure (in.w.g)
Airflow (kcfm)
17.400 10.00
16.400 40.00
15.200 70.00
14.000 110.00
12.200 180.00
11.200 220.00
10.000 260.00
7.600 300.00
5.200 330.00
2.000 355.00
SP
BHP
7 DEG.
12 DEG.
17 DEG.
22 DEG.
27 DEG.
HORSEPOWER x 100
PRESSURE - INCHES WG
VOLUME FLOW - CFM x 1000



Pressure in.w.g.	Airflow kcfm
2.400	140.00
4.700	120.00
5.500	110.00
6.100	90.00
6.700	80.00
6.000	60.00
5.400	50.00
4.850	30.00
5.000	20.00
6.800	0.00

COMPUTER MODEL - LATE EMPLACEMENT / LATE DEVELOPMENT PHASE

1. Outline of Repository VA Layout and Node Distances, Page 2 (Source: Section 4.1.1)
2. Calculation Spreadsheet for airway resistances, Pages 3 - 6
3. VNETPC File (Repvaoa3) input and output, Pages 7-14
4. VNETPC File (Repvaoa3) output - Branch Number Plot, Page 15
5. VNETPC File (Repvaoa3) output - Resistance Plot. 16
6. VNETPC File (Repvaoa3) output - Pressure Plot, Page 17
7. VNETPC File (Repvaoa3) output - Air Power Plot, Page 18
8. VNETPC File (Repvaoa3) output - Airflow Plot, Page 19
9. VNETPC File (Repvaoa3) Fan Curves Used, Pages 20-22

Input values on Tables are shaded.

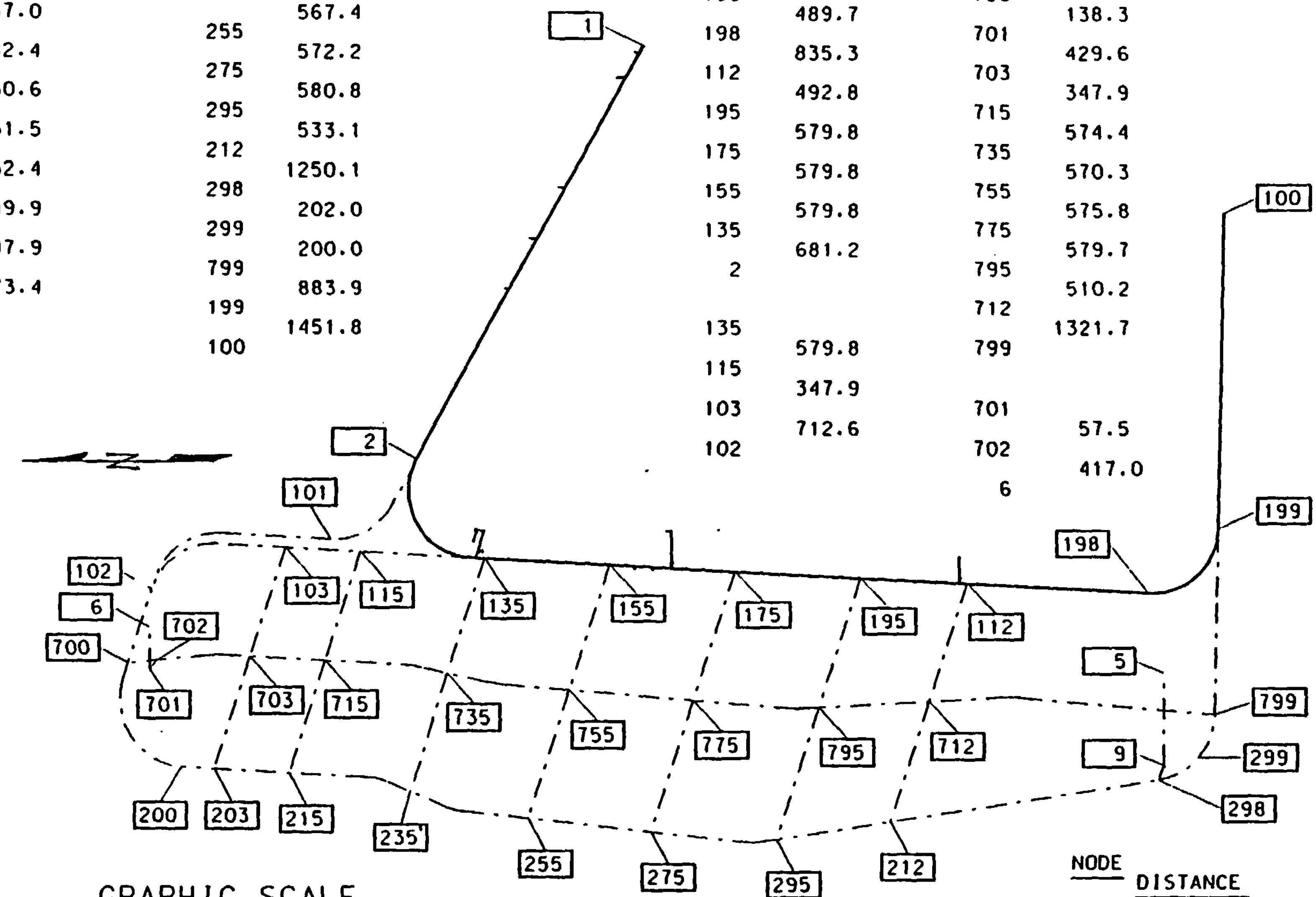
05-AUG-1997 14:42

NODE	DISTANCE
1	
	2187.0
2	
	582.4
101	
	960.6
102	
	361.5
700	
	632.4
200	
	149.9
203	
	347.9
215	
	573.4
235	

NODE	DISTANCE
235	
	567.4
255	
	572.2
275	
	580.8
295	
	533.1
212	
	1250.1
298	
	202.0
299	
	200.0
799	
	883.9
199	
	1451.8
100	

NODE	DISTANCE
199	
	489.7
198	
	835.3
112	
	492.8
195	
	579.8
175	
	579.8
155	
	579.8
135	
	681.2
2	
135	
	579.8
115	
	347.9
103	
	712.6
102	

NODE	DISTANCE
700	
	138.3
701	
	429.6
703	
	347.9
715	
	574.4
735	
	570.3
755	
	575.8
775	
	579.7
795	
	510.2
712	
	1321.7
799	
701	
	57.5
702	
	417.0
6	



NODE	DISTANCE
298	
	69.7
9	
	342.0
5	

GRAPHIC SCALE

1 : 30 000

DISTANCES ARE IN METERS

VENTILATION NODES

CAD FILE: t:*repss*mech*fig*ssme0200.fig

Calculation of airway potential resistances during repository late emplacement/development phase.

Line No.	BRANCH From	BRANCH To	RESISTANCE in PU VNETPC INPUT RPUa+RPUb	REGULATOR RESISTANCE in PU (Field Installed) RPUb	RESISTANCE in PU From R RPUa = R/10	AIRWAY RESISTANCE R = KPL/(5.2A^3) in.min^2/ft^6	FRICTION FACTOR K (x10^-10)	CROSS AREA A (Ft)	PERIMETER P (Ft)	ACTUAL LENGTH meter (m)	ACTUAL LENGTH L' (Ft)	EQUIV. LENGTH L=L'+10% (Ft)	NOTES FOR BRANCH DESCRIPTION	LINE NO.
1	1	2	0.0053		0.0053	0.0533	30	395.1000	72.2600	2187	7175	7893	North Ramp	1
2	2	101	0.0014		0.0014	0.0142	30	395.1000	72.2600	582	1911	2102	North Ramp Ext. (1)	2
3	101	102	0.0023		0.0023	0.0234	30	395.1000	72.2600	961	3152	3467	North Ramp Ext. (2)	3
4	102	103	0.0035		0.0035	0.0348	60	395.1000	72.2600	713	2338	2572	East Main Drift, empl. drift 1 to 5 + drift connection	4
5	103	115	0.0017		0.0017	0.0170	60	395.1000	72.2600	348	1141	1256	East Main Drift, empl drift 6 to 25	5
6	115	135	0.0028		0.0028	0.0283	60	395.1000	72.2600	580	1902	2092	East Main Drift, empl drift 26 to 45	6
7	2	135	0.5017	0.5000	0.0017	0.0166	30	395.1000	72.2600	681	2235	2458	North Ramp curve to East Main	7
8	135	155	0.0028		0.0028	0.0283	60	395.1000	72.2600	580	1902	2092	East Main Drift, empl drift 46 to 65	8
9	155	175	0.0028		0.0028	0.0283	60	395.1000	72.2600	580	1902	2092	East Main Drift, empl drift 66 to 85	9
10	175	195	0.0028		0.0028	0.0283	60	395.1000	72.2600	580	1902	2092	East Main Drift, empl drift 86 to 104	10
11	195	112	0.0024		0.0024	0.0240	60	395.1000	72.2600	493	1617	1778	East Main Drift, empl drift 105 to 120	11
12	112	198	1000.0041	1000.0000	0.0041	0.0408	60	395.1000	72.2600	835	2740	3015	East Main Drift, south end	12
13	198	199	0.0024		0.0024	0.0239	60	395.1000	72.2600	490	1607	1767	East Main Drift curve to South Ramp	13
14	199	100	0.0087		0.0087	0.0865	70	389.1000	72.2600	1452	4763	5239	South Ramp	14
15	102	700	0.0009		0.0009	0.0088	30	395.1000	72.2600	362	1186	1305	North Main - East loop	15
16	700	200	0.0015		0.0015	0.0154	30	395.1000	72.2600	632	2075	2282	North Main - West loop	16
17	200	203	0.0007		0.0007	0.0073	60	395.1000	72.2600	150	492	541	West Main Drift, empl. drift 1 to 5	17
18	203	215	0.0017		0.0017	0.0170	60	395.1000	72.2600	348	1141	1256	West Main Drift, empl drift 6 to 25	18
19	215	235	0.0028		0.0028	0.0280	60	395.1000	72.2600	573	1881	2069	West Main Drift, empl drift 26 to 45	19
20	235	255	0.0028		0.0028	0.0277	60	395.1000	72.2600	567	1862	2048	West Main Drift, empl drift 46 to 65	20
21	275	255	0.0028		0.0028	0.0279	60	395.1000	72.2600	572	1877	2065	West Main Drift, empl drift 66 to 85	21
22	295	275	0.0028		0.0028	0.0283	60	395.1000	72.2600	581	1906	2096	West Main Drift, empl drift 86 to 104	22
23	212	295	0.0026		0.0026	0.0260	60	395.1000	72.2600	533	1749	1924	West Main Drift, empl drift 105 to 120	23
24	298	212	1000.0061	1000.0000	0.0061	0.0610	60	395.1000	72.2600	1250	4101	4512	West Main Drift, empl drift 120 to Dev. Shaft	24
25	298	299	0.0010		0.0010	0.0098	60	395.1000	72.2600	200	656	722	West Main Drift, south end	25
26	299	799	0.0010		0.0010	0.0099	60	395.1000	72.2600	202	663	729	West Main Drift curve to South Ramp Ext/Exh Main	26
27	799	199	0.0043		0.0043	0.0431	60	395.1000	72.2600	884	2900	3190	South Ramp Ext	27
28	103	303	500.0156	500.0000	0.0156	0.1555	85	219.8900	52.5700	533	1749	1924	Emplacement Drifts, empl. drift 1 to 5, Fix 1.06kcfm	28
29	115	315	300.0156	300.0000	0.0156	0.1555	85	219.8900	52.5700	533	1749	1924	Emplacement Drifts, empl drift 6 to 25, Fix 4.24 kcfm	29
30	135	335	200.0164	200.0000	0.0164	0.1639	85	219.8900	52.5700	562	1843	2028	Emplacement Drifts, empl drift 26 to 45, Fix 4.24 kcfm	30
31	155	355	5.0178	5.0000	0.0178	0.1779	85	219.8900	52.5700	610	2001	2201	Emplacement Drifts, empl drift 46 to 65, Fix 4.24 kcfm	31
32	175	375	1.0183	1.0000	0.0183	0.1826	85	219.8900	52.5700	626	2054	2259	Emplacement Drifts, empl drift 66 to 85, Fix 4.24 kcfm	32
33	195	395	1.0183	1.0000	0.0183	0.1835	85	219.8900	52.5700	629	2063	2270	Emplacement Drifts, empl drift 86 to 104, Fix 4.24 kcfm	33
34	112	312	0.0167		0.0167	0.1671	85	219.8900	52.5700	573	1879	2067	Emplacement Drifts, empl drift 105 to 120	34
35	203	303	500.0156	500.0000	0.0156	0.1555	85	219.8900	52.5700	533	1749	1924	Emplacement Drifts, empl. drift 1 to 5, Fix 1.06 kcfm	35
36	215	315	300.0156	300.0000	0.0156	0.1555	85	219.8900	52.5700	533	1749	1924	Emplacement Drifts, empl drift 6 to 25, Fix 4.24 kcfm	36
37	235	335	200.0164	200.0000	0.0164	0.1639	85	219.8900	52.5700	562	1843	2028	Emplacement Drifts, empl drift 26 to 45, Fix 4.24 kcfm	37
38	255	355	5.0178	5.0000	0.0178	0.1779	85	219.8900	52.5700	610	2001	2201	Emplacement Drifts, empl drift 46 to 65, Fix 4.24 kcfm	38
39	275	375	1.0183	1.0000	0.0183	0.1826	85	219.8900	52.5700	626	2054	2259	Emplacement Drifts, empl drift 66 to 85, Fix 4.24 kcfm	39
40	295	395	1.0183	1.0000	0.0183	0.1835	85	219.8900	52.5700	629	2063	2270	Emplacement Drifts, empl drift 86 to 104, Fix 4.24 kcfm	40

FILE # Repva0A3, VNETPC INPUT, Viability Assessment Report, Late Emplacement/Late Development Phase

Calculation of airway potential resistances during repository late emplacement/development phase.

Line No.	BRANCH From	BRANCH To	RESISTANCE in PU VNETPC INPUT RPUa+RPUb	REGULATOR RESISTANCE in PU (Field Installed RPUb	RESISTANCE in PU From R RPUa = R/10	AIRWAY RESISTANCE R = KPL/(5.2A^3) in.min^2/ft^6	FRICTION FACTOR K (x10^-10)	CROSS AREA A (Ft)	PERIMETER P (Ft)	ACTUAL LENGTH meter (m)	ACTUAL LENGTH L' (Ft)	EQUIV. LENGTH L=L'+10% (Ft)	NOTES FOR BRANCH DESCRIPTION	LINE NO.
41	212	312	0.0167		0.0167	0.1671	85	218.8900	52.5700	573	1879	2067	Emplacement Drifts, empl drift 105 to 120	41
42	303	403	0.0167		0.0167	0.1668	20	24.4300	17.5200	10	33	36	Raises, empl. drift 1 to 5	42
43	315	415	0.0167		0.0167	0.1668	20	24.4300	17.5200	10	33	36	Raises, empl drift 6 to 25	43
44	335	435	0.0167		0.0167	0.1668	20	24.4300	17.5200	10	33	36	Raises, empl drift 26 to 45	44
45	355	455	0.0167		0.0167	0.1668	20	24.4300	17.5200	10	33	36	Raises, empl drift 46 to 65	45
46	375	475	0.0167		0.0167	0.1668	20	24.4300	17.5200	10	33	36	Raises, empl drift 66 to 85	46
47	395	495	0.0167		0.0167	0.1668	20	24.4300	17.5200	10	33	36	Raises, empl drift 86 to 104	47
48	312	412	0.0167		0.0167	0.1668	20	24.4300	17.5200	10	33	36	Raises, empl drift 105 to 120	48
49	403	703	99000.005	99000.000	0.0050	0.0500	20	24.4300	17.5200	3	10	11	Raise Door to Exhaust Main, empl. drift 1 to 5	49
50	415	715	99000.005	99000.000	0.0050	0.0500	20	24.4300	17.5200	3	10	11	Raise Door to Exhaust Main, empl drift 6 to 25	50
51	435	735	99000.005	99000.000	0.0050	0.0500	20	24.4300	17.5200	3	10	11	Raise Door to Exhaust Main, empl drift 26 to 45	51
52	455	755	99000.005	99000.000	0.0050	0.0500	20	24.4300	17.5200	3	10	11	Raise Door to Exhaust Main, empl drift 46 to 65	52
53	475	775	99000.005	99000.000	0.0050	0.0500	20	24.4300	17.5200	3	10	11	Raise Door to Exhaust Main, empl drift 66 to 85	53
54	495	795	99000.005	99000.000	0.0050	0.0500	20	24.4300	17.5200	3	10	11	Raise Door to Exhaust Main, empl drift 86 to 104	54
55	412	712	200.0050	200.0000	0.0050	0.0500	20	24.4300	17.5200	3	10	11	Raise Door to Exhaust Main, empl drift 105 to 120	55
56	403	503	100.2141	100.0000	0.2141	2.1412	11	4.2800	7.3300	3	10	11	Gate valve, raise to Duct 1, empl. drift 1 to 5	56
57	403	603	99000.214	99000.000	0.2141	2.1412	11	4.2800	7.3300	3	10	11	Gate valve, raise to Duct 2, empl. drift 1 to 5	57
58	415	515	100.2141	100.0000	0.2141	2.1412	11	4.2800	7.3300	3	10	11	Gate valve raise to Duct 1, empl. drift 6 to 25	58
59	415	615	99000.214	99000.000	0.2141	2.1412	11	4.2800	7.3300	3	10	11	Gate valve raise to Duct 2, empl. drift 6 to 25	59
60	435	535	90.2141	90.0000	0.2141	2.1412	11	4.2800	7.3300	3	10	11	Gate valve raise to Duct 1, empl. drift 26 to 45	60
61	435	635	99000.214	99000.000	0.2141	2.1412	11	4.2800	7.3300	3	10	11	Gate valve raise to Duct 2, empl. drift 26 to 45	61
62	455	555	90.2141	90.0000	0.2141	2.1412	11	4.2800	7.3300	3	10	11	Gate valve raise to Duct 1, empl. drift 46 to 65	62
63	455	655	99000.214	99000.000	0.2141	2.1412	11	4.2800	7.3300	3	10	11	Gate valve raise to Duct 2, empl. drift 46 to 65	63
64	475	575	35.2141	35.0000	0.2141	2.1412	11	4.2800	7.3300	3	10	11	Gate valve raise to Duct 1, empl. drift 66 to 85	64
65	475	675	99000.214	99000.000	0.2141	2.1412	11	4.2800	7.3300	3	10	11	Gate valve raise to Duct 2, empl. drift 66 to 85	65
66	495	595	35.2141	35.0000	0.2141	2.1412	11	4.2800	7.3300	3	10	11	Gate valve raise to Duct 1, empl. drift 86 to 104	66
67	495	695	99000.214	99000.000	0.2141	2.1412	11	4.2800	7.3300	3	10	11	Gate valve raise to Duct 2, empl. drift 86 to 104	67
68	412	512	0.2141		0.2141	2.1412	11	4.2800	7.3300	3	10	11	Gate valve raise to Duct 1, empl. drift 105 to 120	68
69	412	612	0.2141		0.2141	2.1412	11	4.2800	7.3300	3	10	11	Gate valve raise to Duct 2, empl. drift 105 to 120	69
70	512	595	0.3248		0.3248	3.2484	11	28.2700	18.8500	510	1673	1841	Duct 1 from Emplacement Drift 105 to 120	70
71	595	575	0.3694		0.3694	3.6943	11	28.2700	18.8500	580	1903	2093	Duct 1 from Emplacement Drift 86 to 104	71
72	575	555	0.3669		0.3669	3.6688	11	28.2700	18.8500	576	1890	2079	Duct 1 from Emplacement Drift 65 to 85	72
73	555	535	0.3631		0.3631	3.6306	11	28.2700	18.8500	570	1870	2057	Duct 1 from Emplacement Drift 46 to 65	73
74	535	515	0.3659		0.3659	3.6586	11	28.2700	18.8500	574	1885	2073	Duct 1 from Emplacement Drift 26 to 45	74
75	515	503	0.2217		0.2217	2.2166	11	28.2700	18.8500	348	1142	1256	Duct 1 from Emplacement Drift 6 to 25	75
76	503	501	0.2994		0.2994	2.9936	11	28.2700	18.8500	470	1542	1696	Duct 1 from Emplace. Drift 1 to 5 + length to shaft	76
77	501	500	0.0382		0.0382	0.3822	11	28.2700	18.8500	60	197	217	Centrifugal Fan 1	77
78	500	600	0.0003		0.0003	0.0034	60	387.5008	78.7402	60	197	217	Drift connection 6x6 -Duct 1 discharge to Empl Shaft	78
79	612	695	0.3248		0.3248	3.2484	11	28.2700	18.8500	510	1673	1841	Duct 2 from Emplacement Drift 105 to 120	79
80	695	675	0.3694	##############	0.3694	3.6943	11	28.2700	18.8500	580	1903	2093	Duct 2 from Emplacement Drift 86 to 104	80

FILE # Repva0A3, VNETPC INPUT, Viability Assessment Report, Late Emplacement/Late Development Phase

Calculation of airway potential resistances during repository late emplacement/development phase.

Line No.	BRANCH From	BRANCH To	RESISTANCE in PU VNETPC INPUT RPUa+RPUb	REGULATOR RESISTANCE in PU (Field Installed) RPUb	RESISTANCE in PU From R RPUa = R/10	AIRWAY RESISTANCE R = KPL/(5.2A^3) in.min^2/ft^6	FRICTION FACTOR K (x10^-10)	CROSS AREA A (Ft)	PERIMETER P (Ft)	ACTUAL LENGTH meter (m)	ACTUAL LENGTH L' (Ft)	EQUIV. LENGTH L=L'+10% (Ft)	NOTES FOR BRANCH DESCRIPTION	LINE NO.
81	675	655	0.3669		0.3669	3.6688	11	28.2700	18.8500	576	1890	2079	Duct 2 from Emplacement Drift 65 to 85	81
82	655	635	0.3631		0.3631	3.6306	11	28.2700	18.8500	570	1870	2057	Duct 2 from Emplacement Drift 46 to 65	82
83	635	615	0.3659		0.3659	3.6586	11	28.2700	18.8500	574	1885	2073	Duct 2 from Emplacement Drift 26 to 45	83
84	615	603	0.2217		0.2217	2.2166	11	28.2700	18.8500	348	1142	1256	Duct 2 from Emplacement Drift 6 to 25	84
85	603	601	0.2739		0.2739	2.7389	11	28.2700	18.8500	430	1411	1552	Duct 2 from Emplace. Drift 1 to 5 + length to shaft	85
86	601	600	0.0382		0.0382	0.3822	11	28.2700	18.8500	60	197	217	**Centrifugal Fan 2**	86
87	600	702	0.0002		0.0002	0.0017	60	387.5008	78.7402	30	98	108	Drift connection for duct 1 & 2 discharge to Shaft, 6x6	87
88	799	712	1000.0144	1000.0000	0.0144	0.1441	70	318.1400	72.2600	1322	4337	4771	Exhaust Main, South Ramp Ext to Empl Drift	88
89	712	795	0.0056		0.0056	0.0556	70	318.1400	72.2600	510	1673	1841	Exhaust Main from Emplacement Drift 105 to 120	89
90	795	775	0.0063		0.0063	0.0632	70	318.1400	72.2600	580	1903	2093	Exhaust Main from Emplacement Drift 86 to 104	90
91	775	755	0.0063		0.0063	0.0628	70	318.1400	72.2600	576	1890	2079	Exhaust Main from Emplacement Drift 65 to 85	91
92	755	735	0.0062		0.0062	0.0621	70	318.1400	72.2600	570	1870	2057	Exhaust Main from Emplacement Drift 46 to 65	92
93	735	715	0.0063		0.0063	0.0626	70	318.1400	72.2600	574	1885	2073	Exhaust Main from Emplacement Drift 26 to 45	93
94	715	703	0.0038		0.0038	0.0379	70	318.1400	72.2600	348	1142	1256	Exhaust Main from Emplacement Drift 6 to 25	94
95	703	701	0.0047		0.0047	0.0469	70	318.1400	72.2600	430	1411	1552	Exhaust Main from Emplacement Drift 1 to 5	95
96	700	701	1000.0015	1000.0000	0.0015	0.0150	70	318.1400	72.2600	138	453	498	Exhaust Main Airlock to North Main	96
97	701	702	0.0002		0.0002	0.0018	70	527.4316	91.8635	58	190	209	Exhaust Main connection to Emplacement Shaft, 7x7	97
98	702	6	0.0012		0.0012	0.0123	20	309.5700	62.8700	417	1368	1505	**Emplacement Shaft (Collar Elev. 1455m)**	98
99	6	7	0.0002		0.0002	0.0016	11	309.5700	62.8700	100	328	361	**Primary Emplacement Fan**	99
100	7	1002	1000.0000	1000.0000	0.0000	0.0000	0	0	0	0	0	0	Primary Emplacement Fan leakage leg 1	100
101	1002	6	1000.0000	1000.0000	0.0000	0.0000	0	0	0	0	0	0	Primary Emplacement Fan leakage leg 2	101
102	7	8	0.0000		0.0000	0.0000	0	0	0	0	0	0	Surface dummy, Empl Shaft to North Ramp Portal 1	102
103	8	1	0.0000		0.0000	0.0000	0	0	0	0	0	0	Surface dummy, Empl Shaft to North Ramp Portal 2	103
104	1	100	0.0000		0.0000	0.0000	0	0	0	0	0	0	Surface dummy, North Ramp Portal to South Ramp Por.	104
105	100	3	0.0000		0.0000	0.0000	0	0	0	0	0	0	Surface dummy, South Ramp Portal to Dev Shaft leg 1	105
106	3	4	0.0000		0.0000	0.0000	0	0	0	0	0	0	Surface dummy, South Ramp Portal to Dev Shaft leg 2	106
107	4	5	0.0001		0.0001	0.0011	11	309.5700	62.8700	70	230	253	**Primary Development Fan**	107
108	5	1001	1000.0000	1000.0000	0.0000	0.0000	0	0	0	0	0	0	Primary Development Fan leakage leg 1	108
109	1001	4	1000.0000	1000.0000	0.0000	0.0000	0	0	0	0	0	0	Primary Development Fan leakage leg 1	109
110	5	9	0.0048		0.0048	0.0478	95	309.5700	62.8700	342	1122	1234	**Development Shaft (Collar elev. 1452m)**	110
111	9	298	0.0002		0.0002	0.0018	60	527.4316	91.8635	70	230	253	Development Shaft connection to West Main	111
112	115	334	1.0110	1.0000	0.0110	0.1097	60	219.8900	52.5700	533	1749	1924	Vent Drift + PC Bypass Regulator from East Main, 1	112
113	235	334	1.0110	1.0000	0.0110	0.1097	60	219.8900	52.5700	533	1749	1924	Vent Drift + PC Bypass Regulator from West Main, 1	113
114	334	735	0.0167		0.0167	0.1668	20	24.4300	17.5200	10	33	36	Raise for Vent Drift + PC Bypass Regulator, 1	114
115	155	370	1.0128	1.0000	0.0128	0.1279	60	219.8900	52.5700	621	2037	2241	Vent Drift + PC Bypass Regulator from East Main, 2	115
116	275	370	1.0128	1.0000	0.0128	0.1279	60	219.8900	52.5700	621	2037	2241	Vent Drift + PC Bypass Regulator from West Main, 2	116
117	370	775	0.0167		0.0167	0.1668	20	24.4300	17.5200	10	33	36	Raise for Vent Drift + PC Bypass Regulator, 2	117
118	195	304	0.0123		0.0123	0.1233	60	219.8900	52.5700	599	1965	2162	Vent Drift + PC Bypass Regulator from East Main, 3	118
119	212	304	0.0123		0.0123	0.1233	60	219.8900	52.5700	599	1965	2162	Vent Drift + PC Bypass Regulator from West Main, 3	119
120	304	712	0.0167		0.0167	0.1668	20	24.4300	17.5200	10	33	36	Raise for Vent Drift + PC Bypass Regulator, 3	120

FILE # Repva0A3, VNETPC INPUT, Viability Assessment Report, Late Emplacement/Late Development Phase

Calculation of airway potential resistances during repository late emplacement/development phase.

Line No.	BRANCH From	BRANCH To	RESISTANCE in PU VNETPC INPUT RPUa+RPUb	REGULATOR RESISTANCE in PU (Field Installed RPUb	RESISTANCE in PU From R RPUa = R/10	AIRWAY RESISTANCE R = KPL/(5.2A^3) in.min^2/ft^6	FRICTION FACTOR K (x10^-10)	CROSS AREA A (Ft)	PERIMETER P (Ft)	ACTUAL LENGTH meter (m)	ACTUAL LENGTH L' (Ft)	EQUIV. LENGTH L=L'+10% (Ft)	NOTES FOR BRANCH DESCRIPTION	LINE NO.
121	7	303	@ 1.06 kcfm		Inject expanded air								Inject simulated air expansion @ 1.06 kcfm	121
122	7	315	@ 4.24 kcfm		Inject expanded air								Inject simulated air expansion @ 4.24 kcfm	122
123	7	335	@ 4.24 kcfm		Inject expanded air								Inject simulated air expansion @ 4.24 kcfm	123
124	7	355	@ 4.24 kcfm		Inject expanded air								Inject simulated air expansion @ 4.24 kcfm	124
125	7	375	@ 4.24 kcfm		Inject expanded air								Inject simulated air expansion @ 4.24 kcfm	125
126	7	395	@ 4.24 kcfm		Inject expanded air								Inject simulated air expansion @ 4.24 kcfm	126
127	7	312	@ 10 kcfm		Inject expanded air								Inject simulated air expansion @ 10 kcfm	127

Calculation of cross areas and perimeters

Ref. Line		K factor assumptions x 10^(-10) lb	min^2/ft^4	Calculated Gross Cross Area, ft^2	Less Area of Perm. Items Ft^2	Net Are Used Ft^2	Perimeter Used Ft
1							
2							
3							
4							
5	North Ramp / North Main, 7.62m dia	30	DCSS 022	490.88	a, c, u	395.10	72.26
6	East / West Main drifts, 7.62 m dia	60	DCSS 022	490.88	a, c, u	395.10	72.26
7	Emplacement drifts, 5.1 m dia	70	DCSS 022	219.89		219.89	52.57
8	Empl drifts (Loaded), 5.1 m dia	85	DCSS 022	219.89		219.89	52.57
9	Smooth exhaust ducts, 72"ID, 84"OD	11	DCSS 022	28.27		28.27	18.85
10	Exhaust main (raise bottom & duct blockage)	70	DCSS 022	490.88	a, c, 2d,u	318.14	72.26
11	Raises, 1.7 m dia	20		24.43		24.43	17.52
12	Emplacement Shaft, 6.1 m dia	20		314.57	g	309.57	62.87
13	Development Shaft, 6.1 m dia	95	DCSS 022	314.57	g, u	307.57	62.87
14	Regulator valves 28" dia housing	11		4.28		4.28	7.33
15	South Ramp Service Main	70	DCSS 022	490.88	a, b, c, u	389.10	72.26

16
17 Less estimated permanent obstruction in airways:
18 a - main invert (34.34); b - conveyor (6); c - concrete lining above invert (59.44); d - duct 84"OD (38.48); g - guides in shaft (5); s - steel set (42.19); u - utilities & rails (2).
19

20	when "u" has	Water Supply	0.35
21		Water Return	0.35
22		Compressed Air	0.20
23		Power & Hangers	0.60
24		Rail	0.50
25			
26		Net Cross Area	2.00 Ft^2

27
28 Note: Liner in ramps and mains are assumed 12 inches thick for concrete or 8 inches thick for steel.
29
30

VNETPC (Version 3.1)
17:57:09
05-25-1997

Output File Name: OUTPUT.TMP
Network File Name: REPVA0A3
Network Title: REPOSITORY VENTILATION
Mine Name: YUCCA MOUNTAIN PROJECT
Company: M&O/MK/RSJURANI
Comments: LATE EMPLACEMENT/CARE/EXPANDED VOL

**** DATA SUPPLIED BY USER ****

Fan Data:

	Fan Ref No.	From	To	Operating Pressure in.w.g.	No. Characteristic Pts.
1	18	4	5	2.000	10
2	12	6	7	12.000	10
3	35	501	500	35.000	10
4	35	601	600	35.000	10

Fan Characteristic Points:

Fan 1

Pressure in.w.g.	Airflow kcfm
17.400	10.00
16.400	40.00
15.200	70.00
14.000	110.00
12.200	180.00
11.200	220.00
10.000	260.00
7.600	300.00
5.200	330.00
2.000	355.00

Fan 2

Pressure in.w.g.	Airflow kcfm
28.000	60.00
24.000	140.00
20.000	240.00
18.600	310.00
20.000	370.00
20.600	420.00
18.800	500.00
14.800	600.00
8.200	700.00
4.000	740.00

Fan 3

Pressure in.w.g.	Airflow kcfm

44.840	0.00
49.070	26.73
51.610	53.45
50.760	80.18
47.380	106.90
44.840	120.27
42.300	133.63
36.380	160.35
25.380	187.00
13.540	213.80

Fan 4	Pressure in.w.g.	Airflow kcfm
	44.840	0.00
	49.070	26.73
	51.610	53.45
	50.760	80.18
	47.380	106.90
	44.840	120.27
	42.300	133.63
	36.380	160.35
	25.380	187.00
	13.540	213.80

Branch Data:

Branch	From	To	Resistance P.U.	Airflow kcfm	Pressure Dp m.in.wg.	Frict. Factor lbfmin^2/ft^4 X10^10	Len ft	Equiv Len ft	Area ft^2
1	1	2	0.00530						
2	2	101	0.00140						
3	101	102	0.00230						
4	102	103	0.00350						
5	103	115	0.00170						
6	115	135	0.00280						
7	2	135	0.50170						
8	135	155	0.00280						
9	155	175	0.00280						
10	175	195	0.00280						
11	195	112	0.00240						
12	112	198	1000.00403						
13	198	199	0.00240						
14	199	100	0.00870						
15	102	700	0.00090						
16	700	200	0.00150						
17	200	203	0.00070						
18	203	215	0.00170						
19	215	235	0.00280						
20	235	255	0.00280						
21	275	255	0.00280						
22	295	275	0.00280						
23	212	295	0.00260						
24	298	212	1000.00598						
25	298	299	0.00100						
26	299	799	0.00100						
27	799	199	0.00430						

28	103	303	500.01559	1.06 - Fixed
29	115	315	300.01559	4.24 - Fixed
30	135	335	200.01640	4.24 - Fixed
31	155	355	5.01780	4.24 - Fixed
32	175	375	1.01830	4.24 - Fixed
33	195	395	1.01830	4.24 - Fixed
34	112	312	0.01670	
35	203	303	500.01559	1.06 - Fixed
36	215	315	300.01559	4.24 - Fixed
37	235	335	200.01640	4.24 - Fixed
38	255	355	5.01780	4.24 - Fixed
39	275	375	1.01830	4.24 - Fixed
40	295	395	1.01830	4.24 - Fixed
41	212	312	0.01670	
42	303	403	0.01670	
43	315	415	0.01670	
44	335	435	0.01670	
45	355	455	0.01670	
46	375	475	0.01670	
47	395	495	0.01670	
48	312	412	0.01670	
49	403	703	99000.00000	
50	415	715	99000.00000	
51	435	735	99000.00000	
52	455	755	99000.00000	
53	475	775	99000.00000	
54	495	795	99000.00000	
55	412	712	200.00500	
56	403	503	100.21410	
57	403	603	99000.00000	
58	415	515	100.21410	
59	415	615	99000.00000	
60	435	535	90.21410	
61	435	635	99000.00000	
62	455	555	90.21410	
63	455	655	99000.00000	
64	475	575	35.21410	
65	475	675	99000.00000	
66	495	595	35.21410	
67	495	695	99000.00000	
68	412	512	0.21410	
69	412	612	0.21410	
70	512	595	0.32480	
71	595	575	0.36940	
72	575	555	0.36690	
73	555	535	0.36310	
74	535	515	0.36590	
75	515	503	0.22170	
76	503	501	0.29940	
77	501	500	0.03820	
78	500	600	0.00030	
79	612	695	0.32480	
80	695	675	0.36940	
81	675	655	0.36690	
82	655	635	0.36310	
83	635	615	0.36590	
84	615	603	0.22170	
85	603	601	0.27390	
86	601	600	0.03820	
87	600	702	0.00020	

88	799	712	1000.01398	
89	712	795	0.00560	
90	795	775	0.00630	
91	775	755	0.00630	
92	755	735	0.00620	
93	735	715	0.00630	
94	715	703	0.00380	
95	703	701	0.00470	
96	700	701	1000.00201	
97	701	702	0.00020	
98	702	6	0.00120	
99	6	7	0.00020	
100	7	1002	1000.00000	
101	1002	6	1000.00000	
102	7	8	0.00001	
103	8	1	0.00001	
104	1	100	0.00001	
105	100	3	0.00001	
106	3	4	0.00001	
107	4	5	0.00010	
108	5	1001	1000.00000	
109	1001	4	1000.00000	
110	5	9	0.00480	
111	9	298	0.00020	
112	115	334	1.01100	
113	235	334	1.01100	
114	334	735	0.01670	
115	155	370	1.01280	
116	275	370	1.01280	
117	370	775	0.01670	
118	195	304	0.01230	
119	212	304	0.01230	
120	304	712	0.01670	
121	7	303		1.06 - Inject/Reject
122	7	315		4.24 - Inject/Reject
123	7	335		4.24 - Inject/Reject
124	7	355		4.24 - Inject/Reject
125	7	375		4.24 - Inject/Reject
126	7	395		4.24 - Inject/Reject
127	7	312		10.00 - Inject/Reject

**** OUTPUT DATA ****

Annual costs are based on electricity charges of 10.0 cents per kWh and fan efficiencies of 75.0%
Cost given for an NVP represents money saved by natural ventilation

Network File Name - REPVA0A3
Output File Name - OUTPUT.TMP

*** Fan Operating Points ***

Fan No.	Ref	From	To	Pressure in.w.g.	Quantity kcfm	Air Power hp	Op.Cost $/year
1	18	4	5	2.759	376.16	163.54	142434
2	12	6	7	9.609	678.63	1027.55	894950

3	35	501	500	37.067	157.25	918.46	799934
4	35	601	600	41.967	135.13	893.62	778300

Network File Name - REPVA0A3
Output File Name - OUTPUT.TMP

*** Branch Data ***

Branch	From	To	Press.Dp m.in.wg.	Airflow kcfm	Resist. P.U.	AP Loss hp	Op.Cost $/year	
1	1	2	2147	636.60	0.00530	215.4	187578	
2	2	101	466	577.04	0.00140	42.4	36904	
3	101	102	765	577.04	0.00230	69.6	60584	
4	102	103	275	280.64	0.00350	12.2	10592	
5	103	115	132	279.58	0.00170	5.8	5065	
6	115	135	138	222.69	0.00280	4.8	4218	
7	2	135	1779	59.55	0.50170	16.7	14540	
8	135	155	216	278.01	0.00280	9.5	8241	
9	155	175	154	234.64	0.00280	5.7	4959	
10	175	195	148	230.40	0.00280	5.4	4680	
11	195	112	29	110.42	0.00240	0.5	439	
12	112	198	-5650	-2.38	1000.00403	2.1	1843	
13	198	199	0	-2.38	0.00240	0.0	0	
14	199	100	1174	367.40	0.00870	68.0	59196	
15	102	700	79	296.40	0.00090	3.7	3214	
16	700	200	129	294.06	0.00150	6.0	5206	
17	200	203	60	294.06	0.00070	2.8	2421	
18	203	215	145	293.00	0.00170	6.7	5831	
19	215	235	233	288.76	0.00280	10.6	9234	
20	235	255	153	234.17	0.00280	5.6	4917	
21	275	255	-148	-229.93	0.00280	5.4	4670	
22	295	275	-100	-188.99	0.00280	3.0	2594	
23	212	295	-88	-184.75	0.00260	2.6	2231	
24	298	212	6558	2.56	1000.00598	2.6	2305	
25	298	299	138	372.43	0.00100	8.1	7054	
26	299	799	138	372.43	0.00100	8.1	7054	
27	799	199	587	369.77	0.00430	34.2	29789	
28*	103	303	32829	1.06	29218.41016	5.5	4776	-Regulator Required
29*	115	315	12899	4.24	717.52789	8.6	7506	-Regulator Required
30*	135	335	7205	4.24	400.77661	4.8	4193	-Regulator Required
31*	155	355	1568	4.24	87.24360	1.0	912	-Regulator Required
32*	175	375	4253	4.24	236.59450	2.8	2475	-Regulator Required
33*	195	395	285	4.24	15.89272	0.2	166	-Regulator Required
34	112	312	212	112.80	0.01670	3.8	3282	
35*	203	303	32836	1.06	29224.07031	5.5	4777	-Regulator Required
36*	215	315	12892	4.24	717.15527	8.6	7502	-Regulator Required

37*	235	335	7103	4.24	395.14099	4.7	4133	-Regulator Required
38*	255	355	1529	4.24	85.10468	1.0	890	-Regulator Required
39*	275	375	4221	4.24	234.79601	2.8	2456	-Regulator Required
40*	295	395	302	4.24	16.79881	0.2	176	-Regulator Required
41	212	312	169	100.68	0.01670	2.7	2335	
42	303	403	0	3.18	0.01670	0.0	0	
43	315	415	2	12.72	0.01670	0.0	3	
44	335	435	2	12.72	0.01670	0.0	3	
45	355	455	2	12.72	0.01670	0.0	3	
46	375	475	2	12.72	0.01670	0.0	3	
47	395	495	2	12.72	0.01670	0.0	3	
48	312	412	834	223.48	0.01670	29.4	25580	
49	403	703	-28239	-0.53	99000.00000	2.4	2070	
50	415	715	-9000	-0.30	99000.00781	0.4	372	
51	435	735	-4366	-0.21	99000.00000	0.1	126	
52	455	755	568	0.08	99000.00000	0.0	6	
53	475	775	-2763	-0.17	99000.00000	0.1	63	
54	495	795	793	0.09	99000.00000	0.0	10	
55	412	712	-227	-1.07	200.00500	0.0	33	
56	403	503	1170	3.42	100.21410	0.6	549	
57	403	603	8726	0.30	99000.00000	0.4	356	
58	415	515	15718	12.52	100.21410	31.0	27017	
59	415	615	24490	0.50	99000.00000	1.9	1672	
60	435	535	13968	12.44	90.21410	27.4	23854	
61	435	635	23443	0.49	99000.00000	1.8	1566	
62	455	555	13359	12.17	90.21410	25.6	22311	
63	455	655	22357	0.48	99000.00000	1.7	1458	
64	475	575	5524	12.52	35.21410	10.9	9495	
65	475	675	12992	0.36	99000.00000	0.7	646	
66	495	595	5334	12.31	35.21410	10.3	9010	
67	495	695	10275	0.32	99000.00000	0.5	454	
68	412	512	1806	91.86	0.21410	26.1	22768	
69	412	612	3769	132.69	0.21410	78.8	68636	
70	512	595	2740	91.86	0.32480	39.7	34543	
71	595	575	4008	104.17	0.36940	65.8	57299	
72	575	555	4996	116.69	0.36690	91.9	80011	
73	555	535	6029	128.86	0.36310	122.4	106624	
74	535	515	7305	141.31	0.36590	162.7	141665	
75	515	503	5246	153.83	0.22170	127.2	110752	
76	503	501	7403	157.25	0.29940	183.4	159762	
77	501	500	944	157.25	0.03820	23.4	20372	
78	500	600	7	157.25	0.00030	0.2	151	
79	612	695	5718	132.69	0.32480	119.6	104128	
80	695	675	6535	133.01	0.36940	137.0	119295	
81	675	655	6526	133.37	0.36690	137.2	119455	
82	655	635	6505	133.85	0.36310	137.2	119495	
83	635	615	6603	134.34	0.36590	139.8	121736	
84	615	603	4030	134.83	0.22170	85.6	74574	
85	603	601	5001	135.13	0.27390	106.5	92746	
86	601	600	697	135.13	0.03820	14.8	12926	

87	600	702	17	292.38	0.00020	0.8	682	
88	799	712	7057	2.66	1000.01398	3.0	2573	
89	712	795	232	203.95	0.00560	7.5	6494	
90	795	775	262	204.04	0.00630	8.4	7337	
91	775	755	492	279.70	0.00630	21.7	18886	
92	755	735	485	279.78	0.00620	21.4	18623	
93	735	715	922	382.57	0.00630	55.6	48409	
94	715	703	555	382.27	0.00380	33.4	29117	
95	703	701	684	381.74	0.00470	41.1	35835	
96	700	701	5471	2.34	1000.00201	2.0	1756	
97	701	702	29	384.07	0.00020	1.8	1529	
98	702	6	549	676.45	0.00120	58.5	50968	
99	6	7	92	678.63	0.00020	9.8	8569	
100	7	1002	4758	2.18	1000.00000	1.6	1425	
101	1002	6	4758	2.18	1000.00000	1.6	1425	
102	7	8	4	644.19	0.00001	0.4	354	
103	8	1	4	644.19	0.00001	0.4	354	
104	1	100	0	7.59	0.00001	0.0	0	
105	100	3	1	374.99	0.00001	0.1	51	
106	3	4	1	374.99	0.00001	0.1	51	
107	4	5	14	376.16	0.00010	0.8	723	
108	5	1001	1372	1.17	1000.00000	0.3	221	
109	1001	4	1372	1.17	1000.00000	0.3	221	
110	5	9	674	374.99	0.00480	39.8	34687	
111	9	298	28	374.99	0.00020	1.7	1441	
112	115	334	2802	52.65	1.01100	23.2	20248	
113	235	334	2562	50.35	1.01100	20.3	17703	
114	334	735	177	103.00	0.01670	2.9	2502	
115	155	370	1550	39.13	1.01280	9.6	8324	
116	275	370	1364	36.70	1.01280	7.9	6870	
117	370	775	96	75.83	0.01670	1.1	999	
118	195	304	164	115.73	0.01230	3.0	2605	
119	212	304	92	86.63	0.01230	1.3	1094	
120	304	712	683	202.36	0.01670	21.8	18969	
121+	7	303	36493	1.06	32479.21094	6.1	5309	-Inject/Reject Air
122+	7	315	16696	4.24	928.71973	11.2	9715	-Inject/Reject Air
123+	7	335	11140	4.24	619.69208	7.4	6482	-Inject/Reject Air
124+	7	355	5720	4.24	318.19659	3.8	3329	-Inject/Reject Air
125+	7	375	8559	4.24	476.12210	5.7	4981	-Inject/Reject Air
126+	7	395	4740	4.24	263.68799	3.2	2758	-Inject/Reject Air
127+	7	312	4696	10.00	46.96512	7.4	6445	-Inject/Reject Air

Number of Iterations = 3

Network File Name - REPVA0A3
Output File Name - OUTPUT.TMP

*** Regulator List ***

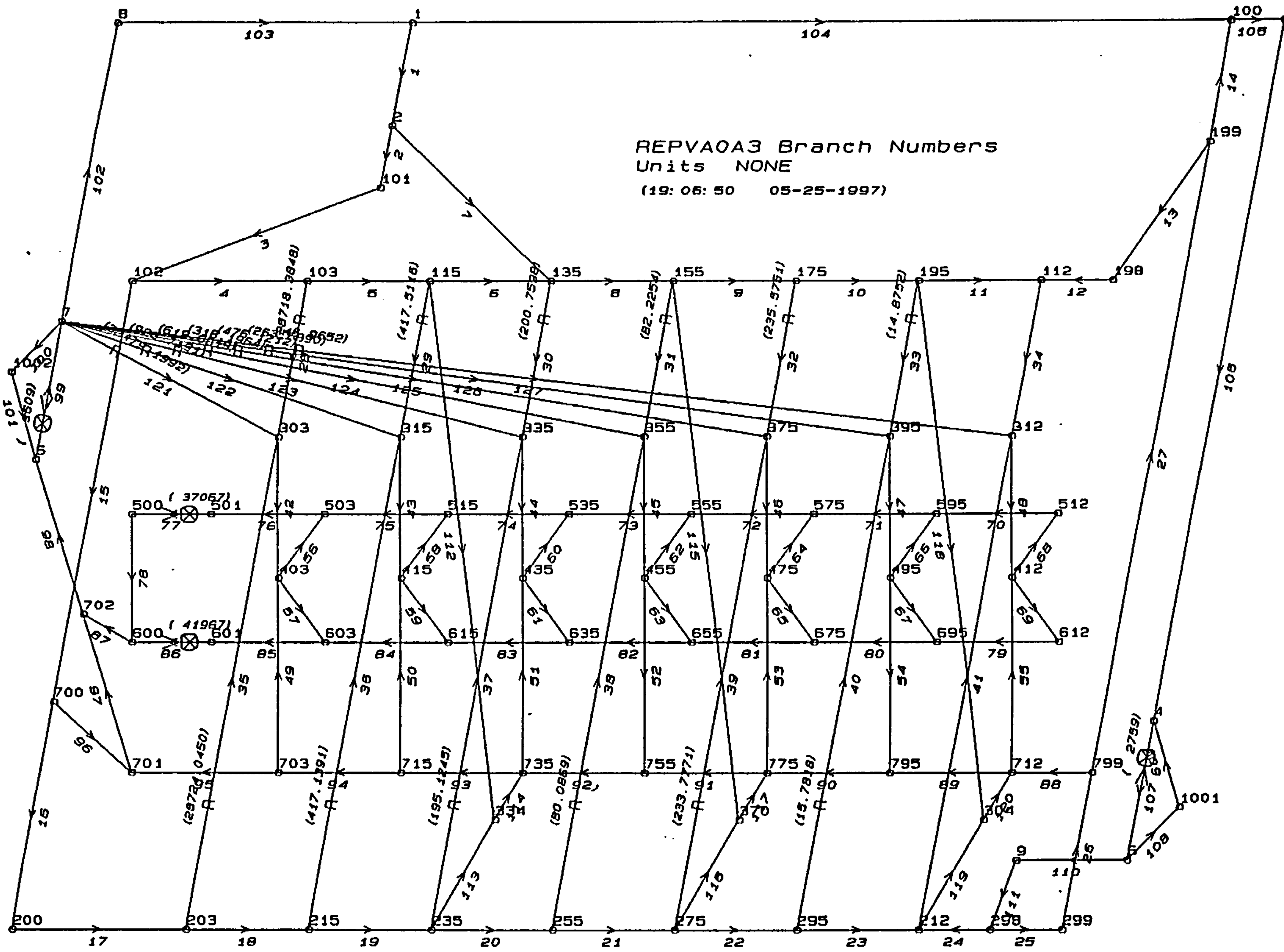
Branch	From	To	Fixed Quantity (kcfm)	Regulator Resistance (P.U.)
28	103	303	1.1	28718.39453
29	115	315	4.2	417.51230
30	135	335	4.2	200.76021
31	155	355	4.2	82.22580
32	175	375	4.2	235.57620
33	195	395	4.2	14.87440
35	203	303	1.1	28724.05469
36	215	315	4.2	417.13968
37	235	335	4.2	195.12459
38	255	355	4.2	80.08690
39	275	375	4.2	233.77771
40	295	395	4.2	15.78050

The following table gives the frictional pressure relative to 0 m.in.wg. at junction No. 1
The table may be used to find neutral points and the pressure difference available to produce flow between any two junctions in the network.
** The value 99999 indicates an inaccessible junction **

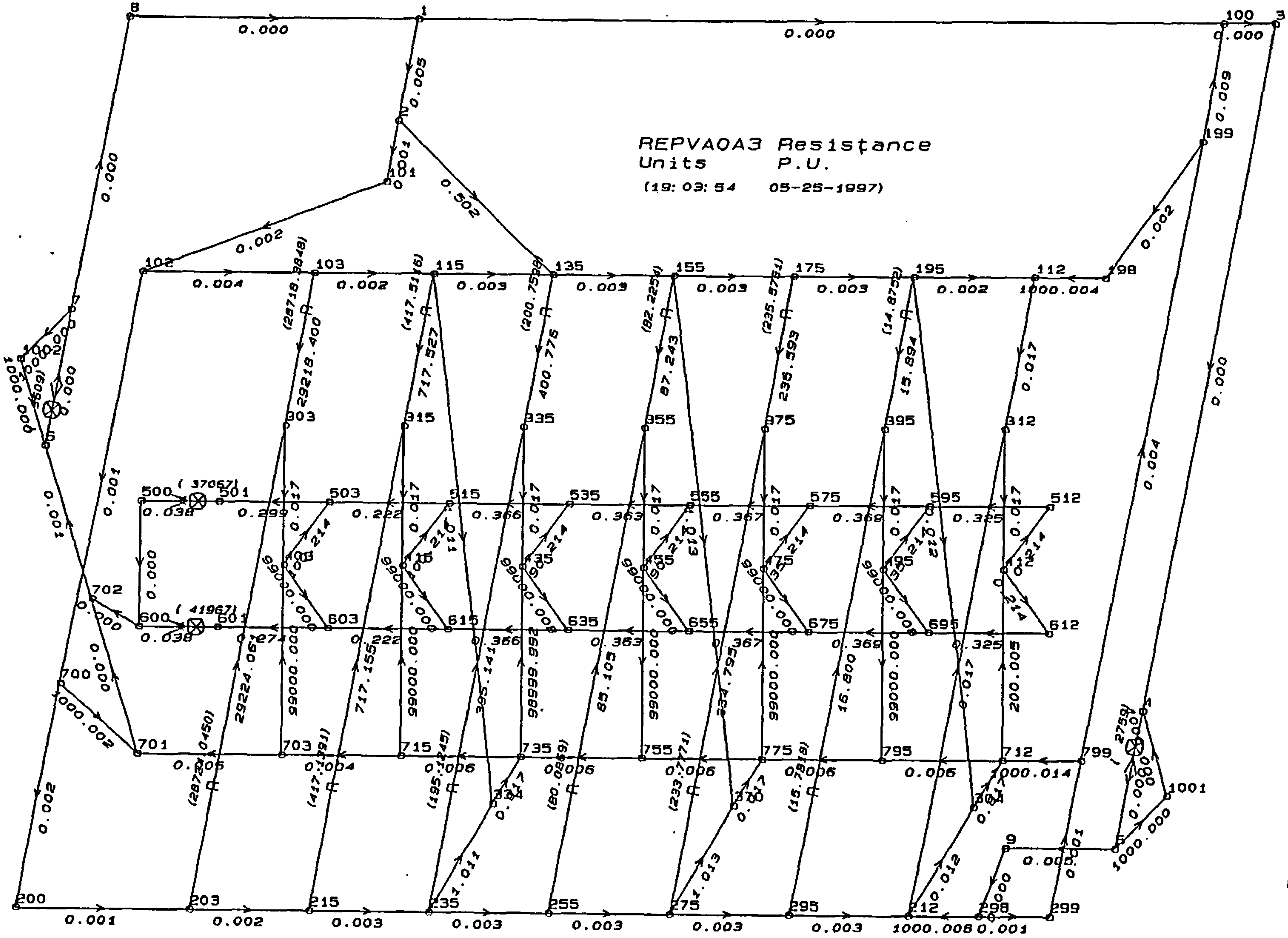
Junction	Pressure	Junction	Pressure	Junction	Pressure	Junction	Pressure
1	0	2	-2147	3	5	4	4
5	2749	6	-9505	7	12	8	8
9	2075	100	6	101	-2613	102	-3378
103	-3653	112	-4470	115	-3785	135	-3923
155	-4139	175	-4293	195	-4441	198	1180
199	1180	200	-3586	203	-3646	212	-4513
215	-3791	235	-4024	255	-4177	275	-4325
295	-4425	298	2045	299	1907	303	-36482
304	-4605	312	-4682	315	-16684	334	-6587
335	-11128	355	-5707	370	-5689	375	-8546
395	-4726	403	-36482	412	-5516	415	-16686
435	-11130	455	-5709	475	-8548	495	-4728
500	-8932	501	-45055	503	-37652	512	-7322
515	-32404	535	-25098	555	-19068	575	-14072
595	-10062	600	-8939	601	-50209	603	-45208
612	-9285	615	-41176	635	-34573	655	-28066
675	-21540	695	-15003	700	-3457	701	-8927
702	-8956	703	-8243	712	-5289	715	-7686
735	-6764	755	-6277	775	-5785	795	-5521
799	1769	1001	1377	1002	-4746		

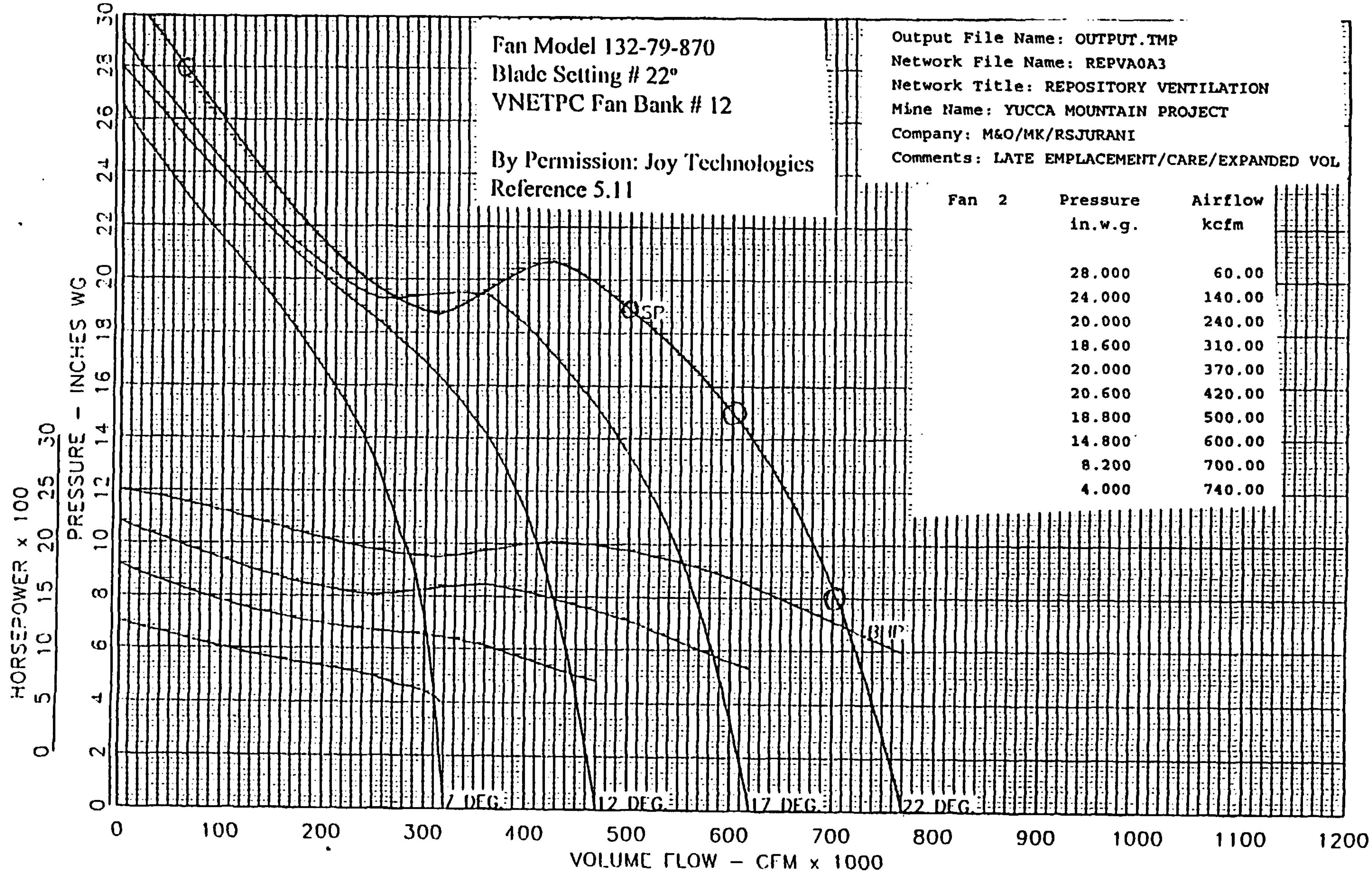
**** NETWORK EXERCISE COMPLETE ****

Some information may be obliterated but may be deduced from Attachment II, pages 7 thru 14.

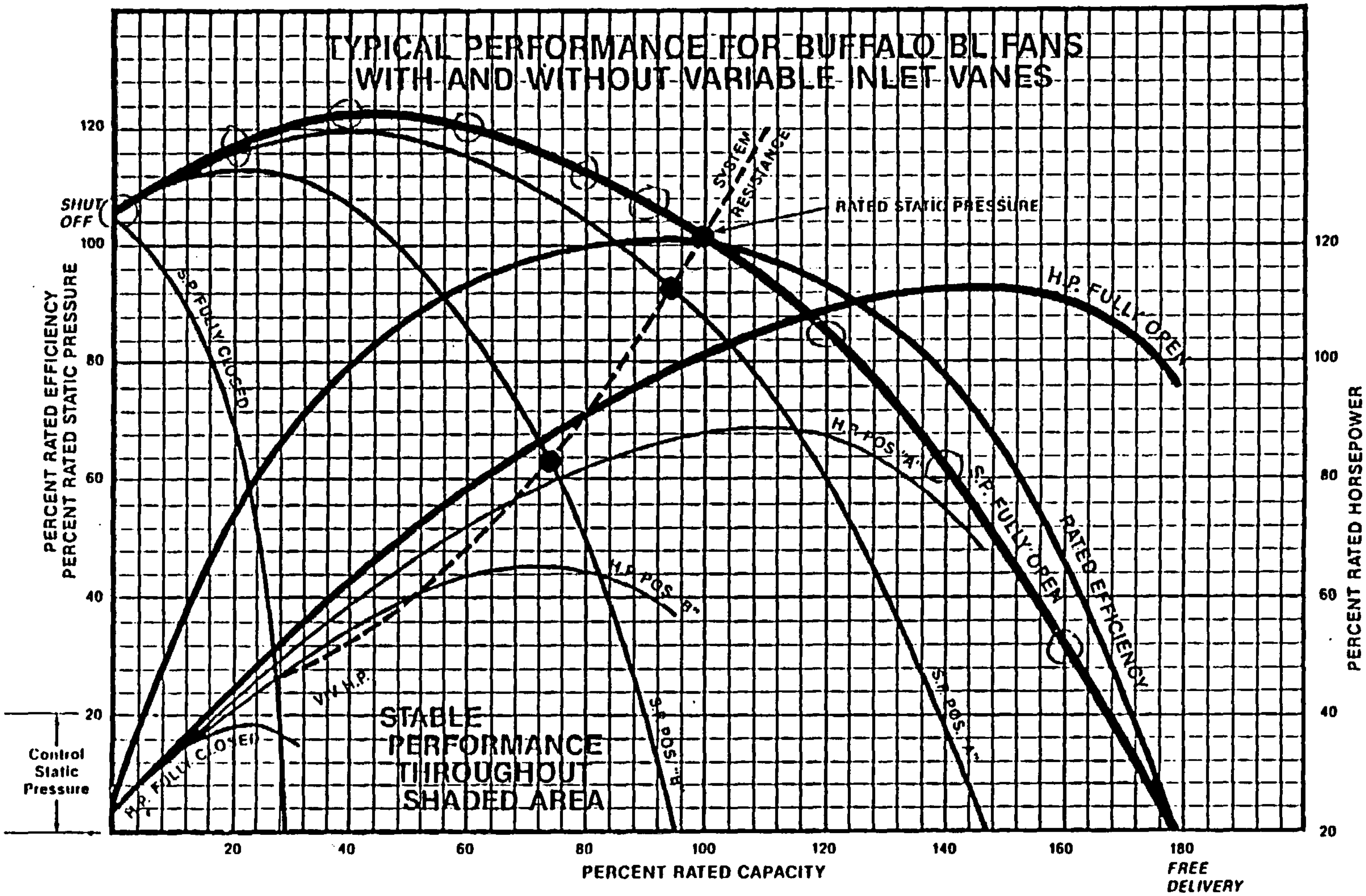


Some information may be obliterated but may be deduced from Attachment II, pages 7 thru 14.





Fan 2	Pressure in.w.g.	Airflow kcfm
	28.000	60.00
	24.000	140.00
	20.000	240.00
	18.600	310.00
	20.000	370.00
	20.600	420.00
	18.800	500.00
	14.800	600.00
	8.200	700.00
	4.000	740.00



				Fan 35	
Base 100%	42.3027	133.628		Pressure	Volume
	%Pressure	% Volume	%Efficienc	Inch WG	kcfm
1	106	0	0	44.84	0.00
2	116	20	54	49.07	26.73
3	122	40	79	51.61	53.45
4	120	60	93	50.76	80.18
5	112	80	100	47.38	106.90
6	106	90	101	44.84	120.27
7	100	100	100	42.30	133.63
8	86	120	93	36.38	160.35
9	60	140	77	25.38	187.08
10	32	160	46	13.54	213.80

Output File Name: OUTPUT.TMP
Network File Name: REPVA0A3
Network Title: REPOSITORY VENTILATION
Mine Name: YUCCA MOUNTAIN PROJECT
Company: M&O/MK/RSJURANI
Comments: LATE EMPLACEMENT/CARE/EXPANDED VOL

Fan Model Buffalo Typical BL Unit
Variable Speed Centrifugal Fan
VNETPC Fan Bank # 35
By Permission: Buffalo Howden
Reference 5.31

COMPUTER MODEL - CARETAKER PHASE

1. Outline of Repository VA Layout and Node Distances, Page 2 (Source: Section 4.1.1)
2. Calculation Spreadsheet for airway resistances, Pages 3 - 6
3. VNETPC File (Repvaoa4) input and output, Pages 7-14
4. VNETPC File (Repvaoa4) output - Branch Number Plot, Page 15
5. VNETPC File (Repvaoa4) output - Resistance Plot, 16
6. VNETPC File (Repvaoa4) output - Pressure Plot, Page 17
7. VNETPC File (Repvaoa4) output - Air Power Plot, Page 18
8. VNETPC File (Repvaoa4) output - Airflow Plot, Page 19
9. VNETPC File (Repvaoa4) Fan Curves Used, Pages 20-21

Input values on Tables are shaded.

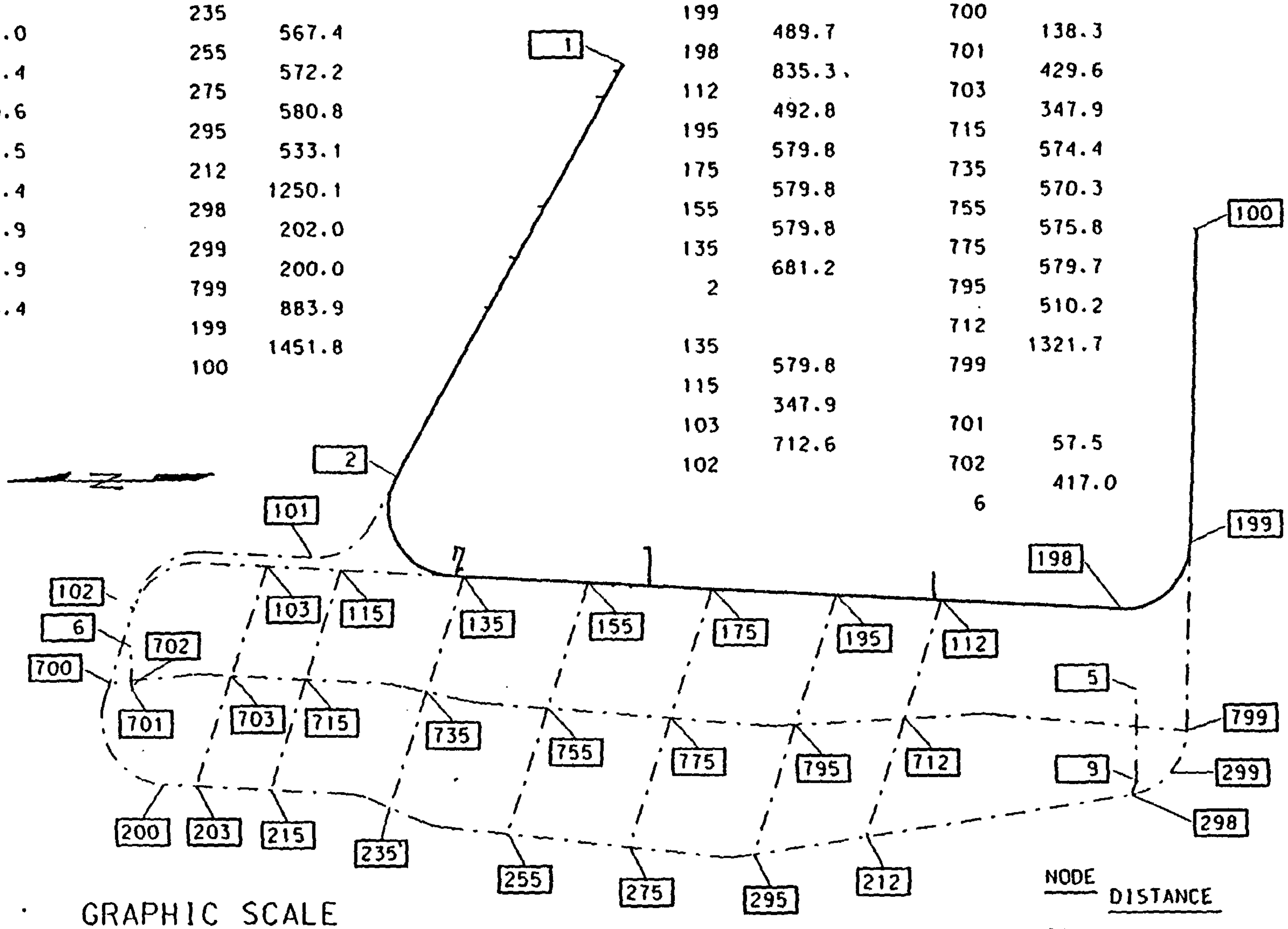
06-AUG-1997 14:42

NODE	DISTANCE
1	
	2187.0
2	
	582.4
101	
	960.6
102	
	361.5
700	
	632.4
200	
	149.9
203	
	347.9
215	
	573.4
235	

NODE	DISTANCE
235	
	567.4
255	
	572.2
275	
	580.8
295	
	533.1
212	
	1250.1
298	
	202.0
299	
	200.0
799	
	883.9
199	
	1451.8
100	

NODE	DISTANCE
199	
	489.7
198	
	835.3
112	
	492.8
195	
	579.8
175	
	579.8
155	
	579.8
135	
	681.2
2	
135	
	579.8
115	
	347.9
103	
	712.6
102	

NODE	DISTANCE
700	
	138.3
701	
	429.6
703	
	347.9
715	
	574.4
735	
	570.3
755	
	575.8
775	
	579.7
795	
	510.2
712	
	1321.7
799	
701	
	57.5
702	
	417.0
6	



NODE	DISTANCE
298	
	69.7
9	
	342.0
5	

VENTILATION NODES

GRAPHIC SCALE

0 400 800 1600 2400 m

1 : 30 000

DISTANCES ARE IN METERS

CAD FILE: t:#repss#mech#fig#ssme0200.fig

FILE # Repva0A4, VNETPC INPUT, Viability Assessment Report - Caretaker

Calculation of airway potential resistances during repository caretaker operation and backfill.

Line No.	BRANCH From	BRANCH To	RESISTANCE in PU VNETPC INPUT RPUa+RPUb	REGULATOR RESISTANCE in PU (Field Installed) RPUb	RESISTANCE in PU From R RPUa = R/10	AIRWAY RESISTANCE R = KPL/(5.2A^3) in min^2/ft^6	FRICTION FACTOR K (x10^-10)	CROSS AREA A (Ft)	PERIMETER P (Ft)	ACTUAL LENGTH meter (m)	ACTUAL LENGTH L' (Ft)	EQUIV. LENGTH L=L'+10% (Ft)	NOTES FOR BRANCH DESCRIPTION	LINE NO.
1	1	2	0.0053		0.0053	0.0533	30	395.1000	72.2600	2187	7175	7893	North Ramp	1
2	2	101	0.0014		0.0014	0.0142	30	395.1000	72.2600	582	1911	2102	North Ramp Ext. (1)	2
3	101	102	0.0023		0.0023	0.0234	30	395.1000	72.2600	961	3152	3467	North Ramp Ext. (2)	3
4	102	103	0.0035		0.0035	0.0348	60	395.1000	72.2600	713	2338	2572	East Main Drift, empl. drift 1 to 5 + drift connection	4
5	103	115	0.0017		0.0017	0.0170	60	395.1000	72.2600	348	1141	1256	East Main Drift, empl drift 6 to 25	5
6	115	135	0.0028		0.0028	0.0283	60	395.1000	72.2600	580	1902	2092	East Main Drift, empl drift 26 to 45	6
7	2	135	0.5017	0.5000	0.0017	0.0166	30	395.1000	72.2600	681	2235	2458	North Ramp curve to East Main	7
8	135	155	0.0028		0.0028	0.0283	60	395.1000	72.2600	580	1902	2092	East Main Drift, empl drift 46 to 65	8
9	155	175	0.0028		0.0028	0.0283	60	395.1000	72.2600	580	1902	2092	East Main Drift, empl drift 66 to 85	9
10	175	195	0.0028		0.0028	0.0283	60	395.1000	72.2600	580	1902	2092	East Main Drift, empl drift 86 to 104	10
11	195	112	0.0024		0.0024	0.0240	60	395.1000	72.2600	493	1617	1778	East Main Drift, empl drift 105 to 120	11
12	112	198	1000.0041	1000.0000	0.0041	0.0408	60	395.1000	72.2600	835	2740	3015	East Main Drift, south end	12
13	198	199	0.0024		0.0024	0.0239	60	395.1000	72.2600	490	1607	1767	East Main Drift curve to South Ramp	13
14	199	100	0.0087		0.0087	0.0865	70	389.1000	72.2600	1452	4763	5239	South Ramp	14
15	102	700	0.0009		0.0009	0.0088	30	395.1000	72.2600	362	1186	1305	North Main - East loop	15
16	700	200	0.0015		0.0015	0.0154	30	395.1000	72.2600	632	2075	2282	North Main - West loop	16
17	200	203	0.0007		0.0007	0.0073	60	395.1000	72.2600	150	492	541	West Main Drift, empl. drift 1 to 5	17
18	203	215	0.0017		0.0017	0.0170	60	395.1000	72.2600	348	1141	1256	West Main Drift, empl drift 6 to 25	18
19	215	235	0.0028		0.0028	0.0280	60	395.1000	72.2600	573	1881	2069	West Main Drift, empl drift 26 to 45	19
20	235	255	0.0028		0.0028	0.0277	60	395.1000	72.2600	567	1862	2048	West Main Drift, empl drift 46 to 65	20
21	275	255	0.0028		0.0028	0.0279	60	395.1000	72.2600	572	1877	2065	West Main Drift, empl drift 66 to 85	21
22	295	275	0.0028		0.0028	0.0283	60	395.1000	72.2600	581	1906	2096	West Main Drift, empl drift 86 to 104	22
23	212	295	0.0026		0.0026	0.0260	60	395.1000	72.2600	533	1749	1924	West Main Drift, empl drift 105 to 120	23
24	298	212	1000.0061	1000.0000	0.0061	0.0610	60	395.1000	72.2600	1250	4101	4512	West Main Drift, empl drift 120 to Dev. Shaft	24
25	298	299	0.0010		0.0010	0.0098	60	395.1000	72.2600	200	656	722	West Main Drift, south end	25
26	299	799	0.0010		0.0010	0.0099	60	395.1000	72.2600	202	663	729	West Main Drift curve to South Ramp Ext/Exh Main	26
27	799	199	0.0043		0.0043	0.0431	60	395.1000	72.2600	884	2900	3190	South Ramp Ext	27
28	103	303	500.0156	500.0000	0.0156	0.1555	85	219.8900	52.5700	533	1749	1924	Emplacement Drifts, empl. drift 1 to 5, Fix 1.06kcfm	28
29	115	315	300.0156	300.0000	0.0156	0.1555	85	219.8900	52.5700	533	1749	1924	Emplacement Drifts, empl drift 6 to 25, Fix 4.24 kcfm	29
30	135	335	200.0164	200.0000	0.0164	0.1639	85	219.8900	52.5700	562	1843	2028	Emplacement Drifts, empl drift 26 to 45, Fix 4.24 kcfm	30
31	155	355	5.0178	5.0000	0.0178	0.1779	85	219.8900	52.5700	610	2001	2201	Emplacement Drifts, empl drift 46 to 65, Fix 4.24 kcfm	31
32	175	375	1.0183	1.0000	0.0183	0.1826	85	219.8900	52.5700	626	2054	2259	Emplacement Drifts, empl drift 66 to 85, Fix 4.24 kcfm	32
33	195	395	1.0183	1.0000	0.0183	0.1835	85	219.8900	52.5700	629	2063	2270	Emplacement Drifts, empl drift 86 to 104, Fix 4.24 kcfm	33
34	112	312	0.0167		0.0167	0.1671	85	219.8900	52.5700	573	1879	2067	Emplacement Drifts, empl drift 105 to 120	34
35	203	303	500.0156	500.0000	0.0156	0.1555	85	219.8900	52.5700	533	1749	1924	Emplacement Drifts, empl. drift 1 to 5, Fix 1.06 kcfm	35
36	215	315	300.0156	300.0000	0.0156	0.1555	85	219.8900	52.5700	533	1749	1924	Emplacement Drifts, empl drift 6 to 25, Fix 4.24 kcfm	36
37	235	335	200.0164	200.0000	0.0164	0.1639	85	219.8900	52.5700	562	1843	2028	Emplacement Drifts, empl drift 26 to 45, Fix 4.24 kcfm	37
38	255	355	5.0178	5.0000	0.0178	0.1779	85	219.8900	52.5700	610	2001	2201	Emplacement Drifts, empl drift 46 to 65, Fix 4.24 kcfm	38
39	275	375	1.0183	1.0000	0.0183	0.1826	85	219.8900	52.5700	626	2054	2259	Emplacement Drifts, empl drift 66 to 85, Fix 4.24 kcfm	39
40	295	395	1.0183	1.0000	0.0183	0.1835	85	219.8900	52.5700	629	2063	2270	Emplacement Drifts, empl drift 86 to 104, Fix 4.24 kcfm	40

FILE # Repva0A4, VNETPC INPUT, Viability Assessment Report - Caretaker

Calculation of airway potential resistances during repository caretaker operation and backfill.

Line No.	BRANCH From	BRANCH To	RESISTANCE in PU VNETPC INPUT RPUa+RPUb	REGULATOR RESISTANCE in PU (Field Installed RPUb	RESISTANCE in PU From R RPUa = R/10	AIRWAY RESISTANCE R = KPL/(5.2A^3) in.min^2/ft^6	FRICTION FACTOR K (x10^-10)	CROSS AREA A (Ft)	PERIMETER P (Ft)	ACTUAL LENGTH meter (m)	ACTUAL LENGTH L' (Ft)	EQUIV. LENGTH L=L'110% (Ft)	NOTES FOR BRANCH DESCRIPTION	LINE NO.
41	212	312	0.0167		0.0167	0.1671	85	219.8800	52.5700	573	1879	2067	Emplacement Drifts, empl drift 105 to 120	41
42	303	403	0.0167		0.0167	0.1668	20	24.4300	17.5200	10	33	36	Raises, empl. drift 1 to 5	42
43	315	415	0.0167		0.0167	0.1668	20	24.4300	17.5200	10	33	36	Raises, empl drift 6 to 25	43
44	335	435	0.0167		0.0167	0.1668	20	24.4300	17.5200	10	33	36	Raises, empl drift 26 to 45	44
45	355	455	0.0167		0.0167	0.1668	20	24.4300	17.5200	10	33	36	Raises, empl drift 46 to 65	45
46	375	475	0.0167		0.0167	0.1668	20	24.4300	17.5200	10	33	36	Raises, empl drift 66 to 85	46
47	395	495	0.0167		0.0167	0.1668	20	24.4300	17.5200	10	33	36	Raises, empl drift 86 to 104	47
48	312	412	0.0167		0.0167	0.1668	20	24.4300	17.5200	10	33	36	Raises, empl drift 105 to 120	48
49	403	703	99000.005	99000.000	0.0050	0.0500	20	24.4300	17.5200	3	10	11	Raise Door to Exhaust Main, empl. drift 1 to 5	49
50	415	715	99000.005	99000.000	0.0050	0.0500	20	24.4300	17.5200	3	10	11	Raise Door to Exhaust Main, empl drift 6 to 25	50
51	435	735	99000.005	99000.000	0.0050	0.0500	20	24.4300	17.5200	3	10	11	Raise Door to Exhaust Main, empl drift 26 to 45	51
52	455	755	99000.005	99000.000	0.0050	0.0500	20	24.4300	17.5200	3	10	11	Raise Door to Exhaust Main, empl drift 46 to 65	52
53	475	775	99000.005	99000.000	0.0050	0.0500	20	24.4300	17.5200	3	10	11	Raise Door to Exhaust Main, empl drift 66 to 85	53
54	495	795	99000.005	99000.000	0.0050	0.0500	20	24.4300	17.5200	3	10	11	Raise Door to Exhaust Main, empl drift 86 to 104	54
55	412	712	2000.0050	2000.0000	0.0050	0.0500	20	24.4300	17.5200	3	10	11	Raise Door to Exhaust Main, empl drift 105 to 120	55
56	403	503	10.2141	10.0000	0.2141	2.1412	11	4.2800	7.3300	3	10	11	Gate valve, raise to Duct 1, empl. drift 1 to 5	56
57	403	603	99000.214	99000.000	0.2141	2.1412	11	4.2800	7.3300	3	10	11	Gate valve, raise to Duct 2, empl. drift 1 to 5	57
58	415	515	10.2141	10.0000	0.2141	2.1412	11	4.2800	7.3300	3	10	11	Gate valve raise to Duct 1, empl. drift 6 to 25	58
59	415	615	99000.214	99000.000	0.2141	2.1412	11	4.2800	7.3300	3	10	11	Gate valve raise to Duct 2, empl. drift 6 to 25	59
60	435	535	10.2141	10.0000	0.2141	2.1412	11	4.2800	7.3300	3	10	11	Gate valve raise to Duct 1, empl. drift 26 to 45	60
61	435	635	99000.214	99000.000	0.2141	2.1412	11	4.2800	7.3300	3	10	11	Gate valve raise to Duct 2, empl. drift 26 to 45	61
62	455	555	10.2141	10.0000	0.2141	2.1412	11	4.2800	7.3300	3	10	11	Gate valve raise to Duct 1, empl. drift 46 to 65	62
63	455	655	99000.214	99000.000	0.2141	2.1412	11	4.2800	7.3300	3	10	11	Gate valve raise to Duct 2, empl. drift 46 to 65	63
64	475	575	10.2141	10.0000	0.2141	2.1412	11	4.2800	7.3300	3	10	11	Gate valve raise to Duct 1, empl. drift 66 to 85	64
65	475	675	99000.214	99000.000	0.2141	2.1412	11	4.2800	7.3300	3	10	11	Gate valve raise to Duct 2, empl. drift 66 to 85	65
66	495	595	10.2141	10.0000	0.2141	2.1412	11	4.2800	7.3300	3	10	11	Gate valve raise to Duct 1, empl. drift 86 to 104	66
67	495	695	99000.214	99000.000	0.2141	2.1412	11	4.2800	7.3300	3	10	11	Gate valve raise to Duct 2, empl. drift 86 to 104	67
68	412	512	0.2141		0.2141	2.1412	11	4.2800	7.3300	3	10	11	Gate valve raise to Duct 1, empl. drift 105 to 120	68
69	412	612	0.2141		0.2141	2.1412	11	4.2800	7.3300	3	10	11	Gate valve raise to Duct 2, empl. drift 105 to 120	69
70	512	595	0.3248		0.3248	3.2484	11	28.2700	18.8500	510	1673	1841	Duct 1 from Emplacement Drift 105 to 120	70
71	595	575	0.3694		0.3694	3.6943	11	28.2700	18.8500	580	1903	2093	Duct 1 from Emplacement Drift 86 to 104	71
72	575	555	0.3669		0.3669	3.6688	11	28.2700	18.8500	576	1890	2079	Duct 1 from Emplacement Drift 65 to 85	72
73	555	535	0.3631		0.3631	3.6306	11	28.2700	18.8500	570	1870	2057	Duct 1 from Emplacement Drift 46 to 65	73
74	535	515	0.3659		0.3659	3.6586	11	28.2700	18.8500	574	1885	2073	Duct 1 from Emplacement Drift 26 to 45	74
75	515	503	0.2217		0.2217	2.2166	11	28.2700	18.8500	348	1142	1256	Duct 1 from Emplacement Drift 6 to 25	75
76	503	501	0.2994		0.2994	2.9936	11	28.2700	18.8500	470	1542	1696	Duct 1 from Emplace. Drift 1 to 5 + length to shaft	76
77	501	500	0.0382		0.0382	0.3822	11	28.2700	18.8500	60	197	217	Centrifugal Fan 1	77
78	500	600	0.0003		0.0003	0.0034	60	387.5008	78.7402	60	197	217	Drift connection 6x6 -Duct 1 discharge to Empl Shaft	78
79	612	695	0.3248		0.3248	3.2484	11	28.2700	18.8500	510	1673	1841	Duct 2 from Emplacement Drift 105 to 120	79
80	695	675	0.3694		0.3694	3.6943	11	28.2700	18.8500	580	1903	2093	Duct 2 from Emplacement Drift 86 to 104	80

FILE # Repva0A4, VNETPC INPUT, Viability Assessment Report - Caretaker

Calculation of airway potential resistances during repository caretaker operation and backfill.

Line No.	BRANCH From	BRANCH To	RESISTANCE in PU VNETPC INPUT RPUa+RPUb	REGULATOR RESISTANCE in PU (Field Installed RPUb	RESISTANCE in PU From R RPUa = R/10	AIRWAY RESISTANCE R = KPL/(5.2A^3) in.min^2/ft^6	FRICTION FACTOR K (x10^-10)	CROSS AREA A (Ft)	PERIMETER P (Ft)	ACTUAL LENGTH meter (m)	ACTUAL LENGTH L' (Ft)	EQUIV. LENGTH L=L'+10% (Ft)	NOTES FOR BRANCH DESCRIPTION	LINE NO.
81	675	655	0.3669		0.3669	3.6688	11	28.2700	18.8500	576	1890	2079	Duct 2 from Emplacement Drift 65 to 85	81
82	655	635	0.3631		0.3631	3.6306	11	28.2700	18.8500	570	1870	2057	Duct 2 from Emplacement Drift 46 to 65	82
83	635	615	0.3659		0.3659	3.6586	11	28.2700	18.8500	574	1885	2073	Duct 2 from Emplacement Drift 26 to 45	83
84	615	603	0.2217		0.2217	2.2166	11	28.2700	18.8500	348	1142	1256	Duct 2 from Emplacement Drift 6 to 25	84
85	603	601	0.2739		0.2739	2.7389	11	28.2700	18.8500	430	1411	1552	Duct 2 from Emplace. Drift 1 to 5 + length to shaft	85
86	601	600	99000.038	99000.00	0.0382	0.3822	11	28.2700	18.8500	60	197	217	**Centrifugal Fan 2**	86
87	600	702	0.0002		0.0002	0.0017	60	387.5008	78.7402	30	98	108	Drift connection for duct 1 & 2 discharge to Shaft, 6x6	87
88	799	712	1000.0144	1000.0000	0.0144	0.1441	70	318.1400	72.2600	1322	4337	4771	Exhaust Main, South Ramp Ext to Empl Drift	88
89	712	795	0.0056		0.0056	0.0556	70	318.1400	72.2600	510	1673	1841	Exhaust Main from Emplacement Drift 105 to 120	89
90	795	775	0.0063		0.0063	0.0632	70	318.1400	72.2600	580	1903	2093	Exhaust Main from Emplacement Drift 86 to 104	90
91	775	755	0.0063		0.0063	0.0628	70	318.1400	72.2600	576	1890	2079	Exhaust Main from Emplacement Drift 65 to 85	91
92	755	735	0.0062		0.0062	0.0621	70	318.1400	72.2600	570	1870	2057	Exhaust Main from Emplacement Drift 46 to 65	92
93	735	715	0.0063		0.0063	0.0626	70	318.1400	72.2600	574	1885	2073	Exhaust Main from Emplacement Drift 26 to 45	93
94	715	703	0.0038		0.0038	0.0379	70	318.1400	72.2600	348	1142	1256	Exhaust Main from Emplacement Drift 6 to 25	94
95	703	701	0.0047		0.0047	0.0469	70	318.1400	72.2600	430	1411	1552	Exhaust Main from Emplacement Drift 1 to 5	95
96	700	701	1000.0015	1000.0000	0.0015	0.0150	70	318.1400	72.2600	138	453	498	Exhaust Main Airlock to North Main	96
97	701	702	0.0002		0.0002	0.0018	70	527.4316	91.8635	58	190	209	Exhaust Main connection to Emplacement Shaft, 7x7	97
98	702	6	0.0012		0.0012	0.0123	20	309.5700	62.8700	417	1368	1505	**Emplacement Shaft (Collar Elev. 1455m)**	98
99	6	7	0.0002		0.0002	0.0016	11	309.5700	62.8700	100	328	361	**Primary Emplacement Fan**	99
100	7	1002	1000.0000	1000.0000	0.0000	0.0000	0	0	0	0	0	0	Primary Emplacement Fan leakage leg 1	100
101	1002	6	1000.0000	1000.0000	0.0000	0.0000	0	0	0	0	0	0	Primary Emplacement Fan leakage leg 2	101
102	7	8	0.0000		0.0000	0.0000	0	0	0	0	0	0	Surface dummy, Empl Shaft to North Ramp Portal 1	102
103	8	1	0.0000		0.0000	0.0000	0	0	0	0	0	0	Surface dummy, Empl Shaft to North Ramp Portal 2	103
104	1	100	0.0000		0.0000	0.0000	0	0	0	0	0	0	Surface dummy, North Ramp Portal to South Ramp Por.	104
105	100	3	0.0000		0.0000	0.0000	0	0	0	0	0	0	Surface dummy, South Ramp Portal to Dev Shaft leg 1	105
106	3	4	0.0000		0.0000	0.0000	0	0	0	0	0	0	Surface dummy, South Ramp Portal to Dev Shaft leg 2	106
107	4	5	0.0001		0.0001	0.0011	11	309.5700	62.8700	70	230	253	**Primary Development Fan**	107
108	5	1001	1000.0000	1000.0000	0.0000	0.0000	0	0	0	0	0	0	Primary Development Fan leakage leg 1	108
109	1001	4	1000.0000	1000.0000	0.0000	0.0000	0	0	0	0	0	0	Primary Development Fan leakage leg 1	109
110	5	9	0.0048		0.0048	0.0478	95	309.5700	62.8700	342	1122	1234	**Development Shaft (Collar elev. 1452m)**	110
111	9	298	0.0002		0.0002	0.0018	60	527.4316	91.8635	70	230	253	Development Shaft connection to West Main	111
112	115	334	1.0110	1.0000	0.0110	0.1097	60	219.8900	52.5700	533	1749	1924	Vent Drift + PC Bypass Regulator from East Main, 1	112
113	235	334	1.0110	1.0000	0.0110	0.1097	60	219.8900	52.5700	533	1749	1924	Vent Drift + PC Bypass Regulator from West Main, 1	113
114	334	735	0.0167		0.0167	0.1668	20	24.4300	17.5200	10	33	36	Raise for Vent Drift + PC Bypass Regulator, 1	114
115	155	370	1.0128	1.0000	0.0128	0.1279	60	219.8900	52.5700	621	2037	2241	Vent Drift + PC Bypass Regulator from East Main, 2	115
116	275	370	1.0128	1.0000	0.0128	0.1279	60	219.8900	52.5700	621	2037	2241	Vent Drift + PC Bypass Regulator from West Main, 2	116
117	370	775	0.0167		0.0167	0.1668	20	24.4300	17.5200	10	33	36	Raise for Vent Drift + PC Bypass Regulator, 2	117
118	195	304	0.0123		0.0123	0.1233	60	219.8900	52.5700	599	1965	2162	Vent Drift + PC Bypass Regulator from East Main, 3	118
119	212	304	0.0123		0.0123	0.1233	60	219.8900	52.5700	599	1965	2162	Vent Drift + PC Bypass Regulator from West Main, 3	119
120	304	712	0.0167		0.0167	0.1668	20	24.4300	17.5200	10	33	36	Raise for Vent Drift + PC Bypass Regulator, 3	120

FILE # Repva0A4, VNETPC INPUT, Viability Assessment Report - Caretaker

Calculation of airway potential resistances during repository caretaker operation and backfill.

Line No.	BRANCH From	To	RESISTANCE in PU VNETPC INPUT RPUa+RPUb	REGULATOR RESISTANCE in PU (Field Installed) RPUb	RESISTANCE in PU From R RPUa = R/10	AIRWAY RESISTANCE R = KPL/(5.2A^3) in.min^2/ft^6	FRICTION FACTOR K (x10^-10)	CROSS AREA A (Ft)	PERIMETER P (Ft)	ACTUAL LENGTH meter (m)	ACTUAL LENGTH L' (Ft)	EQUIV. LENGTH L=L'+10% (Ft)	NOTES FOR BRANCH DESCRIPTION	LINE NO.
121	7	303	@ 1.06 kcfm		Inject expanded air								Inject simulated air expansion @ 1.06 kcfm	121
122	7	315	@ 4.24 kcfm		Inject expanded air								Inject simulated air expansion @ 4.24 kcfm	122
123	7	335	@ 4.24 kcfm		Inject expanded air								Inject simulated air expansion @ 4.24 kcfm	123
124	7	355	@ 4.24 kcfm		Inject expanded air								Inject simulated air expansion @ 4.24 kcfm	124
125	7	375	@ 4.24 kcfm		Inject expanded air								Inject simulated air expansion @ 4.24 kcfm	125
126	7	395	@ 4.24 kcfm		Inject expanded air								Inject simulated air expansion @ 4.24 kcfm	126
127	7	312	@ 10 kcfm		Inject expanded air								Inject simulated air expansion @ 10 kcfm	127

Calculation of cross areas and perimeters

Ref. Line		K factor assumptions x 10^(-10) lb min^2/ft^4		Calculated Gross Cross Area, ft^2	Less Area of Perm. Items Ft^2	Net Are Used Ft^2	Perimeter Used Ft
1							
2							
3							
4							
5	North Ramp / North Main, 7.62m dia	30	DCSS 022	490.88	a, c, u	395.10	72.26
6	East / West Main drifts, 7.62 m dia	60	DCSS 022	490.88	a, c, u	395.10	72.26
7	Emplacement drifts, 5.1 m dia	70	DCSS 022	219.89		219.89	52.57
8	Empl drifts (Loaded), 5.1 m dia	85	DCSS 022	219.89		219.89	52.57
9	Smooth exhaust ducts, 72"ID, 84"OD	11	DCSS 022	28.27		28.27	18.85
10	Exhaust main (raise bottom & duct blockage)	70	DCSS 022	490.88	a, c, 2d,u	318.14	72.26
11	Raises, 1.7 m dia	20		24.43		24.43	17.52
12	Emplacement Shaft, 6.1 m dia	20		314.57	g	309.57	62.87
13	Development Shaft, 6.1 m dia	95	DCSS 022	314.57	g, u	307.57	62.87
14	Regulator valves 28" dia housing	11		4.28		4.28	7.33
15	South Ramp Service Main	70	DCSS 022	490.88	a, b, c, u	389.10	72.26

16
17 Less estimated permanent obstruction in airways:
18 a - main invert (34.34); b - conveyor (6); c - concrete lining above invert (59.44); d - duct 84"OD (38.48); g - guides in shaft (5); s - steel set (42.19); u - utilities & rails (2).
19

20	when "u" has	Water Supply	0.35
21		Water Return	0.35
22		Compressed Air	0.20
23		Power & Hangers	0.60
24		Rail	0.50
25			
26		Net Cross Area	2.00 Ft^2
27			

28 Note: Liner in ramps and mains are assumed 12 inches thick for concrete or 8 inches thick for steel.
29

VNETPC (Version 3.1)
18:23:39
07-24-1997

Output File Name: OUTPUT.TMP
Network File Name: REPVA0A4
Network Title: REPOSITORY VENTILATION
Mine Name: YUCCA MOUNTAIN PROJECT
Company: M&O/MK/RSJURANI
Comments: CARETAKER/ONE AUX.FAN/ONE PRIME FAN

**** DATA SUPPLIED BY USER ****

Fan Data:

	Fan Ref No.	From	To	Operating Pressure in.w.g.	No. Characteristic Pts.
1	17	6	7	7.000	10
2	33	501	500	15.000	10

Fan Characteristic Points:

Fan 1

Pressure in.w.g.	Airflow kcfm
16.400	50.00
14.000	110.00
12.200	200.00
12.300	245.00
12.300	285.00
10.800	340.00
8.400	400.00
6.000	440.00
4.000	460.00
2.000	480.00

Fan 2

Pressure in.w.g.	Airflow kcfm
13.250	0.00
14.500	19.72
15.250	39.43
15.000	59.15
14.000	78.87
13.250	88.72
12.500	98.58
10.750	118.30
7.500	138.02
4.000	157.73

Branch Data:

Branch	From	To	Resistance	Airflow	Pressure Dp	Frict. Factor	Len	Equiv Len	Area

			P.U.	kcfm	m.in.wg.	lbfmin^2/ft^4 X10^10	ft	ft	ft^2
1	1	2	0.00530						
2	2	101	0.00140						
3	101	102	0.00230						
4	102	103	0.00350						
5	103	115	0.00170						
6	115	135	0.00280						
7	2	135	0.50170						
8	135	155	0.00280						
9	155	175	0.00280						
10	175	195	0.00280						
11	195	112	0.00240						
12	112	198	1000.00403						
13	198	199	0.00240						
14	199	100	0.00870						
15	102	700	0.00090						
16	700	200	0.00150						
17	200	203	0.00070						
18	203	215	0.00170						
19	215	235	0.00280						
20	235	255	0.00280						
21	275	255	0.00280						
22	295	275	0.00280						
23	212	295	0.00260						
24	298	212	1000.00598						
25	298	299	0.00100						
26	299	799	0.00100						
27	799	199	0.00430						
28	103	303	500.01559	1.06 - Fixed					
29	115	315	300.01559	4.24 - Fixed					
30	135	335	200.01640	4.24 - Fixed					
31	155	355	5.01780	4.24 - Fixed					
32	175	375	1.01830	4.24 - Fixed					
33	195	395	1.01830	4.24 - Fixed					
34	112	312	0.01670	22.00 - Fixed					
35	203	303	500.01559	1.06 - Fixed					
36	215	315	300.01559	4.24 - Fixed					
37	235	335	200.01640	4.24 - Fixed					
38	255	355	5.01780	4.24 - Fixed					
39	275	375	1.01830	4.24 - Fixed					
40	295	395	1.01830	4.24 - Fixed					
41	212	312	0.01670	4.24 - Fixed					
42	303	403	0.01670						
43	315	415	0.01670						
44	335	435	0.01670						
45	355	455	0.01670						
46	375	475	0.01670						
47	395	495	0.01670						
48	312	412	0.01670						
49	403	703	99000.00000						
50	415	715	99000.00000						
51	435	735	99000.00000						
52	455	755	99000.00000						
53	475	775	99000.00000						
54	495	795	99000.00000						
55	412	712	2000.00500						
56	403	503	10.21410						
57	403	603	99000.00000						

58	415	515	10.21410
59	415	615	99000.00000
60	435	535	10.21410
61	435	635	99000.00000
62	455	555	10.21410
63	455	655	99000.00000
64	475	575	10.21410
65	475	675	99000.00000
66	495	595	10.21410
67	495	695	99000.00000
68	412	512	0.21410
69	412	612	0.21410
70	512	595	0.32480
71	595	575	0.36940
72	575	555	0.36690
73	555	535	0.36310
74	535	515	0.36590
75	515	503	0.22170
76	503	501	0.29940
77	501	500	0.03820
78	500	600	0.00030
79	612	695	0.32480
80	695	675	0.36940
81	675	655	0.36690
82	655	635	0.36310
83	635	615	0.36590
84	615	603	0.22170
85	603	601	0.27390
86	601	600	99000.00000
87	600	702	0.00020
88	799	712	1000.01398
89	712	795	0.00560
90	795	775	0.00630
91	775	755	0.00630
92	755	735	0.00620
93	735	715	0.00630
94	715	703	0.00380
95	703	701	0.00470
96	700	701	1000.00201
97	701	702	0.00020
98	702	6	0.00120
99	6	7	0.00020
100	7	1002	1000.00000
101	1002	6	1000.00000
102	7	8	0.00001
103	8	1	0.00001
104	1	100	0.00001
105	100	3	0.00001
106	3	4	0.00001
107	4	5	0.00010
108	5	1001	1000.00000
109	1001	4	1000.00000
110	5	9	0.00480
111	9	298	0.00020
112	115	334	1.01100
113	235	334	1.01100
114	334	735	0.01670
115	155	370	1.01280
116	275	370	1.01280
117	370	775	0.01670

118	195	304	0.01230	100.00 - Fixed
119	212	304	0.01230	100.00 - Fixed
120	304	712	0.01670	
121	7	303		1.06 - Inject/Reject
122	7	315		4.24 - Inject/Reject
123	7	335		4.24 - Inject/Reject
124	7	355		4.24 - Inject/Reject
125	7	375		4.24 - Inject/Reject
126	7	395		4.24 - Inject/Reject
127	7	312		10.00 - Inject/Reject

**** OUTPUT DATA ****

Annual costs are based on electricity charges of 10.0 cents per kWh and fan efficiencies of 75.0%
Cost given for an NVP represents money saved by natural ventilation

Network File Name - REPVA0A4
Output File Name - OUTPUT.TMP

*** Fan Operating Points ***

Fan No.	Ref	From	To	Pressure in.w.g.	Quantity kcfm	Air Power hp	Op.Cost $/year
1	17	6	7	5.398	446.01	379.37	330416
2	33	501	500	11.964	104.61	197.21	171764

Network File Name - REPVA0A4
Output File Name - OUTPUT.TMP

*** Branch Data ***

Branch	From	To	Press.Dp m.in.wg.	Airflow kcfm	Resist. P.U.	AP Loss hp	Op.Cost $/year
1	1	2	882	407.98	0.00530	56.7	49385
2	2	101	191	370.26	0.00140	11.1	9706
3	101	102	315	370.26	0.00230	18.4	16007
4	102	103	108	175.83	0.00350	3.0	2606
5	103	115	51	174.77	0.00170	1.4	1223
6	115	135	46	129.00	0.00280	0.9	814
7	2	135	713	37.72	0.50170	4.2	3691
8	135	155	73	162.49	0.00280	1.9	1628
9	155	175	46	129.15	0.00280	0.9	815
10	175	195	43	124.91	0.00280	0.8	737
11	195	112	1	20.67	0.00240	0.0	3
12	112	198	-1761	-1.33	1000.00403	0.4	321
13	198	199	0	-1.33	0.00240	0.0	0
14	199	100	0	-1.81	0.00870	0.0	0
15	102	700	34	194.42	0.00090	1.0	907
16	700	200	55	192.51	0.00150	1.7	1453
17	200	203	25	192.51	0.00070	0.8	661

18	203	215	62	191.45	0.00170	1.9	1629	
19	215	235	98	187.21	0.00280	2.9	2518	
20	235	255	57	142.84	0.00280	1.3	1117	
21	275	255	-53	-138.60	0.00280	1.2	1008	
22	295	275	-32	-107.13	0.00280	0.5	470	
23	212	295	-27	-102.89	0.00260	0.4	381	
24	298	212	1835	1.35	1000.00598	0.4	341	
25	298	299	0	0.97	0.00100	0.0	0	
26	299	799	0	0.97	0.00100	0.0	0	
27	799	199	0	-0.48	0.00430	0.0	0	
28*	103	303	11739	1.06	10447.83008	2.0	1708	-Regulator Required
29*	115	315	7799	4.24	433.84650	5.2	4538	-Regulator Required
30*	135	335	4975	4.24	276.73541	3.3	2895	-Regulator Required
31*	155	355	2915	4.24	162.18140	1.9	1696	-Regulator Required
32*	175	375	1526	4.24	84.91602	1.0	888	-Regulator Required
33*	195	395	634	4.24	35.31644	0.4	369	-Regulator Required
34*	112	312	1544	22.00	3.19123	5.4	4662	-Regulator Required
35*	203	303	11731	1.06	10441.29980	2.0	1707	-Regulator Required
36*	215	315	7781	4.24	432.86111	5.2	4528	-Regulator Required
37*	235	335	4905	4.24	272.88351	3.3	2854	-Regulator Required
38*	255	355	2863	4.24	159.26401	1.9	1666	-Regulator Required
39*	275	375	1467	4.24	81.60480	1.0	854	-Regulator Required
40*	295	395	586	4.24	32.64807	0.4	341	-Regulator Required
41*	212	312	1470	4.24	81.77342	1.0	855	-Regulator Required
42	303	403	0	3.18	0.01670	0.0	0	
43	315	415	2	12.72	0.01670	0.0	3	
44	335	435	2	12.72	0.01670	0.0	3	
45	355	455	2	12.72	0.01670	0.0	3	
46	375	475	2	12.72	0.01670	0.0	3	
47	395	495	2	12.72	0.01670	0.0	3	
48	312	412	21	36.24	0.01670	0.1	104	
49	403	703	-8677	-0.30	99000.00781	0.4	353	
50	415	715	-5226	-0.23	99000.00000	0.2	165	
51	435	735	-3169	-0.18	99000.00000	0.1	78	
52	455	755	-1592	-0.13	99000.00000	0.0	28	
53	475	775	-665	-0.08	99000.00000	0.0	7	
54	495	795	-71	-0.03	99000.00000	0.0	0	
55	412	712	-1226	-0.78	2000.00500	0.2	132	
56	403	503	146	3.79	10.21410	0.1	76	
57	403	603	-9907	-0.32	99000.00000	0.5	430	
58	415	515	1778	13.20	10.21410	3.7	3220	
59	415	615	-6022	-0.25	99000.00000	0.2	204	

60	435	535	1747	13.08	10.21410	3.6	3136
61	435	635	-3244	-0.18	99000.00000	0.1	81
62	455	555	1715	12.96	10.21410	3.5	3050
63	455	655	-1259	-0.11	99000.00000	0.0	19
64	475	575	1666	12.77	10.21410	3.4	2921
65	475	675	82	0.03	99000.00000	0.0	0
66	495	595	1634	12.65	10.21410	3.3	2837
67	495	695	930	0.10	99000.00000	0.0	12
68	412	512	279	36.16	0.21410	1.6	1385
69	412	612	0	0.87	0.21410	0.0	0
70	512	595	424	36.16	0.32480	2.4	2104
71	595	575	879	48.81	0.36940	6.8	5888
72	575	555	1391	61.58	0.36690	13.5	11756
73	555	535	2017	74.54	0.36310	23.7	20634
74	535	515	2809	87.62	0.36590	38.8	33779
75	515	503	2253	100.82	0.22170	35.8	31173
76	503	501	3276	104.61	0.29940	54.0	47033
77	501	500	418	104.61	0.03820	6.9	6001
78	500	600	3	104.61	0.00030	0.0	43
79	612	695	0	0.87	0.32480	0.0	0
80	695	675	0	0.96	0.36940	0.0	0
81	675	655	0	0.99	0.36690	0.0	0
82	655	635	0	0.88	0.36310	0.0	0
83	635	615	0	0.70	0.36590	0.0	0
84	615	603	0	0.45	0.22170	0.0	0
85	603	601	0	0.13	0.27390	0.0	0
86	601	600	1786	0.13	99000.00000	0.0	33
87	600	702	2	104.74	0.00020	0.0	29
88	799	712	2101	1.45	1000.01398	0.5	418
89	712	795	225	200.67	0.00560	7.1	6196
90	795	775	253	200.64	0.00630	8.0	6967
91	775	755	415	256.88	0.00630	16.8	14631
92	755	735	408	256.76	0.00620	16.5	14377
93	735	715	720	338.24	0.00630	38.4	33423
94	715	703	434	338.01	0.00380	23.1	20133
95	703	701	536	337.71	0.00470	28.5	24843
96	700	701	3672	1.92	1000.00201	1.1	966
97	701	702	23	339.63	0.00020	1.2	1072
98	702	6	236	444.37	0.00120	16.5	14393
99	6	7	39	446.01	0.00020	2.7	2387
100	7	1002	2679	1.64	1000.00000	0.7	602
101	1002	6	2679	1.64	1000.00000	0.7	602
102	7	8	1	412.11	0.00001	0.1	57
103	8	1	1	412.11	0.00001	0.1	57
104	1	100	0	4.13	0.00001	0.0	0
105	100	3	0	2.32	0.00001	0.0	0
106	3	4	0	2.32	0.00001	0.0	0
107	4	5	0	2.31	0.00010	0.0	0
108	5	1001	0	-0.01	1000.00000	0.0	0
109	1001	4	0	-0.01	1000.00000	0.0	0
110	5	9	0	2.32	0.00480	0.0	0
111	9	298	0	2.32	0.00020	0.0	0
112	115	334	1743	41.53	1.01100	11.4	9935
113	235	334	1628	40.13	1.01100	10.3	8966

114	334	735	111	81.66	0.01670	1.4	1244	
115	155	370	857	29.09	1.01280	3.9	3422	
116	275	370	751	27.23	1.01280	3.2	2807	
117	370	775	52	56.32	0.01670	0.5	402	
118**	195	304	-327	100.00	0.01230	5.2	4488	-Booster Required
119**	212	304	-402	100.00	0.01230	6.3	5517	-Booster Required
120	304	712	668	200.00	0.01670	21.1	18335	
121+	7	303	13240	1.06	11783.71973	2.2	1926	-Inject/Reject Air
122+	7	315	9352	4.24	520.22839	6.2	5442	-Inject/Reject Air
123+	7	335	6574	4.24	365.70920	4.4	3825	-Inject/Reject Air
124+	7	355	4589	4.24	255.26730	3.1	2670	-Inject/Reject Air
125+	7	375	3246	4.24	180.59990	2.2	1889	-Inject/Reject Air
126+	7	395	2398	4.24	133.43050	1.6	1395	-Inject/Reject Air
127+	7	312	3309	10.00	33.09438	5.2	4541	-Inject/Reject Air

Number of Iterations = 6

Network File Name - REPVA0A4
Output File Name - OUTPUT.TMP

*** Regulator List ***

Branch	From	To	Fixed Quantity (kcfm)	Regulator Resistance (P.U.)
28	103	303	1.1	9947.81445
29	115	315	4.2	133.83090
30	135	335	4.2	76.71901
31	155	355	4.2	157.16359
32	175	375	4.2	83.89770
33	195	395	4.2	34.29810
34	112	312	22.0	3.17450
35	203	303	1.1	9941.28418
36	215	315	4.2	132.84552
37	235	335	4.2	72.86711
38	255	355	4.2	154.24620
39	275	375	4.2	80.58649
40	295	395	4.2	31.62980
41	212	312	4.2	81.75670

*** Booster Fan List ***

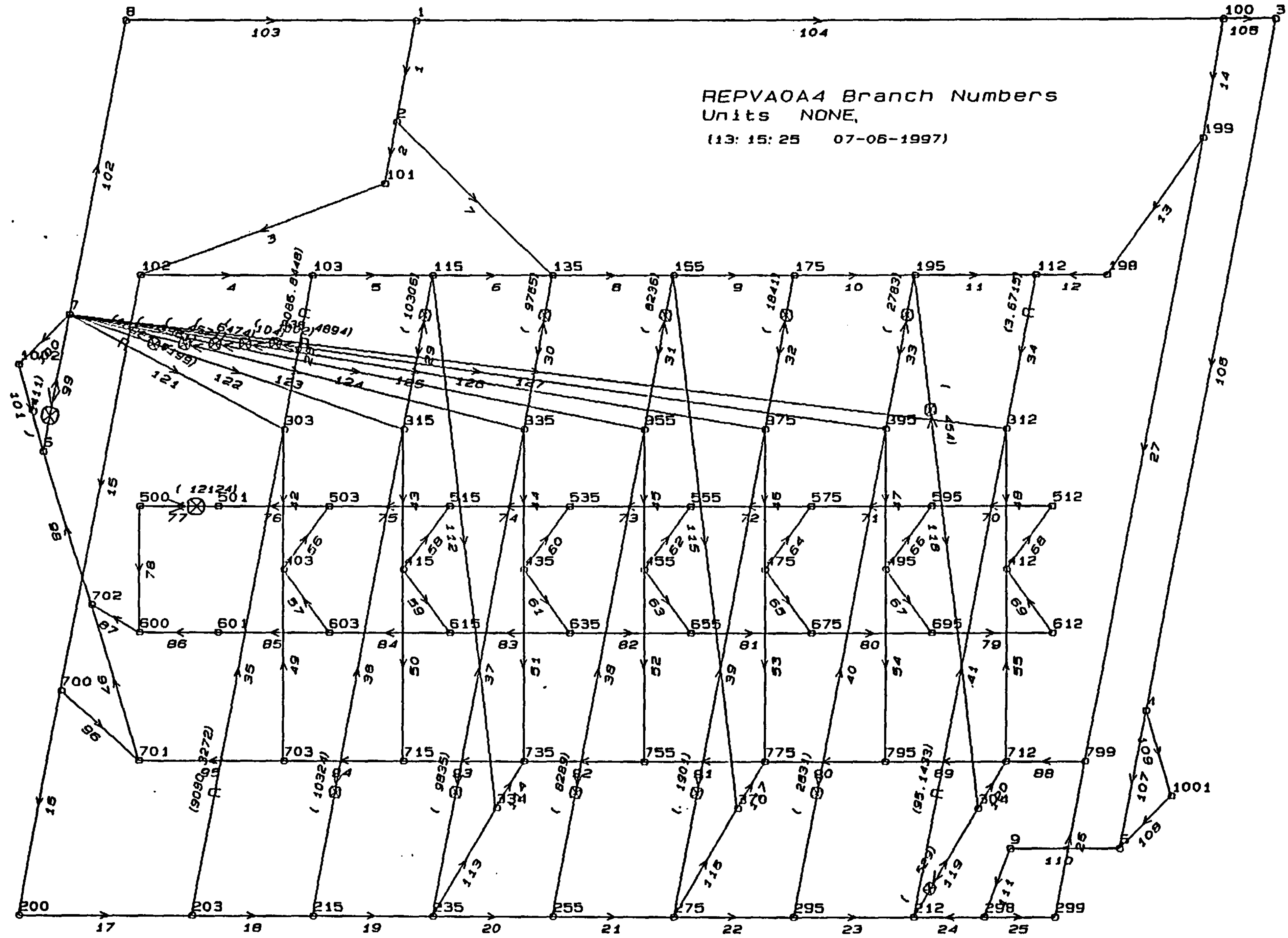
Branch	From	To	Fixed Quantity (kcfm)	Booster Pressure (m.in.wg.)
118	195	304	100.0	450
119	212	304	100.0	526

The following table gives the frictional pressure relative to 0 m.in.wg. at junction No. 1
The table may be used to find neutral points and the pressure difference available to produce flow between any two junctions in the network.
** The value 99999 indicates an inaccessible junction **

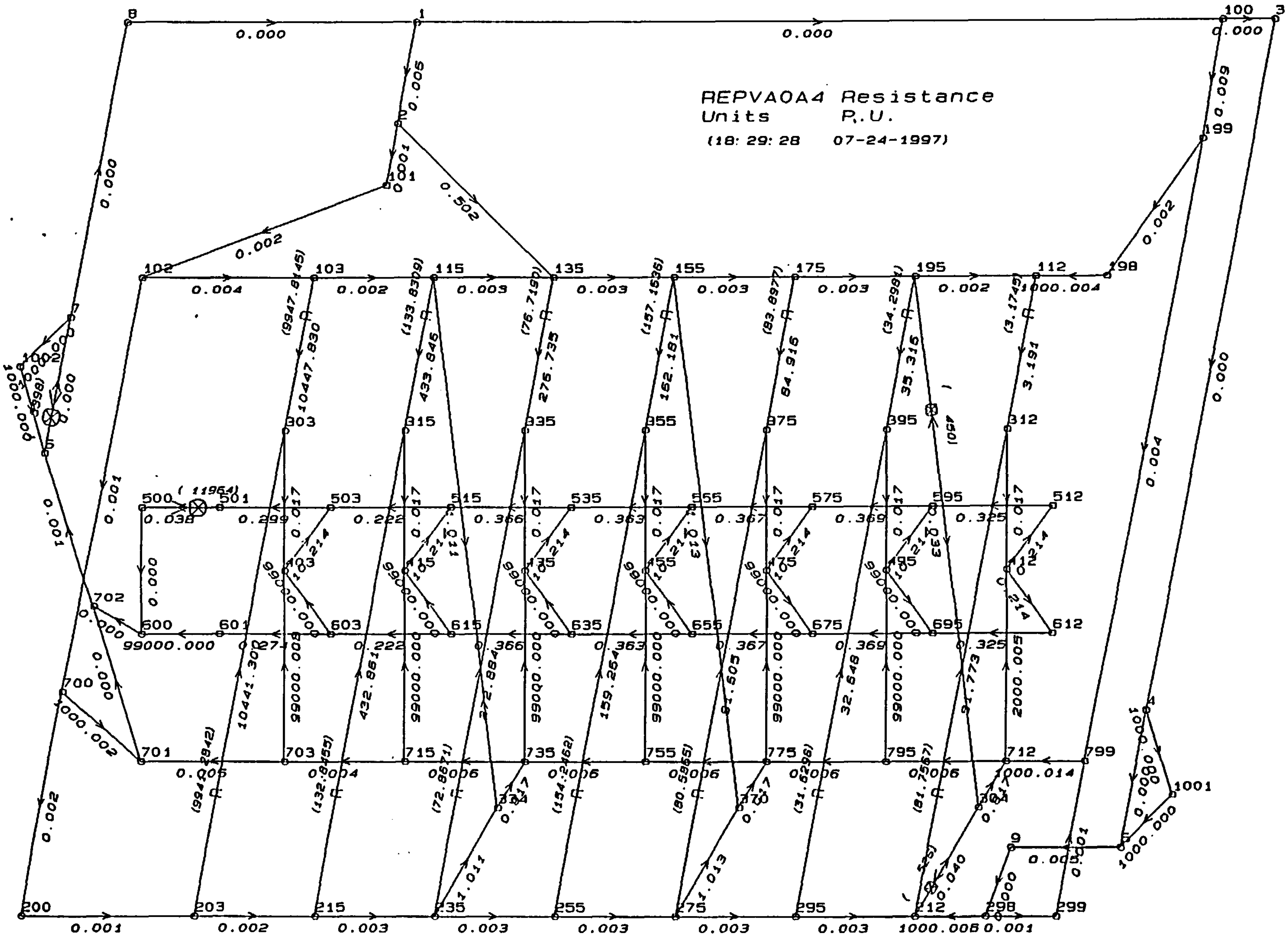
Junction	Pressure	Junction	Pressure	Junction	Pressure	Junction	Pressure
1	0	2	-882	3	5	4	5
5	5	6	-5352	7	7	8	6
9	5	100	5	101	-1073	102	-1388
103	-1496	112	-1756	115	-1547	135	-1593
155	-1666	175	-1712	195	-1755	198	5
199	5	200	-1477	203	-1502	212	-1831
215	-1564	235	-1662	255	-1719	275	-1772
295	-1804	298	4	299	4	303	-13235
304	-1428	312	-3300	315	-9346	334	-3290
335	-6568	355	-4581	370	-2523	375	-3238
395	-2389	403	-13235	412	-3321	415	-9348
435	-6570	455	-4583	475	-3240	495	-2391
500	-5111	501	-16657	503	-13381	512	-3600
515	-11126	535	-8317	555	-6298	575	-4906
595	-4025	600	-5114	601	-3328	603	-3328
612	-3321	615	-3326	635	-3326	655	-3324
675	-3322	695	-3321	700	-1422	701	-5094
702	-5116	703	-4558	712	-2095	715	-4122
735	-3401	755	-2991	775	-2575	795	-2320
799	4	1001	5	1002	-2672		

**** NETWORK EXERCISE COMPLETE ****

Some information may be obliterated but may be deduced from Attachment III, pages 7 thru 14.



Some information may be obliterated but may be deduced from Attachment III, pages 7 thru 14.



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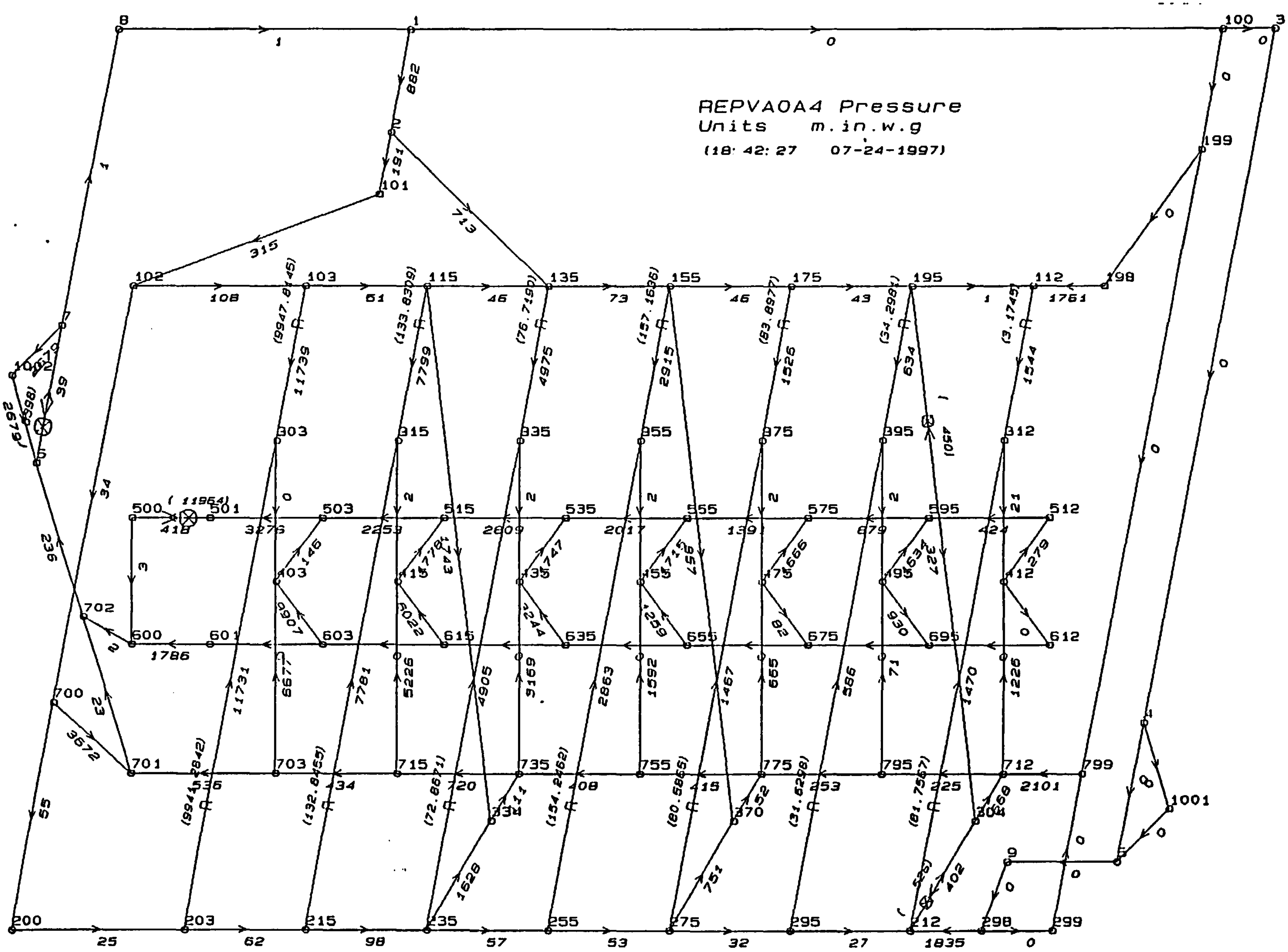

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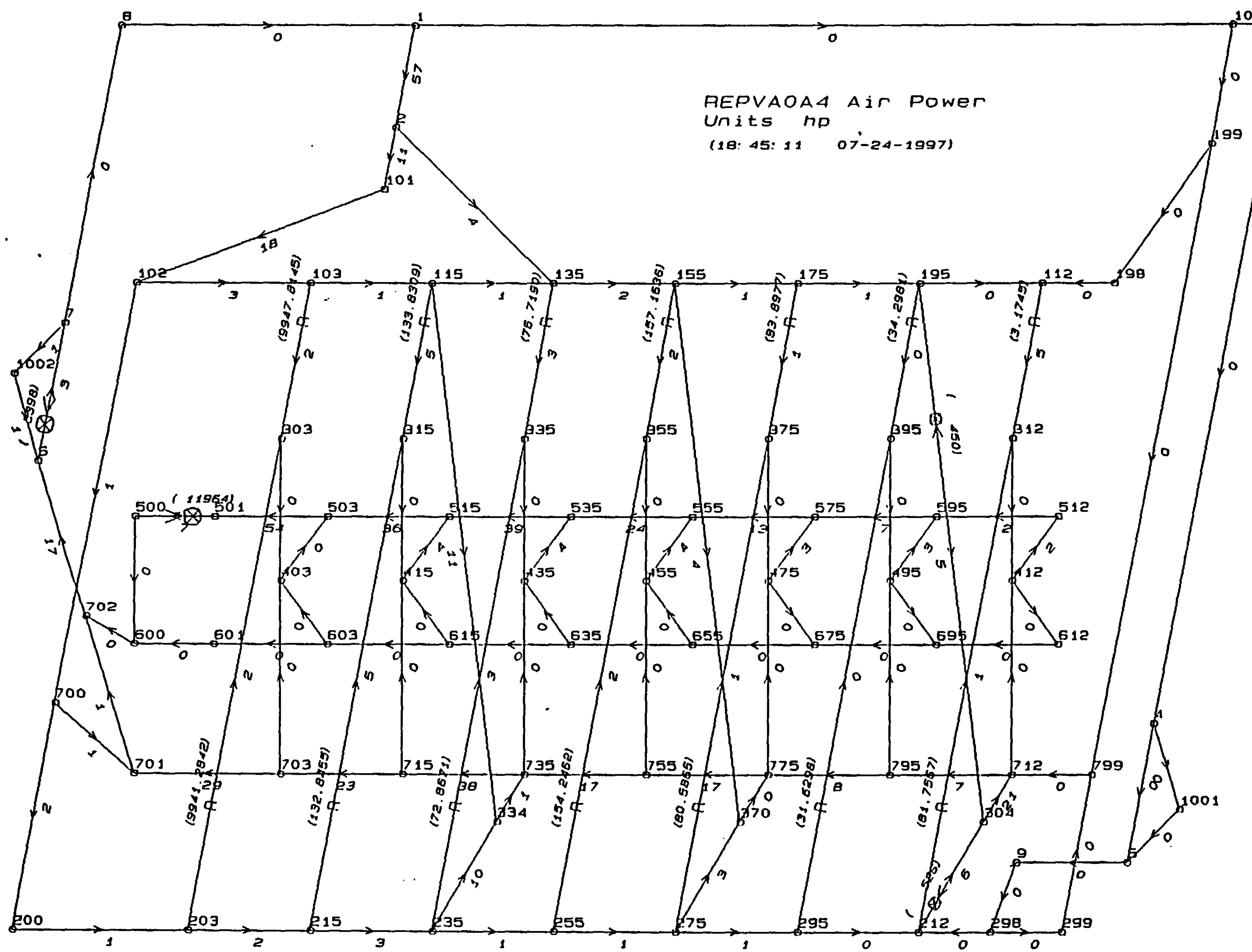
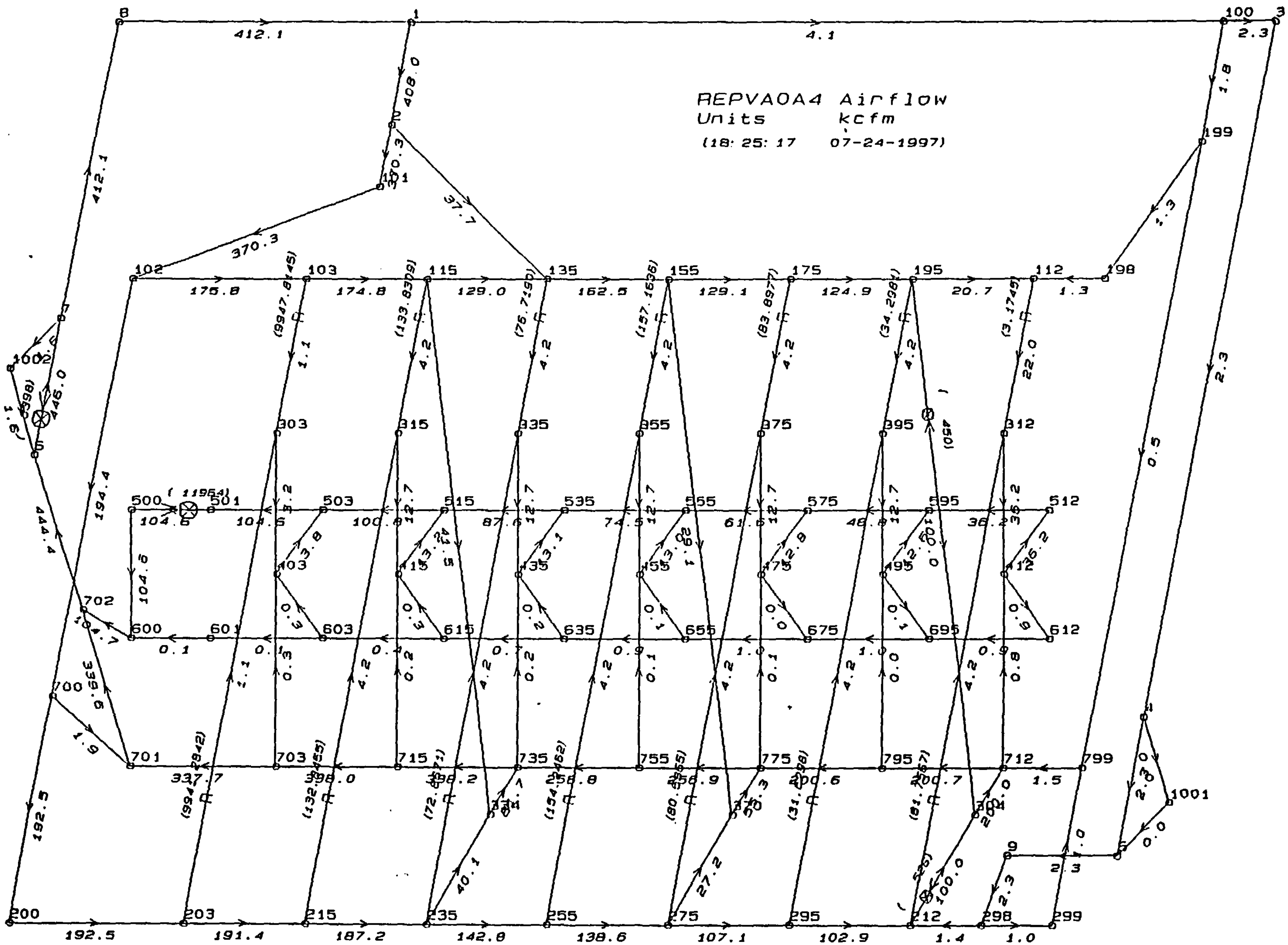
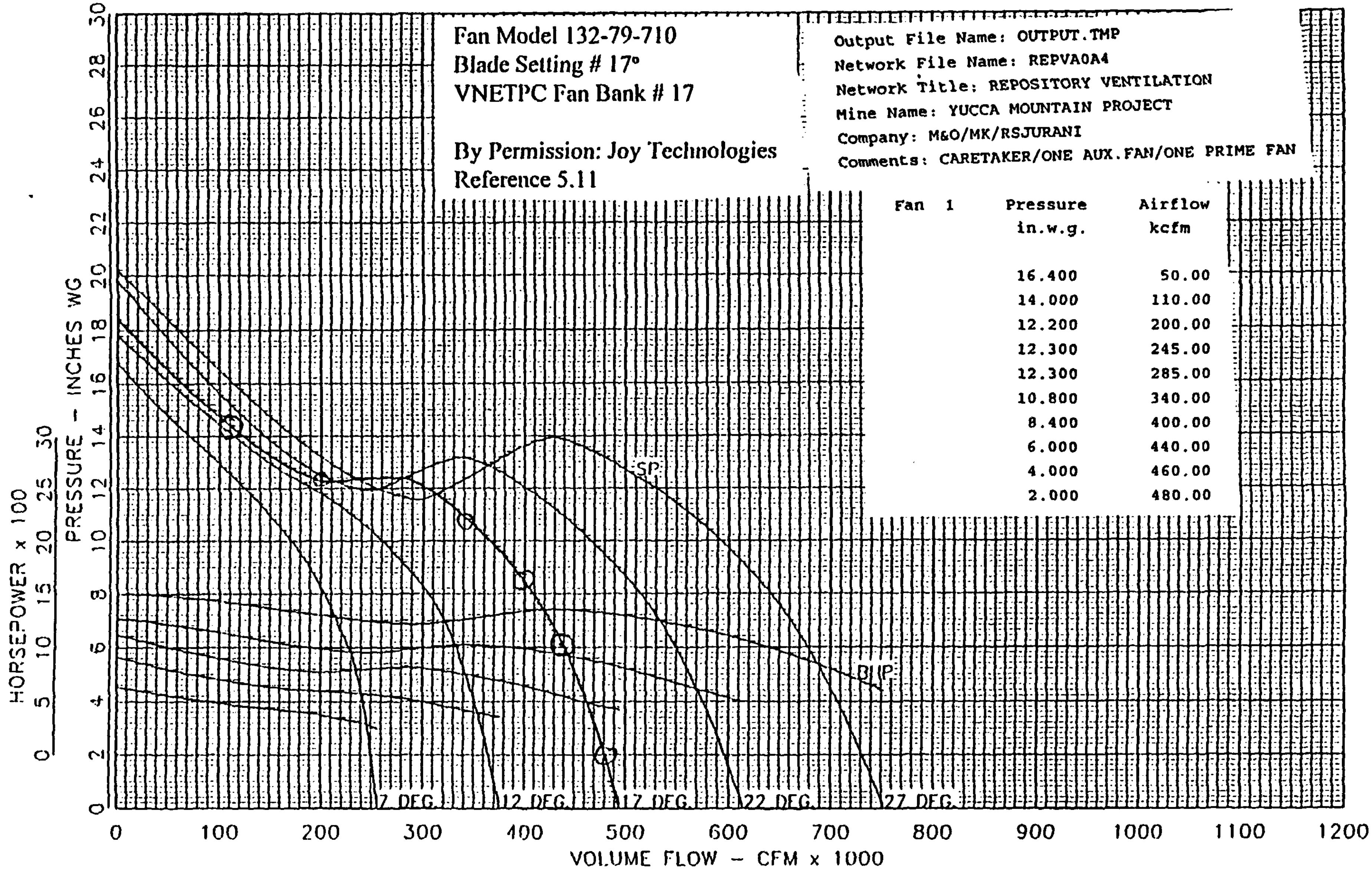
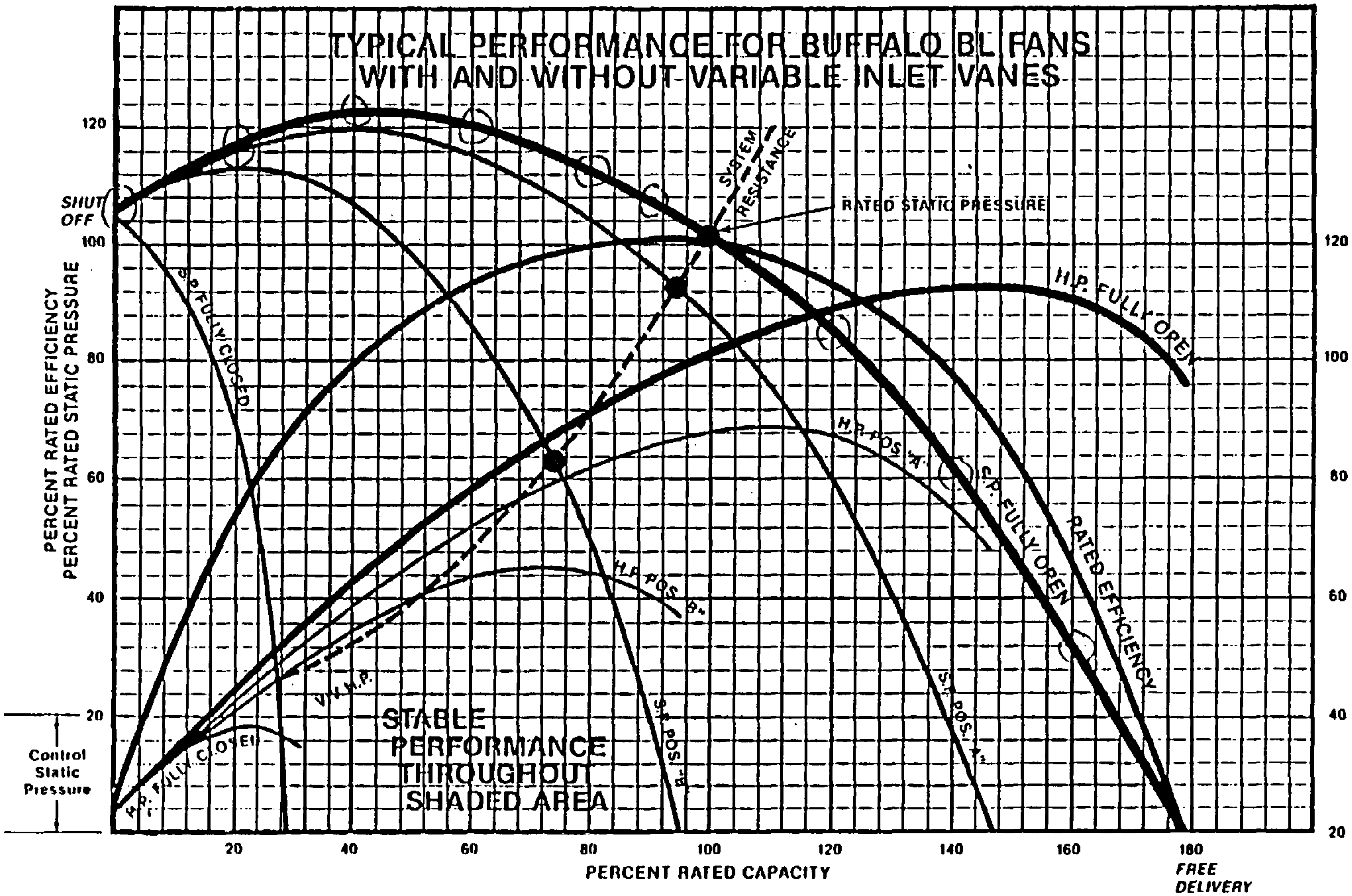


Some information may be obliterated but may be deduced from Attachment III, pages 7 thru 14.





Fan 1	Pressure in.w.g.	Airflow kcfm
	16.400	50.00
	14.000	110.00
	12.200	200.00
	12.300	245.00
	12.300	285.00
	10.800	340.00
	8.400	400.00
	6.000	440.00
	4.000	460.00
	2.000	480.00



Fan 33

Base 100%	12.5021	98.583			
..	%Pressure	% Volume	%Efficienc	Pressure Inch WG	Volume kcfm
1	106	0	0	13.25	0.00
2	116	20	54	14.50	19.72
3	122	40	79	15.25	39.43
4	120	60	93	15.00	59.15
5	112	80	100	14.00	78.87
6	106	90	101	13.25	88.72
7	100	100	100	12.50	98.58
8	86	120	93	10.75	118.30
9	60	140	77	7.50	138.02
10	32	160	46	4.00	157.73

Output File Name: OUTPUT.TMP
Network File Name: REPVA0A4
Network Title: REPOSITORY VENTILATION
Mine Name: YUCCA MOUNTAIN PROJECT
Company: M&O/MK/RSJURANI
Comments: CARETAKER/ONE AUX.FAN/ONE PRIME FAN

Fan Model Buffalo Typical BL Unit
Variable Speed Centrifugal Fan
VNETPC Fan Bank # 33
By Permission: Buffalo Howden
Reference 5.31

VENTILATION APPROACHES FOR DEVELOPMENT AREA CONSTRUCTION

The underground layout and development sequence are established. Ventilation volume for construction drifts are provided through ducts or drifts. For the purpose of comparison, both the minimum drift air velocity of 0.51 m/s (100 fpm) and 0.15 m/s (30 fpm) are evaluated. Ventilation design delivery specification is provided with 15% fluctuation factor and 25% leakage as discussed in Section 7.4.1 and Table 7.4.2.

Each option evaluated has an airflow schematic. The schematic shows corresponding air quantity to the work areas to satisfy the ventilation design delivery specification. More information of each option is discussed in Section 7.7.6. The schematic has also the distances and sizes of airways needed. A spreadsheet is made to calculate the pressure losses and energy requirement of each scenario evaluated. Calculation formula are shown in the headings of the spreadsheet.

There are six cases evaluated in this attachment:

1. Ducted Exhaust Air (Base minimum air velocity at 0.51 m/s (100 fpm)
   - A) Equipment Spreadsheet Calculation, Page 2
   - B) Airflow Circuit Schematic, Page 3

2. Ducted Intake and Exhaust Air (Base minimum air velocity at 0.51 m/s (100 fpm)
   - A) Equipment Spreadsheet Calculation, Page 4
   - B) Airflow Circuit Schematic, Page 5

3. Flow Through Ventilation (Base minimum air velocity at 0.51 m/s (100 fpm)
   - A) Equipment Spreadsheet Calculation, Page 6
   - B) Airflow Circuit Schematic, Page 7

4. Ducted Exhaust Air (Base minimum air velocity at 0.15 m/s (30 fpm)
   - A) Equipment Spreadsheet Calculation, Page 8
   - B) Airflow Circuit Schematic, Page 9

5. Ducted Intake and Exhaust Air (Base minimum air velocity at 0.15 m/s (30 fpm)
   - A) Equipment Spreadsheet Calculation, Page 10
   - B) Airflow Circuit Schematic, Page 11

6. Flow Through Ventilation (Base minimum air velocity at 0.15 m/s (30 fpm)
   - A) Equipment Spreadsheet Calculation, Page 12
   - B) Airflow Circuit Schematic, Page 13

Discussions of advantages and disadvantages of each option are found in Section 7.7.6.

FILE # REPBOC1, Estimation of airflow, ventilation duct lengths and sizes, fans and power requirement.

Option - Ducted Exhaust Air, Minimum Air Velocity Base = 100 fpm | Base 100 fpm

Airway Description	Air Quantity q cfm	Qm cms	Air Quantity for calc cfm	FRICTION FACTOR K (x10^-10)	Length of airway L (ft)	Length of airway Lm (m)	Airway Diameter d (inches)	Airway Perimeter p (ft)	Airway Cross Area A (ft^2)	Airway Resistance R = KPL/(5.2A^3)	Total Static Head Loss H = RQ^2 inch wg Q in q/100000	Air HP Total AHP = H*q/6345 Q q in 1000 units	Brake HP 70% eff Total BHP = AHP/0.7	Fans Model (SPECIAL Joy Fan Reference)	Fan Unit/Characteristics cfm @ inch wg/BHP motor	No of Fan Units	Fan Spacing meters
Intake System																	
West Main Supply (drift)	415000	195 88	415000	70	13376	4077	276	72 26	415 48	0 18	3 12	204	292				
Exhaust Main Drift (drift)	110000	51 92	110000	70	13556	4132	276	72 26	415 48	0 18	0 22	4	6				
South Main Airlock (drift)	35000	16 52	35000	70	2900	884	276	72 26	415 48	0 04	0 00	0	0				
Total Intake	560000	264.32															
Tributary Intake Airway																	
Development Shaft & Drift	560000	264 32	560000	95	1352	412	240	62 83	314 16	0 05	1 57	139	198				
South Main (Shaft to Exh Main)	145000	68 44	145000	70	1319	402	276	72 26	415 48	0 02	0 04	1	1				
												Total Power Intake	497 BHP				
Return System																	
East main return (duct)	141500	66 79	141500	20	13576	4138	66	17 28	23 76	67 28	134.70	3004	4291	M72-50-1180	141500@14"wg/450	10	414
East main return (drift)	217000	102 42	217000	70	13576	4138	276	72 26	415 48	0 18	0 87	30	42				
Exhaust main return (duct)	60000	28 32	60000	20	13556	4132	66	17.28	23 76	67 18	24 18	229	327	48-26-1770	60000@10"wg/150	3	1377
West main return (duct)	106500	50 27	106500	20	14695	4479	66	17.28	23 76	72 82	82 60	1386	1981	M60-36-1780	106500@17"wg/400	5	896
South Main Airlock (drift)	35000	16.52	35000	70	0	0	276	72.26	415 48	0 00	0 00	0	0				
Total Return	560000	264.32															
Tributary Return Airway																	
South Main (duct 1)	83250	39 29	83250	20	2900	884	66	17 28	23.76	14 37	9 96	131	187	60-30-1180	83250@10"wg/200	1	884
South Main (duct 2)	83250	39 29	83250	20	2900	884	66	17 28	23 76	14.37	9 96	131	187	60-30-1180	83250@10"wg/200	1	884
South Ramp (Exhaust duct 1)	154000	72 69	154000	20	4921	1500	72	18 85	28 27	15 78	37.43	909	1298	M72-50-1180	154000@15"wg/500	3	500
South Ramp (Exhaust duct 2)	154000	72 69	154000	20	4921	1500	72	18 85	28.27	15.78	37 43	909	1298	M72-50-1180	154000@15"wg/500	3	500
South Ramp	252000	118 94	252000	70	4921	1500	276	72 26	415.48	0 07	0 42	17	24				
												Total Power Return	9,634 BHP		Primary Fan-Dev. Shaft (SURFACE)	1	

Intake Supply - Duct Installation and Maintenance

None

Return - Duct Installation and Maintenance

a) 66" dia x 13576' (4138m) East Main Exhaust
b) 66" dia x 13556' (4132m) Exhaust Main Duct
c) 66" dia x 14695' (4479m) West Main
d) 66" dia x 2900' (884m) South Main Duct 1
e) 66" dia x 2900' (884m) South Main Duct 2
f) 72" dia x 4921' (1500m) South Ramp Duct 1
g) 72" dia x 4921' (1500m) South Ramp Duct 2

Total 66" Di	47627	ft	14517	m
Total 72" Di	9842	ft	3000	m
Total ducts	57469		17517	

Total length of duct = 57469 ft = 17517 m

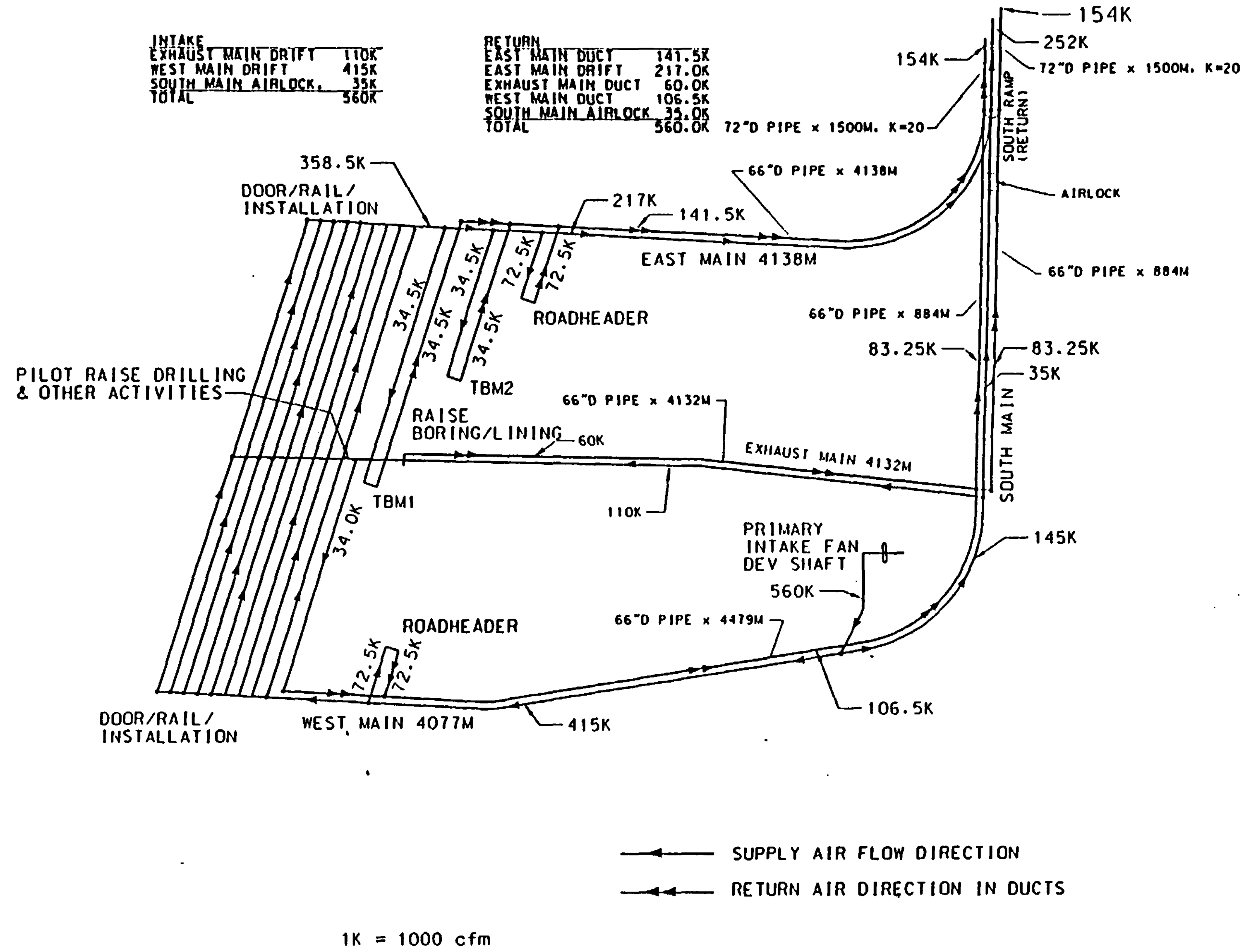
Total Energy Requirement (hp)* 7092 Ahp 10131 Bhp

Total fan units* 27

* Excluding auxiliary ventilation equipment for the faces or headings of excavation.

INTAKE	
EXHAUST MAIN DRIFT	110K
WEST MAIN DRIFT	415K
SOUTH MAIN AIRLOCK.	35K
TOTAL	560K

RETURN	
EAST MAIN DUCT	141.5K
EAST MAIN DRIFT	217.0K
EXHAUST MAIN DUCT	60.0K
WEST MAIN DUCT	106.5K
SOUTH MAIN AIRLOCK	35.0K
TOTAL	560.0K



REFERENCE 7.7.6.1
DUCTED EXHAUST AIR

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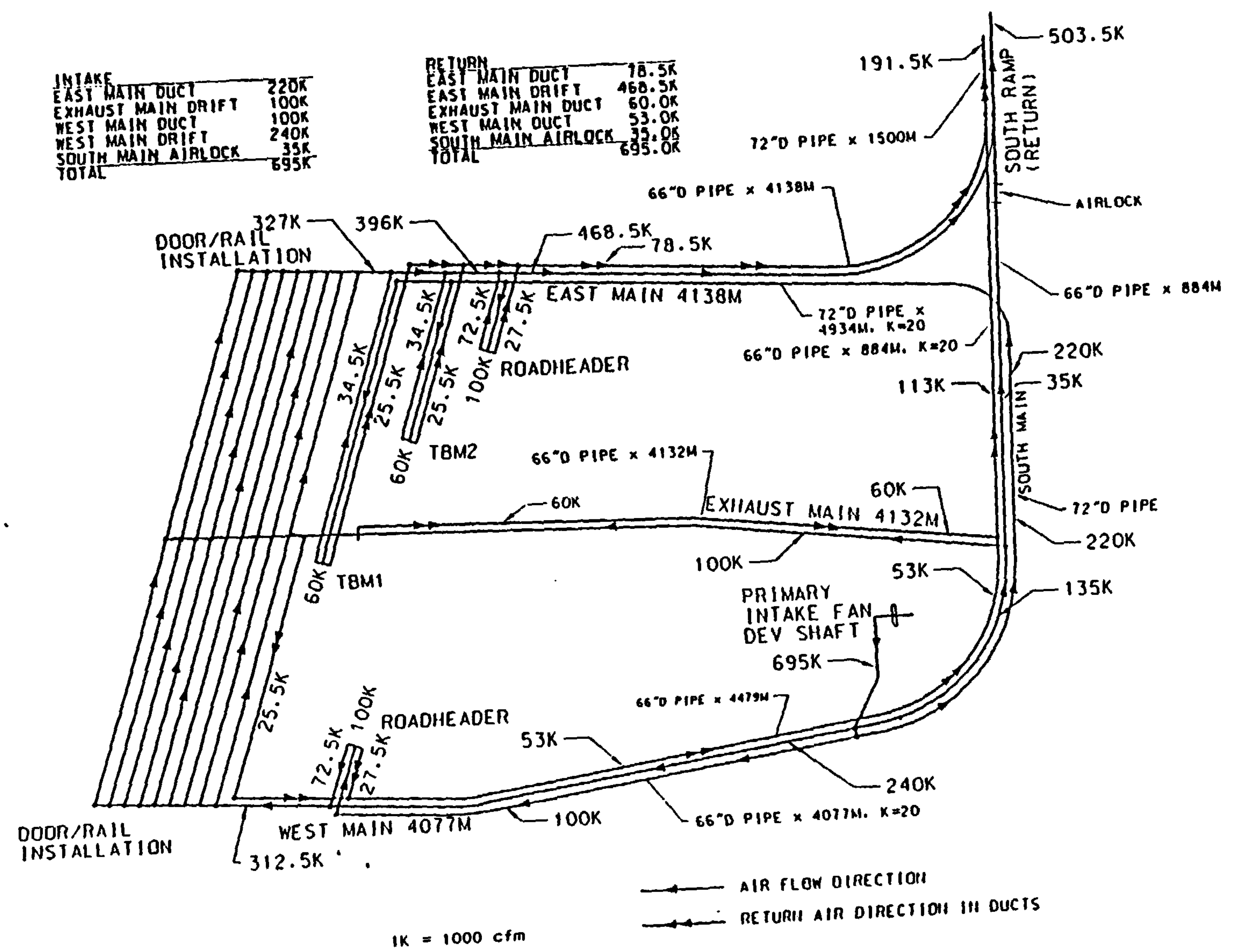
FILE # REPBOC1, Estimation of airflow, ventilation duct lengths and sizes, fans and power requirement

Option - Ducted Intake and Exhaust Air, Minimum Air Velocity Base = 100 fpm | Base 100 fpm

Airway Description	Air Quantity q cfm	Qm cms	Air Quantity for calc cfm	FRICTION FACTOR K (x10^-10)	Length of airway L (ft)	Length of airway Lm (m)	Airway Diameter d (inches)	Airway Perimeter p (ft)	Airway Cross Area A (ft^2)	Airway Resistance R = KPL/5.2A^3	Total Static Head Loss H = RQ^2 inch wg Q in q/100000	Air HP Total AHP = H*q/6345 Q=q in 100000 units	Brake HP 70% eff Total BHP = AHP/0.7	Fans Model (SPECIAL Joy Fan Reference)	Fan Unit/Characteristics cfm @ inch wg/BHP motor	No of Fan Units	Fan Spacing meters
Intake System																	
East main supply (duct)	220000	103 84	220000	20	16188	4934	72	18 85	28 27	51 92	251 29	8713	12447	M72-50-1180	220000@14"wg/700BH	18	274
Exhaust Main Drift (drift)	100000	47.20	100000	70	13556	4132	276	72 26	415 48	0 18	0 18	3	4				
West Main Supply (duct)	100000	47 20	100000	20	13376	4077	66	17 28	23 76	66 29	66 29	1045	1492	M60-36-1780	100000@16 5"wg/350B	4	1019
West Main Supply (drift)	240000	113 28	240000	70	13376	4077	276	72 26	415 48	0 18	1 04	40	56				
South Main Airlock	35000	16.52	35000	70	2900	884	276	72 26	415 48	0 04	0 00	0	0				
Total Intake	**695000**	**328.04**															
Tributary Intake Airway																	
Development Shaft & Drift	695000	328 04	695000	95	1352	412	240	62 83	314.16	0 05	2 42	265	378				
South Main (Shaft to Exh Main)	135000	63.72	135000	70	1319	402	276	72.26	415.48	0 02	0 03	1	1				
												Total Power Intake	14,379 BHP				
Return System																	
East main return (duct)	78500	37 05	78500	20	13576	4138	66	17 28	23.76	67 28	41 46	513	733	48-26-1770	78500@11"wg/200BHP	4	1035
East main return (drift)	468500	221.13	468500	70	13576	4138	276	72 26	415 48	0 18	4 04	298	426				
Exhaust main return (duct)	60000	28.32	60000	20	13556	4132	66	17.28	23 76	67 18	24 18	229	327	48-26-1770	60000@10"wg/150BHP	3	1377
West main return (duct)	53000	25 02	53000	20	14695	4479	54	14 14	15 90	198 61	55 79	466	666	48-26-1770	53000@10"wg/125BHP	6	747
South Main Airlock	35000	16.52	35000	70	0	0	276	72 26	415.48	0.00	0.00	0	0				
Total Return	**695000**	**328.04**															
Tributary Return Airway																	
South Main (duct)	113000	53 34	113000	20	2900	884	66	17 28	23.76	14 37	18 35	327	467	M60-36-1780	113000@18 5"wg/450B	1	884
South Ramp (Exhaust duct)	191500	90 39	191500	20	4921	1500	72	18 85	28 27	15 78	57.88	1747	2496	M72-50-1180	191500@16"wg/700BH	4	375
South Ramp	503500	237 65	503500	70	4921	1500	276	72.26	415 48	0 07	1 69	134	192				
												Total Power Return	5,306 BHP				
	Intake Supply - Duct Installation and Maintenance						Return - Duct Installation and Maintenance										
	a) 66" dia x 13376' (4077m) West Main						a) 66" dia x 13576' (4138m) East Main Exhaust								Primary Fan-Dev Shaft (SURFACE)	1	
	b) 72" dia x 16188' (4934m) Shaft to East Main Supply						b) 66" dia x 13556' (4132m) Exhaust Main Duct										
							c) 54" dia x 14695' (4479m) West Main										
							d) 66" dia x 2900' (884m) South Main										
							e) 72" dia x 4921' (1500m) South Ramp										
								Total 54" Di	14695	ft	4479	m					
								Total 66" Di	30032	ft	9154	m					
								Total 72" Di	4921	ft	1500	m					
				29564	ft				49648		15133						
	Total length of duct =			79212	ft =	24144	m		Total Energy Requirement (hp) *			13780 Ahp	19685 Bhp		Total fan units*	41	
										* Not including auxiliary ventilation equipment for the faces or headings of excavation.							



REFERENCE 7.7.6.2
DUCTED INTAKE & EXHAUST AIR

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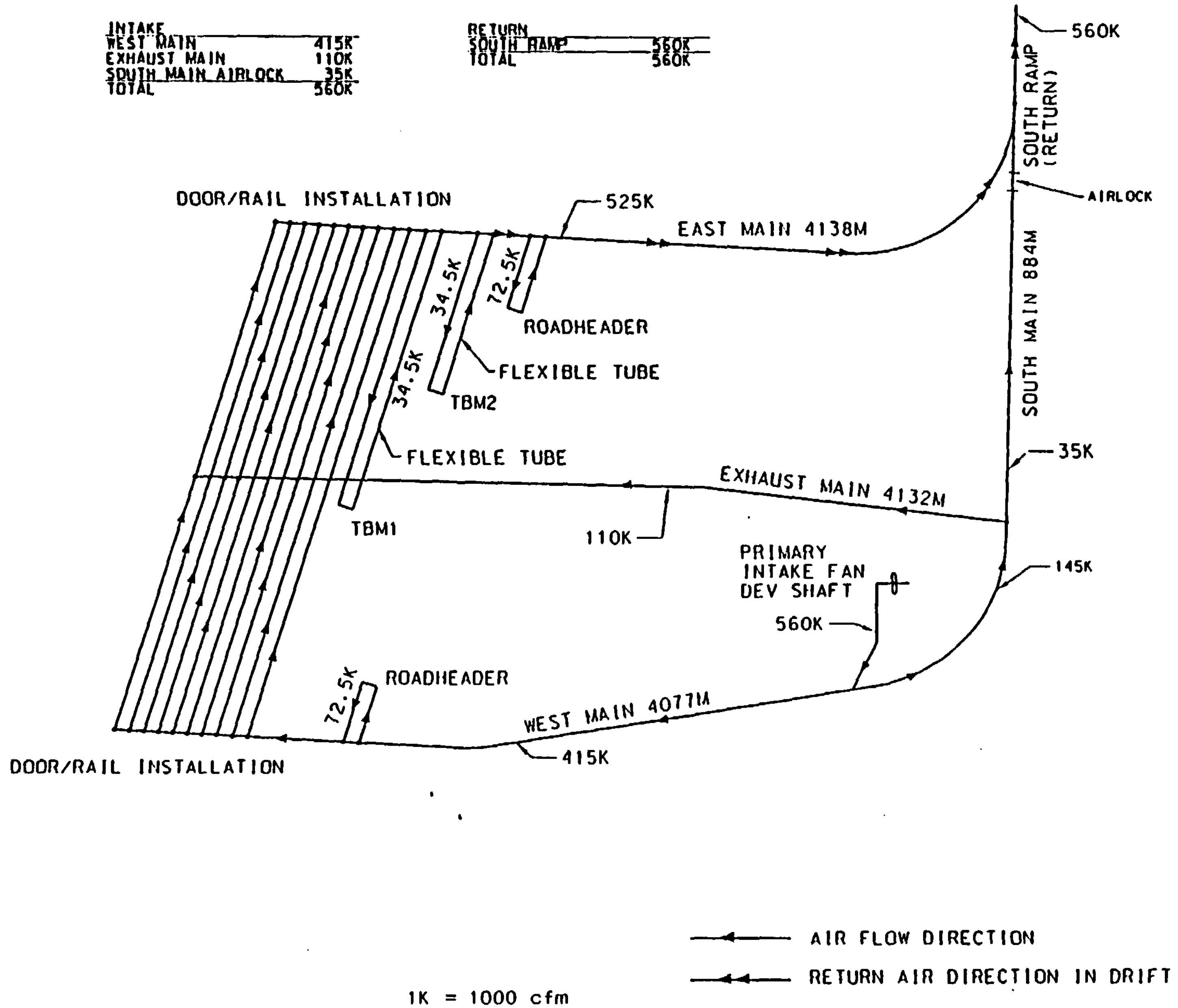
FILE # REPBOC1, Estimation of airflow, ventilation duct lengths and sizes, fans and power requirement

Option - Optimum Flow Through Ventilation, Minimum Air Velocity Base = 100 fpm Base 100 fpm

Energy requirement and duct calculation

Airway Description	Air Quantity q cfm	Qm cms	Air Quantity for calc cfm	FRICTION FACTOR K (x10^-10)	Length of airway L (ft)	Length of airway Lm (m)	Airway Diameter d (inches)	Airway Perimeter p (ft)	Airway Cross Area A (ft^2)	Airway Resistance R = KPL/5.2A^3	Total Static Head Loss H = RQ^2 inch wg (Q in q/100000)	Air HP * Total AHP = H*q/6345 (Q-q in 1000-0 units)	Brake HP 70% eff Total BHP = AHP/0.7	Fans Model (SPECIAL Joy Fan Reference)	Fan Unit/Characteristics cfm @ inch wg/BHP motor	No. of Fan Units	Fan Spacing meters
Intake System																	
West Main Supply (drift)	415000	195 88	415000	70	13376	4077	276	72 26	415 48	0 18	3 12	204	292				
Exhaust Main Drift (drift)	110000	51.92	110000	70	13556	4132	276	72 26	415 48	0 18	0 22	4	6				
South Main Airlock (drift)	35000	16 52	35000	70	2900	884	276	72.26	415 48	0 04	0 00	0	0				
Total Intake	560000	264.32															
Tributary Intake Airway																	
Development Shaft & Drift	560000	264 32	560000	95	1352	412	240	62 83	314 16	0 05	1 57	139	198				
South Main (Shaft to Exh Main)	145000	68 44	145000	70	1319	402	276	72 26	415 48	0 02	0 04	1	1				
Return System																	
East main return (drift)	525000	247 80	525000	70	13576	4138	276	72 26	415 48	0 18	5 07	420	600				
South Main Airlock (drift)	35000	16 52	35000	70	0	0	276	72.26	415 48	0 00	0 00	0	0				
Total Return	560000	264.32															
Tributary Return Airway																	
South Ramp	560000	264.32	560000	70	4921	1500	276	72 26	415.48	0 07	2 09	185	264				
	Intake Supply - Duct Installation and Maintenance							Return - Duct Installation and Maintenance							Primary Fan-Dev Shaft (SURFACE)	1	
		None							None								
	Total length of duct =			0	ft =	0	m		Total Energy Requirement (hp)*			952	1360		Total fan unit*	1	
												Ahp	Bhp				

* Excluding auxiliary ventilation equipment for the faces or headings of excavation



REFERENCE 7.7.6.3
DEVELOPMENT FLOW THROUGH VENTILATION

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FILE # REPBOC1, Estimation of airflow, ventilation duct lengths and sizes, fans and power requirement.

Option - Ducted Exhaust Air, Minimum Air Velocity Base = 30 fpm | base 30 fpm

Airway Description	Air Quantity q cfm	Qm cms	Air Quantity for calc cfm	FRICTION FACTOR K (x10^-10)	Length of airway L (ft)	Length of airway Lm (m)	Airway Diameter d (inches)	Airway Perimeter p (ft)	Airway Cross Area A (ft^2)	Airway Resistance R = KPL/5.2A^3	Total Static Head Loss H = RQ^2 inch wg Q in q/100000	Air HP Total AHP = H*q/6345 Q=q in (1000)	Brake HP 70% eff Total BHP = AHP/0.7 units	Fans Model (SPECIAL Joy Fan Reference)	Fan Unit/Characteristics cfm @ inch wg/BHP motor	No. of Fan Units	Fan Spacing meters
Intake System																	
West Main Supply (drift)	152100	71.79	152100	70	13376	4077	276	72.26	415.48	0.18	0.42	10	14				
Exhaust Main Drift (drift)	46200	21.81	46200	70	13556	4132	276	72.26	415.48	0.18	0.04	0	0				
South Main Airlock (drift)	23100	10.90	23100	70	2900	884	276	72.26	415.48	0.04	0.00	0	0				
Total Intake	221400	104.50															
Tributary Intake Airway																	
Development Shaft & Drift	221400	104.50	221400	95	1352	412	240	62.83	314.16	0.05	0.25	9	12				
South Main (Shaft to Exh Main)	69300	32.71	69300	70	1319	402	276	72.26	415.48	0.02	0.01	0	0				
												Total Power Intake		27			
Return System																	
East main return (duct)	52700	24.87	52700	20	13576	4138	54	14.14	15.90	183.49	50.96	423	605	48-26-1770	52700@9"wg/100	6	690
East main return (drift)	90400	42.67	90400	70	13576	4138	276	72.26	415.48	0.18	0.15	2	3				
Exhaust main return (duct)	23100	10.90	23100	20	13556	4132	36	9.42	7.07	1391.37	74.25	270	386	36-26-1770/2	23100@17"wg/100	5	826
West main return (duct)	32100	15.15	32100	20	14695	4479	42	11.00	9.62	697.80	71.90	364	520	38-26-1770	32100@17"wg/125	5	896
South Main Airlock (drift)	23100	10.90	23100	70	0	0	276	72.26	415.48	0.00	0.00	0	0				
Total Return	221400	104.50															
Tributary Return Airway																	
South Main (duct)	55200	26.05	55200	20	2900	884	54	14.14	15.90	39.20	11.94	104	148	48-26-1770	55200@12"wg/125/2s	1	884
South Ramp (Exhaust duct 1)	107900	50.93	107900	20	4921	1500	66	17.28	23.76	24.39	28.39	483	690	60-30-1170/2	107900@12"wg/250	3	500
South Ramp	113500	53.57	113500	70	4921	1500	276	72.26	415.48	0.07	0.09	2	2				
							Return - Duct installation and Maintenance										
							a) 54" dia x 13576' (4138m) East Main Exhaust					Total		2354			
	Intake Supply - Duct Installation and Maintenance						b) 36" dia x 13556' (4132m) Exhaust Main Duct					Power			Primary Fan-Dev. Shaft	1	
							c) 42" dia x 14695' (4479m) West Main					Return			(SURFACE)		
		None					d) 54" dia x 2900' (884m) South Main Duct										
							e) 66" dia x 4921' (1500m) South Ramp Duct										
								Total 36" Di	13556	ft	4132	m					
								Total 42" Di	14695	ft	4479	m					
								Total 54" Di	16476	ft	5022	m					
								Total 66" Di	4921	ft	1500	m					
								Total ducts	49648	ft	15133	m					
									Total Energy Requirement (hp) *			1667	2381		Total fan units*	21	
												Ahp	Bhp				
										* Excluding auxiliary ventilation equipment for the faces or headings of excavation.							

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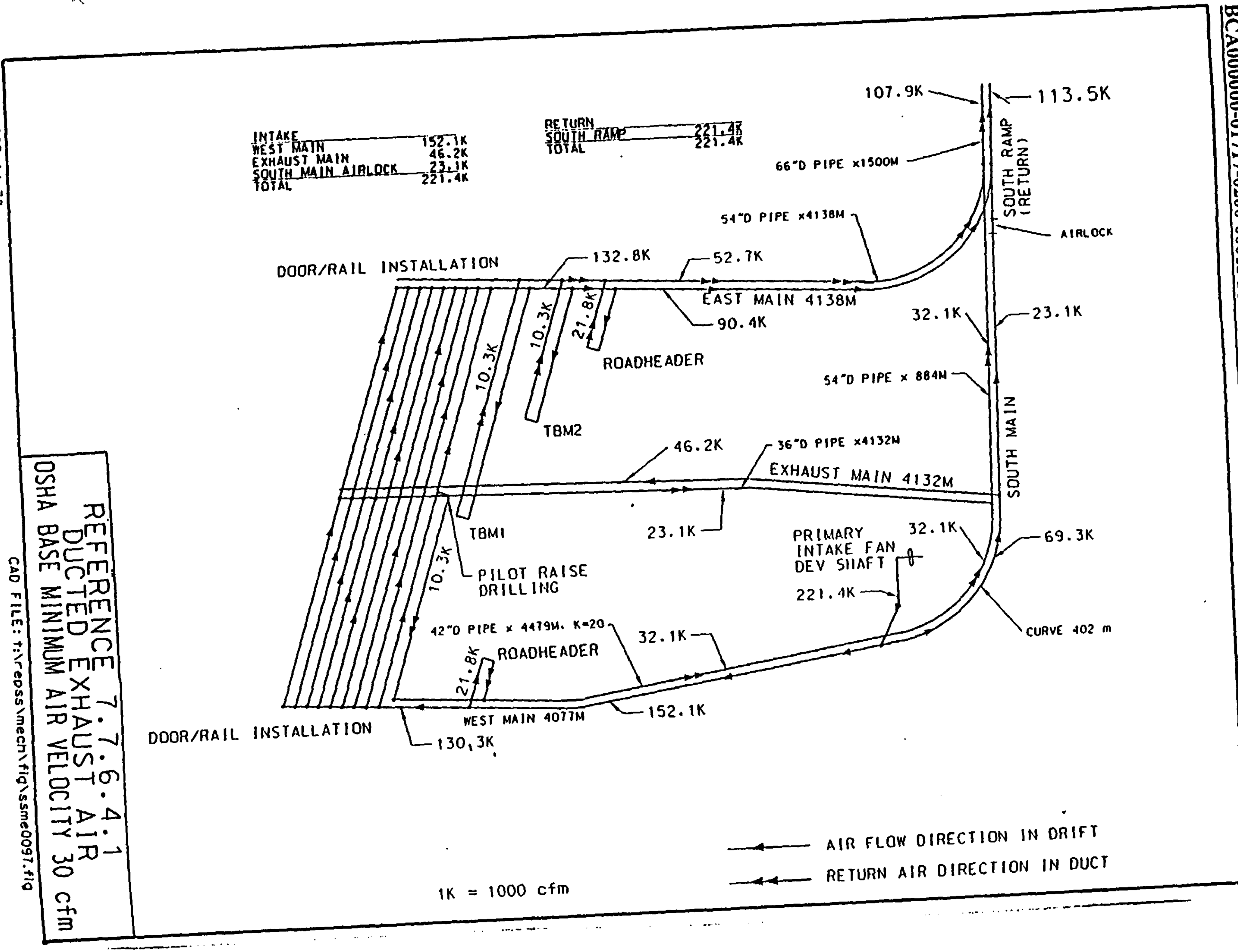
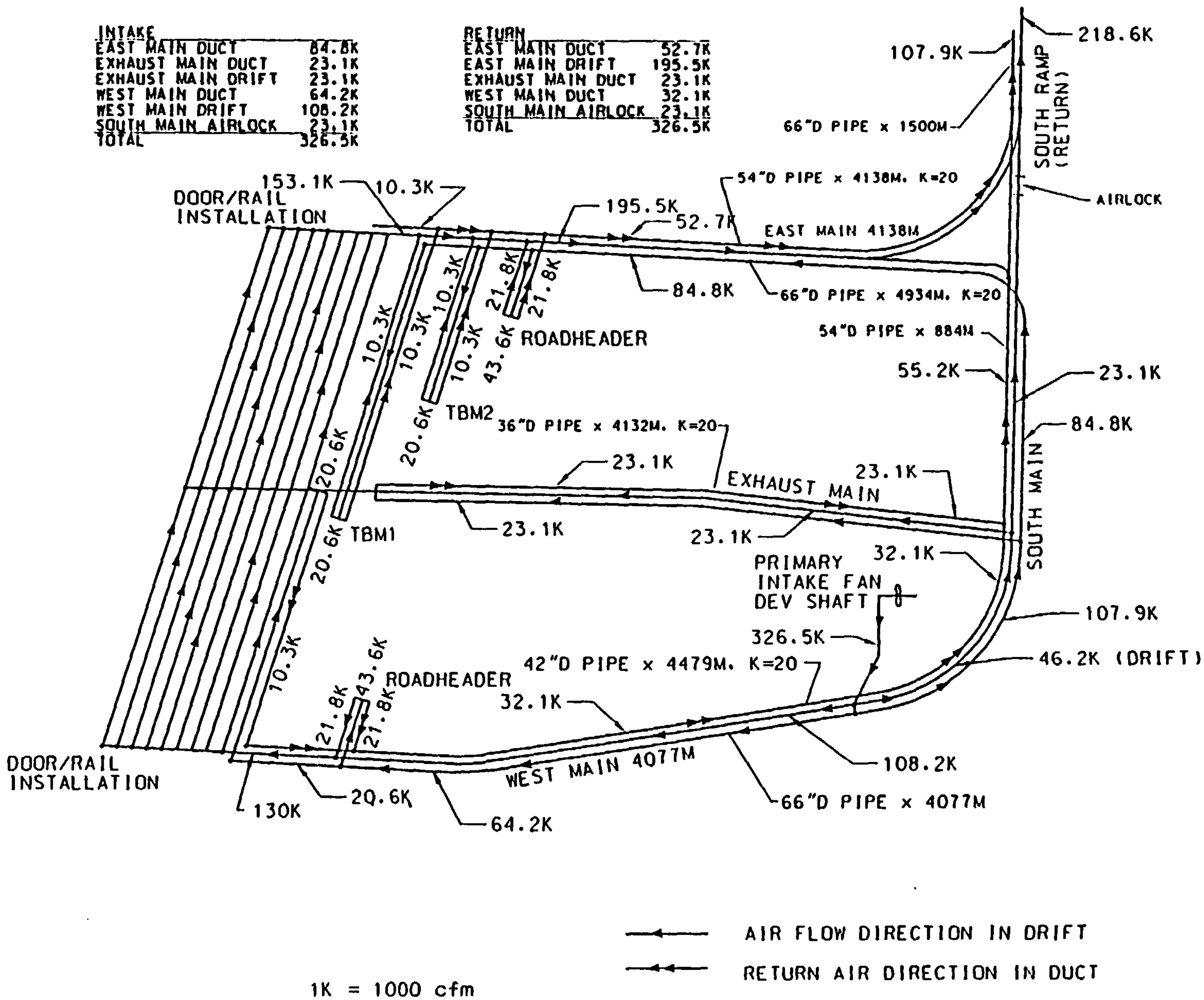


FILE # REPBOC1, Estimation of airflow, ventilation duct lengths and sizes, fans and power requirement.																	
Option - Ducted Intake and Exhaust Air, Minimum Air Velocity Base =						30 fpm							Base 30 fpm				
Airway Description	Air Quantity q cfm	Qm cms	Air Quantity for calc cfm	FRICTION FACTOR K (x10^-10)	Length of airway L (ft)	Length of airway Lm (m)	Airway Diameter d (inches)	Airway Perimeter p (ft)	Airway Cross Area A (ft^2)	Airway Resistance R = KPL/(5.2A^3)	Total Static Head Loss H = RQ^2 inch wg Q in q/100000	Air HP Total AHP = H*q/6345 Q=q in 100000 units	Brake HP 70% eff Total BHP = AHP/0.7	Fans Model (SPECIAL Joy Fan Reference)	Fan Unit/Characteristics cfm @ inch wg/BHP motor	No of Fan Units	Fan Spacing meters
Intake System																	
East main supply (duct)	84800	40 03	84800	20	16188	4934	66	17 28	23 76	80 22	57 69	771	1101	60-30-1170	84800@13"wg/250BHP	5	987
Exhaust Main Drift (drift)	23100	10 90	23100	70	13556	4132	276	72 26	415 48	0 18	0 01	0	0				
Exhaust Main Drift (duct)	23100	10 90	23100	20	13556	4132	36	9 42	7 07	1391 37	74 25	270	386	36-26-1770/2	23100@17"wg/100	5	826
West Main Supply (duct)	64200	30 30	64200	20	13376	4077	66	17 28	23 76	66 29	27 32	276	395	48-26-1770	64200@10"wg/125BHP	3	1359
West Main Supply (drift)	108200	51.07	108200	70	13376	4077	276	72 26	415 48	0 18	0 21	4	5				
South Main Airlock	23100	10.90	23100	70	2900	884	276	72 26	415 48	0 04	0 00	0	0				
Total Intake	326500	154.11															
Tributary Intake Airway																	
Development Shaft & Drift	326500	154.11	326500	95	1352	412	240	62 83	314 16	0 05	0 53	27	39				
South Main (Shaft to Exh Main)	46200	21 81	46200	70	1319	402	276	72.26	415 48	0 02	0 00	0	0				
												Total		1927			
												Power					
												Intake					
Return System																	
East main return (duct)	52700	24 87	52700	20	13576	4138	54	14.14	15 90	183 49	50 96	423	605	48-26-1770	52700@9"wg/100	6	690
East main return (drift)	195500	92 28	195500	70	13576	4138	276	72 26	415 48	0 18	0 70	22	31				
Exhaust main return (duct)	23100	10 90	23100	20	13556	4132	36	9.42	7 07	1391 37	74 25	270	386	36-26-1770/2	23100@17"wg/100	3	1377
West main return (duct)	32100	15.15	32100	20	14695	4479	42	11 00	9 62	697 80	71.90	364	520	38-26-1770	32100@17"wg/125	6	747
South Main Airlock	23100	10.90	23100	70	0	0	276	72.26	415 48	0 00	0.00	0	0				
Total Return	326500	154.11															
Tributary Return Airway																	
South Main (duct)	55200	26.05	55200	20	2900	884	54	14 14	15 90	39 20	11 94	104	148	48-26-1770	55200@12"wg/125/2s	1	884
South Ramp (Exhaust duct)	107900	50 93	107900	20	4921	1500	66	17.28	23 76	24 39	28 39	483	690	60-30-1170/2	107900@12"wg/250	4	375
South Ramp	218600	103.18	218600	70	4921	1500	276	72 26	415.48	0 07	0.32	11	16				
	Intake Supply - Duct Installation and Maintenance						Exhaust Duct Installation and Maintenance										
	a) 36" dia x 13556' (4132m) Exhaust Main						a) 54" dia x 13576' (4138m) East Main Exhaust					Total		2395			
	b) 66" dia x 16188' (4934m)			Shaft/West Main to East Main Supply			b) 36" dia x 13556' (4132m) Exhaust Main Duct					Power					
	c) 66" dia x 13376' (4077m)			West Main Supply			c) 42" dia x 14695' (4479m) West Main					Return					
							d) 54" dia x 2900' (884m) South Main Duct								Primary Fan-Dev Shaft	1	
	Total 36	13556	ft	4132	m		e) 66" dia x 4921' (1500m) South Ramp Duct								(SURFACE)		
	Total 66	29564	ft	9011	m												
								Total 36" Di	13556	ft	4132	m					
								Total 42" Di	14695	ft	4479	m					
	Total							Total 54" Di	16476	ft	5022	m					
	Ducts	43120	ft	13143	m			Total 66" Di	4921	ft	1500	m					
								Total ducts	49648	ft	15133	m					
									Total Energy Requirement (hp)*			3026	4322		Total fan units*	34	
												Ahp	Bhp				
										* Not including auxiliary ventilation equipment for the faces or headings of excavation.							



REFERENCE 7.7.6.4.2
DUCTED INTAKE & EXHAUST AIR
OSHA BASE MINIMUM AIR VELOCITY 30 cfm

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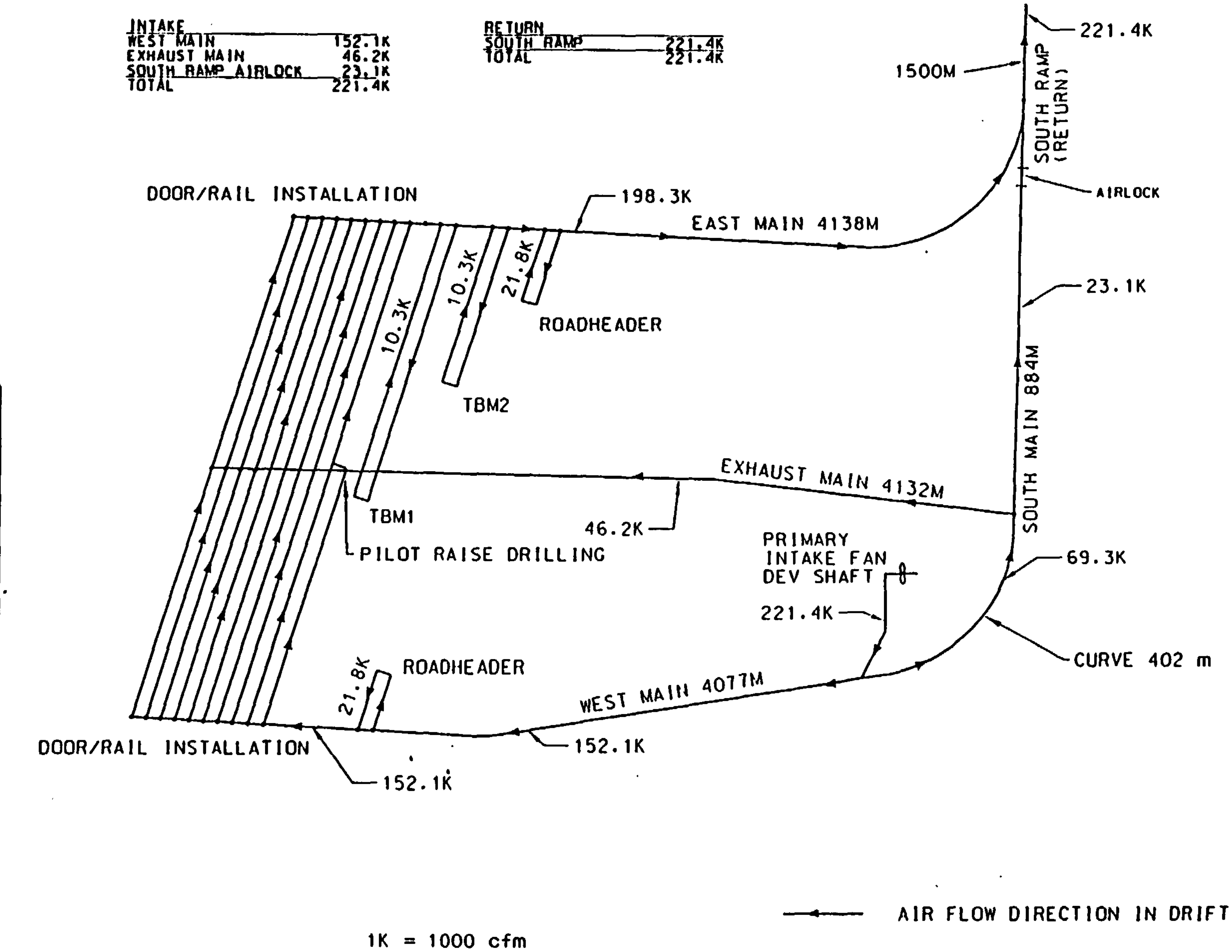
FILE # REPBOC1, Estimation of airflow, ventilation duct lengths and sizes, fans and power requirement

Option - Optimum Flow Through Ventilation, Minimum Air Velocity Base = 30 fpm — base 30 fpm

Energy requirement and duct calculation

Airway Description	Air Quantity q cfm	Qm cms	Air Quantity for calc cfm	FRICTION FACTOR K (x10^-10)	Length of airway L (ft)	Length of airway Lm (m)	Airway Diameter d (inches)	Airway Perimeter P (ft)	Airway Cross Area A (ft^2)	Airway Resistance R = KPL/(5.2A^3)	Total Static Head Loss H = RQ^2 inch wg, Q in q/100000	Air HP Total AHP = H*q/6345, Q=q in 100000 units	Brake HP 70% eff Total BHP = AHP/0.7	Fans Model (SPECIAL Joy Fan Reference)	Fan Unit/Characteristics cfm @ inch wg/BHP motor	No. of Fan Units	Fan Spacing meters
Intake System																	
West Main Supply (drift)	152100	71.79	152100	70	13376	4077	276	72.26	415.48	0.18	0.42	10	14				
Exhaust Main Drift (drift)	46200	21.81	46200	70	13556	4132	276	72.26	415.48	0.18	0.04	0	0				
South Main Airlock (drift)	23100	10.90	23100	70	2900	884	276	72.26	415.48	0.04	0.00	0	0				
*Total Intake	221400	104.50															
Tributary Intake Airway																	
Development Shaft & Drift	221400	104.50	221400	95	1352	412	240	62.83	314.16	0.05	0.25	9	12				
South Main (Shaft to Exh Main)	23100	10.90	23100	70	1319	402	276	72.26	415.48	0.02	0.00	0	0				
Return System																	
East main return (drift)	198300	93.60	198300	70	13576	4138	276	72.26	415.48	0.18	0.72	23	32				
South Main Airlock (drift)	23100	10.90	23100	70	0	0	276	72.26	415.48	0.00	0.00	0	0				
Total Return	221400	104.50															
Tributary Return Airway																	
South Ramp	221400	104.50	221400	70	4921	1500	276	72.26	415.48	0.07	0.33	11	16				
	Intake Supply - Duct Installation and Maintenance							Return - Duct Installation and Maintenance							Primary Fan-Dev. Shaft (SURFACE)	1	
		None							None								
	Total length of duct =			0	ft =	0	m		Total Energy Requirement (hp)*			53 Ahp	76 Bhp		Total fan unit*	1	

* Excluding auxiliary ventilation equipment for the faces or headings of excavation



REFERENCE 7.7.6.4.3
FLOW THROUGH VENTILATION
OSHA BASE MINIMUM AIR VELOCITY 30 cfm

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Predicting Air Psychrometry of Repository Environment

The psychrometric properties of air is determined with three conditions given, namely:

td - temperature dry bulb, °F
tw - temperature wet bulb, °F
P*b* - barometric pressure, inch Hg

The air characteristic is calculated by the following formulas (Reference 5.6, p 596):

Saturated Vapor Pressure (at *td*), Ps
Ps = 0.18079e^(((17.27*td*)-552.64)/(*td*+395.14)), inches Hg

Saturated Vapor Pressure (at t*w*), Ps'
Ps' = 0.18079e^(((17.27t*w*)-552.64)/(t*w*+395.14)), inches Hg

Vapor Pressure, P*v*
P*v* = Ps'-((P*b*-Ps')(*td*-t*w*))/(2800-1.3t*w*), inches Hg

Relative Humidity, R
R = (P*v*/Ps)100%

Specific Humidity, W
W = 0.622(P*v*/(P*b*-P*v*)), lb/lb dry air

Grains Specific Humidity, G
G = 7000W = 7000(0.622)(P*v*/(P*b*-P*v*)), grains water vapor/lb dry air

Specific Volume, v
v = 53.35(460+*td*)/((P*b*-P*v*)(0.491)(144), ft^3/lb

Moist Air density, w
w = (1.325/(460+*td*))(P*b*-.378Ps'), lb/ft^3

Enthalpy, h
h = 0.24*td*+W(1060+0.45*td*), Btu/lb dry air

These formulas are applied to tabulate the air characteristics shown in succeeding pages of Attachment V.

Description of Table as Used in the Analysis

Page 3 - General psychrometry of air supply (inlet side) for typical emplacement drift at temperature dry bulb, td = 50 to 80 °F, relative humidity at 20, 25, 30, 35 & 40 %.

Page 4 - Air psychrometry of exhaust air from emplacement drift after heating it to temperature dry bulb, td = 95 to 392 °F and moisture content of air, G = 26 & 30 grains of moisture/lb dry air.

Page 5 - Air psychrometry of exhaust air from emplacement drift after heating it to temperature dry bulb, td = 95 to 392 °F and moisture content of air, G = 35 & 40 grains of moisture/lb dry air.

Page 6 - Air psychrometry of exhaust air from emplacement drift after heating it to temperature dry bulb, td = 95 to 392 °F and moisture content of air, G = 50 & 60 grains of moisture/lb dry air.

Page 7 - Air psychrometry of exhaust air from emplacement drift after heating it to temperature dry bulb, td = 95 to 392 °F and moisture content of air, G = 70 & 80 grains of moisture/lb dry air.

Page 8 - Air psychrometry of exhaust air from emplacement drift after heating it to temperature dry bulb, td = 95 to 392 °F and moisture content of air, G = 100 & 120 grains of moisture/lb dry air.

Page 9 - Air psychrometry of exhaust air from emplacement drift after heating it to temperature dry bulb, td = 95 to 392 °F and moisture content of air, G = 140 & 160 grains of moisture/lb dry air.

Page 10 - Air psychrometry of exhaust air from emplacement drift after heating it to temperature dry bulb, td = 95 to 392 °F and moisture content of air, G = 180 & 200 grains of moisture/lb dry air.

Page 11 - Air psychrometry of ambient air at effective temperature of 81 °F (27 °C).

Predicted Psychrometric Properties of Ventilation Air in Repository Emplacement Side

Temperature dry bulb (50 to 80 ^oF) and wet bulb indicating possible inlet moisture range of 12 to 70 grains per pound air.

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Line	Ref.	Dry Bulb Temp. Td (Measured)	Dry Bulb Temp. Td (Measured)	Wet Bulb Temp Tw (Calculated)	Wet Bulb Temp Tw (Calculated)	Bar. Pres. Ave Pb (Measured)	Sat. Vapor Pressure at Td Ps (Calculated)	Sat. Vapor Pres at Tw Ps' (Calculated)	Partial Vapor Pressu Pv (Calculated)	Relative Humidity R (Measured)	Specific Humidity Moisture W (H2O) (Calculated)	Specific Humidity Moisture W*7000 (Calculated)	Specific Volume v (Calculated)	Air Densit Moist Air w (Calculated)	Enthalpy Heat Cont. h (Calculated)
6															
7	Temperature Cases	^o F	^o C	^o F	^o C	inch Hg	inch Hg	inch Hg	inch Hg	% Rel. Hu	lb/lb dry air	Grains/lb air	ft^3/lb dry air	lb/ft^3	Btu/lb air
8	Empl Inlet Rel20-80	80.0	26.7	55.250	12.9	26.2	1.03484	0.44091	0.20723	20.02	0.005	34.712	15.67587	0.06388	24.63492
9	Empl Inlet Rel20-78	78.0	25.6	54.000	12.2	26.2	0.96911	0.42127	0.19462	20.08	0.005	32.585	15.61024	0.06413	23.81771
10	Empl Inlet Rel20-76	76.0	24.4	52.700	11.5	26.2	0.90704	0.40165	0.18159	20.02	0.004	30.388	15.54442	0.06439	22.99003
11	Empl Inlet Rel20-74	74.0	23.3	51.420	10.8	26.2	0.84848	0.38313	0.16984	20.02	0.004	28.409	15.47943	0.06465	22.19712
12	Empl Inlet Rel20-72	72.0	22.2	50.150	10.1	26.2	0.79324	0.36550	0.15909	20.06	0.004	26.600	15.41509	0.06491	21.43107
13	Empl Inlet Rel20-68	68.0	20.0	47.550	8.6	26.2	0.69211	0.33161	0.13842	20.00	0.003	23.124	15.28704	0.06543	19.92278
14	Empl Inlet Rel20-59	59.0	15.0	41.652	5.4	26.2	0.50476	0.26480	0.10094	20.00	0.002	16.839	15.00489	0.06663	16.77384
15	Empl Inlet Rel20-50	50.0	10.0	35.600	2.0	26.2	0.36346	0.20886	0.07295	20.07	0.002	12.156	14.72890	0.06786	13.87990
16															
17	Empl Inlet Rel25-80	80.0	26.7	57.250	14.0	26.2	1.03484	0.47402	0.25929	25.06	0.006	43.521	15.70733	0.06385	26.01409
18	Empl Inlet Rel25-78	78.0	25.6	55.900	13.3	26.2	0.96911	0.45144	0.24280	25.05	0.006	40.726	15.63921	0.06411	25.09137
19	Empl Inlet Rel25-76	76.0	24.4	54.550	12.5	26.2	0.90704	0.42981	0.22727	25.06	0.005	38.098	15.57175	0.06437	24.19530
20	Empl Inlet Rel25-74	74.0	23.3	53.200	11.8	26.2	0.84848	0.40910	0.21266	25.06	0.005	35.629	15.50493	0.06463	23.32479
21	Empl Inlet Rel25-72	72.0	22.2	51.850	11.0	26.2	0.79324	0.38927	0.19894	25.08	0.005	33.313	15.43871	0.06489	22.47880
22	Empl Inlet Rel25-68	68.0	20.0	49.120	9.5	26.2	0.69211	0.35173	0.17337	25.05	0.004	29.003	15.30757	0.06541	20.83861
23	Empl Inlet Rel25-59	59.0	15.0	42.920	6.1	26.2	0.50476	0.27806	0.12617	25.00	0.003	21.069	15.01941	0.06662	17.43031
24	Empl Inlet Rel25-50	50.0	10.0	36.610	2.6	26.2	0.36346	0.21740	0.09100	25.04	0.002	15.175	14.73908	0.06786	14.34672
25															
26	Empl Inlet Rel30-80	80.0	26.7	59.150	15.1	26.2	1.03484	0.50748	0.31076	30.03	0.007	52.263	15.73856	0.06382	27.38284
27	Empl Inlet Rel30-78	78.0	25.6	57.750	14.3	26.2	0.96911	0.48263	0.29152	30.08	0.007	48.990	15.66862	0.06408	26.38420
28	Empl Inlet Rel30-76	76.0	24.4	56.310	13.5	26.2	0.90704	0.45820	0.27232	30.02	0.007	45.730	15.59881	0.06434	25.38828
29	Empl Inlet Rel30-74	74.0	23.3	54.900	12.7	26.2	0.84848	0.43533	0.25498	30.05	0.006	42.790	15.53022	0.06460	24.44325
30	Empl Inlet Rel30-72	72.0	22.2	53.465	11.9	26.2	0.79324	0.41309	0.23805	30.01	0.006	39.923	15.46197	0.06486	23.51020
31	Empl Inlet Rel30-68	68.0	20.0	50.630	10.4	26.2	0.69211	0.37208	0.20799	30.05	0.005	34.842	15.32797	0.06540	21.74833
32	Empl Inlet Rel30-59	59.0	15.0	44.160	6.8	26.2	0.50476	0.29160	0.15141	30.00	0.004	25.308	15.03397	0.06661	18.08834
33	Empl Inlet Rel30-50	50.0	10.0	37.610	3.1	26.2	0.36346	0.22615	0.10918	30.04	0.003	18.219	14.74935	0.06785	14.81750
34															
35	Empl Inlet Rel35-80	80.0	26.7	61.000	16.1	26.2	1.03484	0.54202	0.36284	35.06	0.009	61.145	15.77028	0.06378	28.77356
36	Empl Inlet Rel35-78	78.0	25.6	59.500	15.3	26.2	0.96911	0.51386	0.33933	35.01	0.008	57.131	15.69759	0.06405	27.65767
37	Empl Inlet Rel35-76	76.0	24.4	58.030	14.5	26.2	0.90704	0.48752	0.31793	35.05	0.008	53.483	15.62630	0.06431	26.60018
38	Empl Inlet Rel35-74	74.0	23.3	56.550	13.6	26.2	0.84848	0.46219	0.29747	35.06	0.007	50.002	15.55570	0.06458	25.56957
39	Empl Inlet Rel35-72	72.0	22.2	55.050	12.8	26.2	0.79324	0.43772	0.27767	35.00	0.007	46.639	15.48560	0.06484	24.55830
40	Empl Inlet Rel35-68	68.0	20.0	52.100	11.2	26.2	0.69211	0.39287	0.24269	35.07	0.006	40.709	15.34846	0.06538	22.66243
41	Empl Inlet Rel35-59	59.0	15.0	45.380	7.4	26.2	0.50476	0.30548	0.17681	35.03	0.004	29.582	15.04864	0.06659	18.75183
42	Empl Inlet Rel35-50	50.0	10.0	38.600	3.7	26.2	0.36346	0.23513	0.12748	35.07	0.003	21.289	14.75970	0.06784	15.29222
43															
44	Empl Inlet Rel40-80	80.0	26.7	62.780	17.1	26.2	1.03484	0.57719	0.41488	40.09	0.010	70.055	15.80211	0.06375	30.16867
45	Empl Inlet Rel40-78	78.0	25.6	61.210	16.2	26.2	0.96911	0.54607	0.38774	40.01	0.009	65.404	15.72703	0.06402	28.95199
46	Empl Inlet Rel40-76	76.0	24.4	59.670	15.4	26.2	0.90704	0.51699	0.36293	40.01	0.009	61.161	15.65352	0.06428	27.80026
47	Empl Inlet Rel40-74	74.0	23.3	58.150	14.5	26.2	0.84848	0.48962	0.34004	40.08	0.008	57.253	15.58131	0.06455	26.70203
48	Empl Inlet Rel40-72	72.0	22.2	56.600	13.7	26.2	0.79324	0.46303	0.31766	40.05	0.008	53.437	15.50952	0.06482	25.61925
49	Empl Inlet Rel40-68	68.0	20.0	53.520	12.0	26.2	0.69211	0.41393	0.27718	40.05	0.007	46.555	15.36888	0.06536	23.57328
50	Empl Inlet Rel40-59	59.0	15.0	46.560	8.1	26.2	0.50476	0.31946	0.20193	40.01	0.005	33.818	15.06318	0.06658	19.40931
51	Empl Inlet Rel40-50	50.0	10.0	39.560	4.2	26.2	0.36346	0.24413	0.14554	40.04	0.003	24.321	14.76993	0.06783	15.76105
												Ave	15.39	0.0652	

Predicted Psychrometric Properties of Ventilation Air in Repository Emplacement Side

Ref. Line	Temperature dry bulb and wet bulb maintaining moisture at 26 grains per pound air.														
1	File:Lotus\JuraniR\airpsyva		26	grains/lb											
2		Dry Bulb	Dry Bulb	Wet Bulb	Wet Bulb	Bar.	Sat. Vapor	Sat. Vapor	Partial	Relative	Specific Humidity		Specific	Air Densit	Enthalpy
3		Temp.	Temp.	Temp	Temp	Pres. Ave	Pressure at Td	Pres at Tw	Vapor Pressu	Humidity	Moisture	Moisture	Volume	Moist Air	Heat Cont.
4		Td	Td	Tw	Tw	Pb	Ps	Ps'	Pv	R	W (H2O)	W*7000	v	w	h
5		(Measured)	(Measured)	Calculated	Calculated	(Measured)	Calculated	Calculated	Calculated	(Measured)	Calculated	Calculated	Calculated	Calculated	Calculated
6	Repository Level														
7	Temp. Dry Bulb	^°F	^°C	^°F	^°C	inch Hg	inch Hg	inch Hg	inch Hg	% Rel. Hu	lb/lb dry air	Grains/lb air	ft^3/lb dry air	lb/ft^3	Btu/lb air
8	Empl. Outlet Td 95	95.0	35.0	58.660	14.8	26.2	1.66425	0.49866	0.15575	9.36	0.00372	26.038	16.079	0.06210	26.90194
9	Empl. Outlet Td 105	105.0	40.6	61.980	16.7	26.2	2.24857	0.56115	0.15555	6.92	0.00371	26.004	16.369	0.06095	29.31335
10	Empl. Outlet Td 122	122.0	50.0	67.140	19.5	26.2	3.65154	0.67190	0.15564	4.26	0.00372	26.019	16.862	0.05907	33.42406
11	Empl. Outlet Td 130	130.0	54.4	69.380	20.8	26.2	4.53786	0.72564	0.15576	3.43	0.00372	26.040	17.093	0.05822	35.36086
12	Empl. Outlet Td 150	150.0	65.6	74.520	23.6	26.2	7.59746	0.86338	0.15590	2.05	0.00372	26.062	17.673	0.05620	40.19790
13	Empl. Outlet Td 175	175.0	79.4	80.180	26.8	26.2	13.75175	1.04094	0.15600	1.13	0.00373	26.081	18.397	0.05385	46.24275
14	Empl. Outlet Td 200	200.0	93.3	85.150	29.5	26.2	23.68091	1.22228	0.15558	0.66	0.00372	26.009	19.121	0.05167	52.27289
15	Empl. Outlet Td 225	225.0	107.2	89.585	32.0	26.2	39.03081	1.40670	0.15559	0.40	0.00372	26.012	19.846	0.04965	58.31516
16	Empl. Outlet Td 250	250.0	121.1	93.580	34.2	26.2	61.88679	1.59304	0.15595	0.25	0.00372	26.072	20.570	0.04777	64.36711
17	Empl. Outlet Td 275	275.0	135.0	97.200	36.2	26.2	94.80951	1.78002	0.15607	0.16	0.00373	26.091	21.295	0.04602	70.41223
18	Empl. Outlet Td 286	285.8	141.0	98.660	37.0	26.2	112.89484	1.86065	0.15582	0.14	0.00372	26.050	21.607	0.04530	73.01527
19	Empl. Outlet Td 325	325.0	162.8	103.540	39.7	26.2	203.59762	2.15354	0.15559	0.08	0.00372	26.011	22.743	0.04285	82.48229
20	Empl. Outlet Td 342	341.6	172.0	105.430	40.8	26.2	256.45355	2.27724	0.15559	0.06	0.00372	26.011	23.224	0.04188	86.49396
21	Empl. Outlet Td 375	375.0	190.6	108.965	42.8	26.2	395.90840	2.52516	0.15589	0.04	0.00372	26.062	24.192	0.04006	94.57474
22	Empl. Outlet Td 392	392.0	200.0	110.635	43.7	26.2	486.89536	2.65016	0.15556	0.03	0.00372	26.006	24.684	0.03919	98.67344
23		^°F	^°C	^°F	^°C										
24															
25															

Predicted Psychrometric Properties of Ventilation Air in Repository Emplacement Side

Ref. Line	Temperature dry bulb and wet bulb at moisture of 30 grains per pound air in emplacement outlet.														
28	File:Lotus\JuraniR\airpsyva		30	grains/lb											
29		Dry Bulb	Dry Bulb	Wet Bulb	Wet Bulb	Bar.	Sat. Vapor	Sat. Vapor	Partial	Relative	Specific Humidity		Specific	Air Densit	Enthalpy
30		Temp.	Temp.	Temp	Temp	Pres. Ave	Pressure at Td	Pres at Tw	Vapor Pressu	Humidity	Moisture	Moisture	Volume	Moist Air	Heat Cont.
31		Td	Td	Tw	Tw	Pb	Ps	Ps'	Pv	R	W (H2O)	W*7000	v	w	h
32		(Measured)	(Measured)	Calculated	Calculated	(Measured)	Calculated	Calculated	Calculated	(Measured)	Calculated	Calculated	Calculated	Calculated	Calculated
33	Repository Level														
34	Temp. Dry Bulb	^°F	^°C	^°F	^°C	inch Hg	inch Hg	inch Hg	inch Hg	% Rel. Hu	lb/lb dry air	Grains/lb air	ft^3/lb dry air	lb/ft^3	Btu/lb air
35	Empl. Outlet Td 95	95.0	35.0	59.520	15.3	26.2	1.66425	0.51423	0.17950	10.79	0.00429	30.036	16.094	0.06209	27.53177
36	Empl. Outlet Td 105	105.0	40.6	62.800	17.1	26.2	2.24857	0.57760	0.17983	8.00	0.00430	30.092	16.384	0.06093	29.95989
37	Empl. Outlet Td 122	122.0	50.0	67.860	19.9	26.2	3.65154	0.68878	0.17946	4.91	0.00429	30.028	16.877	0.05906	34.06263
38	Empl. Outlet Td 130	130.0	54.4	70.070	21.2	26.2	4.53786	0.74294	0.17974	3.96	0.00430	30.076	17.109	0.05821	36.00577
39	Empl. Outlet Td 150	150.0	65.6	75.135	24.0	26.2	7.59746	0.88129	0.17987	2.37	0.00430	30.097	17.689	0.05619	40.84783
40	Empl. Outlet Td 175	175.0	79.4	80.710	27.1	26.2	13.75175	1.05909	0.17951	1.31	0.00429	30.037	18.414	0.05383	46.88644
41	Empl. Outlet Td 200	200.0	93.3	85.635	29.8	26.2	23.68091	1.24137	0.17973	0.76	0.00430	30.074	19.139	0.05166	52.94081
42	Empl. Outlet Td 225	225.0	107.2	90.020	32.2	26.2	39.03081	1.42602	0.17965	0.46	0.00429	30.061	19.864	0.04964	58.98687
43	Empl. Outlet Td 250	250.0	121.1	93.970	34.4	26.2	61.88679	1.61233	0.17968	0.29	0.00430	30.066	20.589	0.04776	65.03603
44	Empl. Outlet Td 275	275.0	135.0	97.550	36.4	26.2	94.80951	1.79907	0.17930	0.19	0.00429	30.002	21.314	0.04601	71.07356
45	Empl. Outlet Td 286	285.8	141.0	99.005	37.2	26.2	112.89484	1.88016	0.17955	0.16	0.00429	30.044	21.627	0.04528	73.69351
46	Empl. Outlet Td 325	325.0	162.8	103.850	39.9	26.2	203.59762	2.17342	0.17962	0.09	0.00429	30.056	22.764	0.04284	83.17924
47	Empl. Outlet Td 342	341.6	172.0	105.725	41.0	26.2	256.45355	2.29709	0.17954	0.07	0.00429	30.043	23.245	0.04187	87.19313
48	Empl. Outlet Td 375	375.0	190.6	109.234	42.9	26.2	395.90840	2.54495	0.17974	0.05	0.00430	30.076	24.214	0.04005	95.27938
49	Empl. Outlet Td 392	392.0	200.0	110.895	43.8	26.2	486.89536	2.67010	0.17959	0.04	0.00429	30.052	24.707	0.03918	99.38796
50		^°F	^°C	^°F	^°C										

Predicted Psychrometric Properties of Ventilation Air in Repository Emplacement Side

Temperature dry bulb and wet bulb at moisture of 35 grains per pound air in emplacement outlet.

File:Lotus\JuraniR\airpsyva 35 grains/lb

Repository Level Temp. Dry Bulb	Dry Bulb Temp. Td (Measured) ^oF	Dry Bulb Temp. Td (Measured) ^oC	Wet Bulb Temp Tw Calculated ^oF	Wet Bulb Temp Tw Calculated ^oC	Bar. Pres. Ave Pb (Measured) inch Hg	Sat. Vapor Pressure at Td Ps Calculated inch Hg	Sat. Vapor Pres at Tw Ps' Calculated inch Hg	Partial Vapor Pressu Pv Calculated inch Hg	Relative Humidity R (Measured) % Rel. Hu	Specific Humidity Moisture W (H2O) Calculated lb/lb dry air	Specific Humidity Moisture W*7000 Calculated Grains/lb air	Specific Volume v Calculated ft^3/lb dry air	Air Densit Moist Air w Calculated lb/ft^3	Enthalpy Heat Cont. h Calculated Btu/lb air
Empl. Outlet Td 95	95.0	35.0	60.580	15.9	26.2	1.66425	0.53401	0.20937	12.58	0 00501	35.073	16.113	0 06207	28.32531
Empl. Outlet Td 105	105.0	40.6	63.770	17.7	26.2	2.24857	0 59760	0 20910	9.30	0 00500	35.029	16.403	0.06091	30.74088
Empl. Outlet Td 122	122.0	50.0	68.750	20.4	26.2	3.65154	0.71016	0.20941	5.73	0.00501	35.081	16.897	0.05904	34 86747
Empl. Outlet Td 130	130.0	54 4	70.900	21.6	26.2	4.53786	0.76422	0.20906	4.61	0 00500	35.022	17.129	0 05819	36 79609
Empl. Outlet Td 150	150 0	65.6	75.880	24.4	26.2	7.59746	0.90343	0.20934	2.76	0 00501	35.070	17.709	0.05617	41.64870
Empl. Outlet Td 175	175.0	79.4	81.370	27.4	26 2	13.75175	1.08208	0 20917	1.52	0.00501	35.041	18.435	0 05382	47.70042
Empl. Outlet Td 200	200 0	93.3	86.220	30.1	26 2	23.68091	1.26473	0.20922	0.88	0.00501	35.048	19.161	0 05164	53.75789
Empl. Outlet Td 225	225 0	107.2	90.550	32 5	26.2	39 03081	1.44988	0.20928	0 54	0 00501	35.058	19.887	0 04962	59.81595
Empl. Outlet Td 250	250.0	121.1	94.450	34.7	26.2	61.88679	1 63635	0.20917	0 34	0 00501	35.040	20.612	0.04774	65.86916
Empl. Outlet Td 275	275.0	135.0	98.000	36.7	26.2	94.80951	1.82382	0.20944	0 22	0.00501	35.086	21.338	0 04599	71.93334
Empl. Outlet Td 286	285 8	141.0	99.430	37.5	26.2	112 89484	1.90443	0.20904	0.19	0 00500	35.018	21.652	0 04527	74.53806
Empl. Outlet Td 325	325.0	162 8	104.230	40 1	26.2	203 59762	2.19801	0.20930	0 10	0 00501	35.062	22.790	0 04282	84 04200
Empl. Outlet Td 342	341 6	172.0	106 090	41 2	26.2	256 45355	2 32186	0 20940	0 08	0.00501	35.080	23.272	0 04186	88 06644
Empl. Outlet Td 375	375.0	190 6	109 567	43.1	26.2	395 90840	2.56962	0.20946	0.05	0 00501	35 089	24 242	0 04003	96.15938
Empl. Outlet Td 392	392 0	200.0	111.211	44 0	26 2	486 89536	2.69450	0.20899	0 04	0.00500	35.010	24.735	0 03916	100.26378
	^oF	^oC	^oF	^oC										

Predicted Psychrometric Properties of Ventilation Air in Repository Emplacement Side

Temperature dry bulb and wet bulb at moisture of 40 grains per pound air in emplacement outlet.

File:Lotus\JuraniR\airpsyva 40 grains/lb

Repository Level Temp. Dry Bulb	Dry Bulb Temp. Td (Measured) ^oF	Dry Bulb Temp. Td (Measured) ^oC	Wet Bulb Temp Tw Calculated ^oF	Wet Bulb Temp Tw Calculated ^oC	Bar. Pres. Ave Pb (Measured) inch Hg	Sat. Vapor Pressure at Td Ps Calculated inch Hg	Sat. Vapor Pres at Tw Ps' Calculated inch Hg	Partial Vapor Pressu Pv Calculated inch Hg	Relative Humidity R (Measured) % Rel. Hu	Specific Humidity Moisture W (H2O) Calculated lb/lb dry air	Specific Humidity Moisture W*7000 Calculated Grains/lb air	Specific Volume v Calculated ft^3/lb dry air	Air Densit Moist Air w Calculated lb/ft^3	Enthalpy Heat Cont. h Calculated Btu/lb air
Empl. Outlet Td 95	95.0	35.0	61.600	16.4	26.2	1.66425	0 55366	0.23873	14.34	0.00572	40.038	16.131	0.06205	29.10740
Empl. Outlet Td 105	105.0	40.6	64.730	18.2	26.2	2.24857	0.61800	0.23867	10.61	0 00572	40.028	16.421	0 06089	31.53155
Empl. Outlet Td 122	122.0	50.0	69.600	20.9	26.2	3.65154	0.73112	0 23857	6.53	0.00572	40.010	16.915	0 05902	35.65252
Empl. Outlet Td 130	130.0	54.4	71.730	22.1	26.2	4.53786	0.78603	0.23892	5 27	0 00572	40.070	17.148	0.05817	37.60267
Empl. Outlet Td 150	150.0	65.6	76.610	24.8	26.2	7.59746	0 92559	0 23870	3.14	0.00572	40.033	17.729	0.05615	42.44817
Empl. Outlet Td 175	175.0	79.4	82.020	27.8	26.2	13.75175	1.10514	0.23882	1.74	0.00572	40.053	18.456	0.05380	48.51574
Empl. Outlet Td 200	200.0	93.3	86.800	30 4	26.2	23.68091	1.28827	0.23884	1 01	0 00572	40.056	19.183	0.05162	54.58055
Empl. Outlet Td 225	225.0	107.2	91.070	32.8	26 2	39.03081	1.47363	0.23869	0.61	0.00572	40.032	19.909	0 04960	60 64096
Empl. Outlet Td 250	250.0	121.1	94.930	35.0	26 2	61.88679	1.66068	0.23898	0.39	0.00573	40.079	20.636	0.04772	66.71330
Empl. Outlet Td 275	275.0	135.0	98.430	36.9	26.2	94.80951	1.84774	0.23853	0.25	0.00571	40.004	21.362	0.04597	72.76499
Empl. Outlet Td 286	285.8	141.0	99.855	37.7	26.2	112.89484	1.92898	0.23881	0.21	0.00572	40.051	21.676	0.04525	75.39269
Empl. Outlet Td 325	325.0	162.8	104.605	40.3	26.2	203.59762	2.22251	0.23884	0.12	0.00572	40.057	22.816	0.04280	84.90263
Empl. Outlet Td 342	341.6	172.0	106.450	41.4	26.2	256.45355	2.34652	0.23910	0 09	0 00573	40.100	23.299	0.04184	88 93683
Empl. Outlet Td 375	375.0	190.6	109.895	43.3	26.2	395.90840	2.59413	0.23895	0.06	0.00572	40.075	24.269	0.04002	97.03459
Empl. Outlet Td 392	392.0	200.0	111.530	44.2	26.2	486.89536	2.71933	0.23888	0.05	0.00572	40.063	24.763	0.03915	101.15624
	^oF	^oC	^oF	^oC										

Predicted Psychrometric Properties of Ventilation Air in Repository Emplacement Side

Temperature dry bulb and wet bulb at moisture of 50 grains per pound air in emplacement outlet.

File:Lotus\JuraniR\airpsyva 50 grains/lb

Repository Level Temp. Dry Bulb	Dry Bulb Temp. Td (Measured) ^o F	Dry Bulb Temp. Td (Measured) ^o C	Wet Bulb Temp Tw Calculated ^o F	Wet Bulb Temp Tw Calculated ^o C	Bar. Pres. Ave Pb (Measured) inch Hg	Sat. Vapor Pressure at Td Ps Calculated inch Hg	Sat. Vapor Pres at Tw Ps' Calculated inch Hg	Partial Vapor Pressu Pv Calculated inch Hg	Relative Humidity R (Measured) % Rel. Hu	Specific Humidity Moisture W (H2O) Calculated lb/lb dry air	Specific Humidity Moisture W*7000 Calculated Grains/lb air	Specific Volume v Calculated ft^3/lb dry air	Air Densit Moist Air w Calculated lb/ft^3	Enthalpy Heat Cont. h Calculated Btu/lb air
Empl. Outlet Td 95	95.0	35.0	63.580	17.5	26.2	1.66425	0.59364	0.29756	17.88	0 00715	50.017	16.167	0.06201	30 67946
Empl. Outlet Td 105	105.0	40 6	66.600	19.2	26.2	2 24857	0.65948	0.29803	13.25	0 00716	50.097	16.459	0 06086	33.12433
Empl. Outlet Td 122	122.0	50.0	71.280	21.8	26.2	3 65154	0.77413	0.29780	8.16	0 00715	50.058	16.954	0.05898	37 25284
Empl. Outlet Td 130	130.0	54.4	73.320	23 0	26.2	4.53786	0.82933	0.29766	6.56	0 00715	50.034	17.187	0.05813	39 19469
Empl. Outlet Td 150	150.0	65.6	78.050	25 6	26.2	7.59746	0.97070	0 29803	3.92	0 00716	50.097	17.770	0.05611	44 06913
Empl. Outlet Td 175	175.0	79.4	83.280	28.5	26 2	13.75175	1.15100	0.29753	2.16	0.00714	50.012	18.498	0.05376	50.13592
Empl. Outlet Td 200	200.0	93.3	87.930	31.1	26.2	23.68091	1.33523	0.29766	1.26	0.00715	50.035	19.226	0 05159	56.22007
Empl. Outlet Td 225	225.0	107.2	92.100	33.4	26.2	39.03081	1.52165	0.29799	0.76	0 00716	50.091	19.955	0.04957	62.30967
Empl. Outlet Td 250	250.0	121.1	95.860	35.5	26 2	61.88679	1.70871	0 29766	0.48	0.00715	50.034	20.683	0.04769	68.38077
Empl. Outlet Td 275	275.0	135.0	99.290	37.4	26.2	94.80951	1.89641	0.29756	0 31	0.00715	50.018	21.411	0.04594	74.45845
Empl. Outlet Td 286	285.8	141.0	100.685	38.2	26.2	112.89484	1.97771	0 29778	0.26	0 00715	50.055	21.726	0.04522	77.09133
Empl. Outlet Td 325	325.0	162.8	105.340	40.7	26 2	203.59762	2.27122	0.29747	0.15	0.00714	50.002	22.867	0.04277	86.61648
Empl. Outlet Td 342	341.6	172.0	107.150	41.8	26.2	256.45355	2.39511	0.29752	0.12	0.00714	50.011	23.351	0.04181	90.65533
Empl. Outlet Td 375	375.0	190 6	110.540	43 6	26 2	395 90840	2 64291	0.29758	0 08	0 00715	50 021	24.324	0.03999	98.78042
Empl. Outlet Td 392	392.0	200.0	112.150	44.5	26.2	486.89536	2.76815	0.29758	0.06	0.00715	50.021	24.819	0.03912	102.91507
	^o F	^o C	^o F	^o C										

Predicted Psychrometric Properties of Ventilation Air in Repository Emplacement Side

Temperature dry bulb and wet bulb at moisture of 60 grains per pound air in emplacement outlet.

File:Lotus\JuraniR\airpsyva 60 grains/lb

Repository Level Temp. Dry Bulb	Dry Bulb Temp. Td (Measured) ^o F	Dry Bulb Temp. Td (Measured) ^o C	Wet Bulb Temp Tw Calculated ^o F	Wet Bulb Temp Tw Calculated ^o C	Bar. Pres. Ave Pb (Measured) inch Hg	Sat. Vapor Pressure at Td Ps Calculated inch Hg	Sat. Vapor Pres at Tw Ps' Calculated inch Hg	Partial Vapor Pressu Pv Calculated inch Hg	Relative Humidity R (Measured) % Rel. Hu	Specific Humidity Moisture W (H2O) Calculated lb/lb dry air	Specific Humidity Moisture W*7000 Calculated Grains/lb air	Specific Volume v Calculated ft^3/lb dry air	Air Densit Moist Air w Calculated lb/ft^3	Enthalpy Heat Cont. h Calculated Btu/lb air
Empl. Outlet Td 95	95.0	35.0	65.480	18 6	26.2	1.66425	0.63435	0.35636	21.41	0 00858	60.038	16.204	0.06198	32.25816
Empl. Outlet Td 105	105.0	40.6	68.361	20 2	26.2	2 24857	0.70074	0 35614	15 84	0 00857	60.000	16.496	0.06082	34.69073
Empl. Outlet Td 122	122.0	50.0	72.890	22.7	26.2	3.65154	0.81742	0.35663	9.77	0.00858	60.084	16.993	0.05894	38.84967
Empl. Outlet Td 130	130.0	54.4	74.851	23.8	26.2	4.53786	0.87298	0.35618	7.85	0 00857	60.006	17.226	0.05810	40.78817
Empl. Outlet Td 150	150.0	65.6	79.420	26.3	26.2	7.59746	1.01539	0.35625	4.69	0.00857	60.019	17.810	0 05608	45.66736
Empl. Outlet Td 175	175.0	79.4	84.510	29.2	26.2	13.75175	1.19749	0.35646	2.59	0 00858	60.055	18.540	0.05372	51.76964
Empl. Outlet Td 200	200.0	93.3	89.030	31.7	26.2	23 68091	1 38237	0 35639	1.50	0.00858	60.042	19.270	0.05155	57.86407
Empl. Outlet Td 225	225.0	107.2	93.090	33.9	26.2	39.03081	1.56909	0.35630	0.91	0.00858	60.027	20.000	0.04953	63.95799
Empl. Outlet Td 250	250.0	121.1	96.768	36.0	26.2	61.88679	1.75675	0.35615	0.58	0.00857	60.003	20.730	0.04766	70.05043
Empl. Outlet Td 275	275.0	135.0	100.130	37.9	26.2	94.80951	1.94501	0.35634	0 38	0.00858	60.034	21.460	0.04591	76.15221
Empl. Outlet Td 286	285.8	141.0	101.498	38.6	26.2	112.89484	2.02646	0.35662	0.32	0.00858	60.082	21.775	0.04519	78.79399
Empl. Outlet Td 325	325.0	162.8	106.070	41.2	26.2	203.59762	2.32050	0.35667	0.18	0.00858	60.090	22.920	0.04274	88.35478
Empl. Outlet Td 342	341.6	172 0	107.845	42.1	26.2	256.45355	2.44421	0.35644	0.14	0.00858	60.052	23.404	0.04178	92.39632
Empl. Outlet Td 375	375.0	190.6	111.179	44.0	26 2	395.90840	2.69202	0.35650	0.09	0.00858	60.062	24.380	0.03996	100.54295
Empl. Outlet Td 392	392.0	200.0	112.765	44.9	26.2	486.89536	2.81732	0.35661	0.07	0.00858	60.081	24.876	0.03909	104.69194
	^o F	^o C	^o F	^o C										

Predicted Psychrometric Properties of Ventilation Air in Repository Emplacement Side

Temperature dry bulb and wet bulb at moisture of 70 grains per pound air in emplacement outlet.

File:Lotus\JuraniR\airpsyva 70 grains/lb

Repository Level Temp. Dry Bulb	Dry Bulb Temp. Td (Measured) ^o F	Dry Bulb Temp. Td (Measured) ^o C	Wet Bulb Temp Tw Calculated ^o F	Wet Bulb Temp Tw Calculated ^o C	Bar. Pres. Ave Pb (Measured) inch Hg	Sat. Vapor Pressure at Td Ps Calculated inch Hg	Sat. Vapor Pres at Tw Ps' Calculated inch Hg	Partial Vapor Pressu Pv Calculated inch Hg	Relative Humidity R (Measured) % Rel. Hu	Specific Humidity Moisture W,(H2O) Calculated lb/lb dry air	Specific Humidity Moisture W*7000 Calculated Grains/lb air	Specific Volume v Calculated ft^3/lb dry air	Air Densit Moist Air w Calculated lb/ft^3	Enthalpy Heat Cont. h Calculated Btu/lb air
Empl. Outlet Td 95	95.0	35.0	67.300	19.6	26.2	1.66425	0.67562	0.41496	24.93	0.01001	70.070	16.241	0.06194	33.83852
Empl. Outlet Td 105	105.0	40.6	70.080	21.2	26.2	2.24857	0.74319	0.41503	18.46	0.01001	70.081	16.534	0.06078	36.28531
Empl. Outlet Td 122	122.0	50.0	74.430	23.8	26.2	3.65154	0.86078	0.41488	11.36	0.01001	70.055	17.031	0.05891	40.43775
Empl. Outlet Td 130	130.0	54.4	76.330	24.6	26.2	4.53786	0.91704	0.41461	9.14	0.01000	70.010	17.265	0.05806	42.38653
Empl. Outlet Td 150	150.0	65.6	80.760	27.1	26.2	7.59746	1.06082	0.41494	5.46	0.01001	70.066	17.851	0.05604	47.28568
Empl. Outlet Td 175	175.0	79.4	85.700	29.8	26.2	13.75175	1.24394	0.41504	3.02	0.01001	70.083	18.582	0.05369	53.40106
Empl. Outlet Td 200	200.0	93.3	90.100	32.3	26.2	23.68091	1.42960	0.41492	1.75	0.01001	70.062	19.314	0.05151	59.51020
Empl. Outlet Td 225	225.0	107.2	94.060	34.5	26.2	39.03081	1.61681	0.41470	1.06	0.01000	70.024	20.045	0.04950	65.61656
Empl. Outlet Td 250	250.0	121.1	97.660	36.5	26.2	61.88679	1.80509	0.41480	0.67	0.01001	70.041	20.777	0.04762	71.73190
Empl. Outlet Td 275	275.0	135.0	100.950	38.3	26.2	94.80951	1.99349	0.41480	0.44	0.01001	70.041	21.508	0.04587	77.84450
Empl. Outlet Td 286	285.8	141.0	102.290	39.1	26.2	112.89484	2.07496	0.41499	0.37	0.01001	70.073	21.825	0.04515	80.49058
Empl. Outlet Td 325	325.0	162.8	106.775	41.5	26.2	203.59762	2.36897	0.41476	0.20	0.01001	70.035	22.971	0.04271	90.06854
Empl. Outlet Td 342	341.6	172.0	108.521	42.5	26.2	256.45355	2.49280	0.41464	0.16	0.01000	70.014	23.457	0.04175	94.12370
Empl. Outlet Td 375	375.0	190.6	111.800	44.3	26.2	395.90840	2.74050	0.41457	0.10	0.01000	70.003	24.434	0.03993	102.28795
Empl. Outlet Td 392	392.0	200.0	113.361	45.2	26.2	486.89536	2.86569	0.41460	0.09	0.01000	70.007	24.932	0.03906	106.44520
	^o F	^o C	^o F	^o C										

Predicted Psychrometric Properties of Ventilation Air in Repository Emplacement Side

Temperature dry bulb and wet bulb at moisture of 80 grains per pound air in emplacement outlet.

File.Lotus\JuraniR\airpsyva 80 grains/lb

Repository Level Temp. Dry Bulb	Dry Bulb Temp. Td (Measured) ^o F	Dry Bulb Temp. Td (Measured) ^o C	Wet Bulb Temp Tw Calculated ^o F	Wet Bulb Temp Tw Calculated ^o C	Bar. Pres. Ave Pb (Measured) inch Hg	Sat. Vapor Pressure at Td Ps Calculated inch Hg	Sat. Vapor Pres at Tw Ps' Calculated inch Hg	Partial Vapor Pressu Pv Calculated inch Hg	Relative Humidity R (Measured) % Rel. Hu	Specific Humidity Moisture W (H2O) Calculated lb/lb dry air	Specific Humidity Moisture W*7000 Calculated Grains/lb air	Specific Volume v Calculated ft^3/lb dry air	Air Densit Moist Air w Calculated lb/ft^3	Enthalpy Heat Cont. h Calculated Btu/lb air
Empl. Outlet Td 95	95.0	35.0	69.030	20.6	26.2	1.66425	0.71700	0.47282	28.41	0.01143	80.019	16.278	0.06190	35.40591
Empl. Outlet Td 105	105.0	40.6	71.710	22.1	26.2	2.24857	0.78549	0.47293	21.03	0.01143	80.037	16.571	0.06075	37.86018
Empl. Outlet Td 122	122.0	50.0	75.920	24.4	26.2	3.65154	0.90463	0.47314	12.96	0.01144	80.073	17.070	0.05887	42.03337
Empl. Outlet Td 130	130.0	54.4	77.760	25.4	26.2	4.53786	0.96147	0.47295	10.42	0.01143	80.042	17.304	0.05802	43.98952
Empl. Outlet Td 150	150.0	65.6	82.050	27.8	26.2	7.59746	1.10621	0.47312	6.23	0.01144	80.071	17.891	0.05600	48.89716
Empl. Outlet Td 175	175.0	79.4	86.850	30.5	26.2	13.75175	1.29032	0.47316	3.44	0.01144	80.077	18.624	0.05365	55.02687
Empl. Outlet Td 200	200.0	93.3	91.140	32.9	26.2	23.68091	1.47685	0.47318	2.00	0.01144	80.080	19.357	0.05148	61.15603
Empl. Outlet Td 225	225.0	107.2	95.010	35.0	26.2	39.03081	1.66476	0.47315	1.21	0.01144	80.076	20.091	0.04946	67.28398
Empl. Outlet Td 250	250.0	121.1	98.530	37.0	26.2	61.88679	1.85335	0.47314	0.76	0.01144	80.074	20.824	0.04759	73.41236
Empl. Outlet Td 275	275.0	135.0	101.750	38.8	26.2	94.80951	2.04179	0.47288	0.50	0.01143	80.029	21.557	0.04584	79.53348
Empl. Outlet Td 286	285.8	141.0	103.060	39.5	26.2	112.89484	2.12307	0.47273	0.42	0.01143	80.004	21.874	0.04512	82.17682
Empl. Outlet Td 325	325.0	162.8	107.470	41.9	26.2	203.59762	2.41761	0.47294	0.23	0.01143	80.039	23.023	0.04268	91.79244
Empl. Outlet Td 342	341.6	172.0	109.190	42.9	26.2	256.45355	2.54170	0.47311	0.18	0.01144	80.069	23.510	0.04172	95.86696
Empl. Outlet Td 375	375.0	190.6	112.415	44.7	26.2	395.90840	2.78925	0.47288	0.12	0.01143	80.029	24.490	0.03990	104.04797
Empl. Outlet Td 392	392.0	200.0	113.952	45.5	26.2	486.89536	2.91436	0.47286	0.10	0.01143	80.026	24.988	0.03903	108.21479
	^o F	^o C	^o F	^o C										

Ref. Line															
	Predicted Psychrometric Properties of Ventilation Air in Repository Emplacement Side														
	Temperature dry bulb and wet bulb at moisture of 100 grains per pound air in emplacement outlet.														
1	File:Lotus\JuraniR\airpsyva		100	grains/lb											
2		Dry Bulb	Dry Bulb	Wet Bulb	Wet Bulb	Bar.	Sat. Vapor	Sat. Vapor	Partial	Relative	Specific Humidity		Specific	Air Densit	Enthalpy
3		Temp.	Temp.	Temp	Temp	Pres. Ave	Pressure at Td	Pres at Tw	Vapor Pressu	Humidity	Moisture	Moisture	Volume	Moist Air	Heat Cont.
4		Td	Td	Tw	Tw	Pb	Ps	Ps'	Pv	R	W (H2O)	W*7000	v	w	h
5		(Measured)	(Measured)	Calculated	Calculated	(Measured)	Calculated	Calculated	Calculated	(Measured)	Calculated	Calculated	Calculated	Calculated	Calculated
6	Repository Level														
7	Temp. Dry Bulb	^o F	^o C	^o F	^o C	inch Hg	inch Hg	inch Hg	inch Hg	% Rel. Hu	lb/lb dry air	Grains/lb air	ft^3/lb dry air	lb/ft^3	Btu/lb air
8	Empl. Outlet Td 95	95.0	35.0	72.300	22.4	26.2	1.66425	0.80132	0.58825	35.35	0.01429	100.003	16.351	0.06183	38.55409
9	Empl. Outlet Td 105	105.0	40.6	74.800	23.8	26.2	2.24857	0.87149	0.58848	26.17	0.01429	100.042	16.646	0.06067	41.02458
10	Empl. Outlet Td 122	122.0	50.0	78.740	26.0	26.2	3.65154	0.99299	0.58876	16.12	0.01430	100.092	17.147	0.05879	45.22179
11	Empl. Outlet Td 130	130.0	54.4	80.470	26.9	26.2	4.53786	1.05084	0.58870	12.97	0.01430	100.081	17.382	0.05795	47.19152
12	Empl. Outlet Td 150	150.0	65.6	84.500	29.2	26.2	7.59746	1.19710	0.58833	7.74	0.01429	100.017	17.971	0.05593	52.10982
13	Empl. Outlet Td 175	175.0	79.4	89.050	31.7	26.2	13.75175	1.38324	0.58860	4.28	0.01429	100.064	18.708	0.05358	58.27823
14	Empl. Outlet Td 200	200.0	93.3	93.130	34.0	26.2	23.68091	1.57104	0.58852	2.49	0.01429	100.049	19.445	0.05141	64.43666
15	Empl. Outlet Td 225	225.0	107.2	96.830	36.0	26.2	39.03081	1.76008	0.58868	1.51	0.01430	100.077	20.181	0.04939	70.60207
16	Empl. Outlet Td 250	250.0	121.1	100.200	37.9	26.2	61.88679	1.94910	0.58838	0.95	0.01429	100.025	20.918	0.04752	76.75417
17	Empl. Outlet Td 275	275.0	135.0	103.300	39.6	26.2	94.80951	2.13826	0.58842	0.62	0.01429	100.033	21.654	0.04577	82.91629
18	Empl. Outlet Td 286	285.8	141.0	104.565	40.3	26.2	112.89484	2.21989	0.58853	0.52	0.01429	100.051	21.972	0.04506	85.58088
19	Empl. Outlet Td 325	325.0	162.8	108.819	42.7	26.2	203.59762	2.51448	0.58847	0.29	0.01429	100.041	23.127	0.04262	95.23919
20	Empl. Outlet Td 342	341.6	172.0	110.480	43.6	26.2	256.45355	2.63834	0.58834	0.23	0.01429	100.019	23.616	0.04166	99.32607
21	Empl. Outlet Td 375	375.0	190.6	113.610	45.3	26.2	395.90840	2.88611	0.58848	0.15	0.01429	100.043	24.600	0.03984	107.56108
22	Empl. Outlet Td 392	392.0	200.0	115.100	46.2	26.2	486.89536	3.01094	0.58824	0.12	0.01429	100.000	25.101	0.03898	111.74293
23		^o F	^o C	^o F	^o C										
24															
25															

Ref. Line															
26	**Predicted Psychrometric Properties of Ventilation Air in Repository Emplacement Side**														
27	Temperature dry bulb and wet bulb at moisture of 120 grains per pound air in emplacement outlet.														
28	File:Lotus\JuraniR\airpsyva		120	grains/lb											
29		Dry Bulb	Dry Bulb	Wet Bulb	Wet Bulb	Bar.	Sat. Vapor	Sat. Vapor	Partial	Relative	Specific Humidity		Specific	Air Densit	Enthalpy
30		Temp.	Temp.	Temp	Temp	Pres. Ave	Pressure at Td	Pres at Tw	Vapor Pressu	Humidity	Moisture	Moisture	Volume	Moist Air	Heat Cont.
31		Td	Td	Tw	Tw	Pb	Ps	Ps'	Pv	R	W (H2O)	W*7000	v	w	h
32		(Measured)	(Measured)	Calculated	Calculated	(Measured)	Calculated	Calculated	Calculated	(Measured)	Calculated	Calculated	Calculated	Calculated	Calculated
33	Repository Level														
34	Temp. Dry Bulb	^o F	^o C	^o F	^o C	inch Hg	inch Hg	inch Hg	inch Hg	% Rel. Hu	lb/lb dry air	Grains/lb air	ft^3/lb dry air	lb/ft^3	Btu/lb air
35	Empl. Outlet Td 95	95.0	35.0	75.340	24.1	26.2	1.66425	0.88734	0.70316	42.25	0.01715	120.077	16.425	0.06175	41.71639
36	Empl. Outlet Td 105	105.0	40.6	77.670	25.4	26.2	2.24857	0.95862	0.70303	31.27	0.01715	120.053	16.721	0.06059	44.18976
37	Empl. Outlet Td 122	122.0	50.0	81.370	27.4	26.2	3.65154	1.08208	0.70329	19.26	0.01716	120.098	17.224	0.05872	48.40824
38	Empl. Outlet Td 130	130.0	54.4	83.000	28.3	26.2	4.53786	1.14072	0.70322	15.50	0.01716	120.086	17.461	0.05787	50.38809
39	Empl. Outlet Td 150	150.0	65.6	86.810	30.5	26.2	7.59746	1.28868	0.70288	9.25	0.01715	120.026	18.052	0.05585	55.33280
40	Empl. Outlet Td 175	175.0	79.4	91.130	32.9	26.2	13.75175	1.47639	0.70311	5.11	0.01715	120.067	18.792	0.05350	61.53232
41	Empl. Outlet Td 200	200.0	93.3	95.020	35.0	26.2	23.68091	1.66527	0.70294	2.97	0.01715	120.038	19.532	0.05133	67.72049
42	Empl. Outlet Td 225	225.0	107.2	98.560	37.0	26.2	39.03081	1.85503	0.70296	1.80	0.01715	120.041	20.272	0.04932	73.91395
43	Empl. Outlet Td 250	250.0	121.1	101.800	38.8	26.2	61.88679	2.04484	0.70291	1.14	0.01715	120.033	21.012	0.04745	80.10552
44	Empl. Outlet Td 275	275.0	135.0	104.785	40.4	26.2	94.80951	2.23435	0.70295	0.74	0.01715	120.040	21.751	0.04571	86.29959
45	Empl. Outlet Td 286	285.8	141.0	106.005	41.1	26.2	112.89484	2.31607	0.70304	0.62	0.01715	120.055	22.071	0.04499	88.97748
46	Empl. Outlet Td 325	325.0	162.8	110.120	43.4	26.2	203.59762	2.61106	0.70323	0.35	0.01716	120.089	23.231	0.04256	98.69390
47	Empl. Outlet Td 342	341.6	172.0	111.730	44.3	26.2	256.45355	2.73500	0.70320	0.27	0.01715	120.084	23.723	0.04160	102.80515
48	Empl. Outlet Td 375	375.0	190.6	114.765	46.0	26.2	395.90840	2.98247	0.70316	0.18	0.01715	120.076	24.711	0.03979	111.07770
49	Empl. Outlet Td 392	392.0	200.0	116.215	46.8	26.2	486.89536	3.10737	0.70314	0.14	0.01715	120.073	25.214	0.03892	115.28826
50		^o F	^o C	^o F	^o C										

Predicted Psychrometric Properties of Ventilation Air in Repository Emplacement Side

Temperature dry bulb and wet bulb at moisture of 140 grains per pound air in emplacement outlet.

File:Lotus\JuraniR\airpsyva 140 grains/lb

	Dry Bulb	Dry Bulb	Wet Bulb	Wet Bulb	Bar.	Sat. Vapor	Sat. Vapor	Partial	Relative	Specific Humidity		Specific	Air Densit	Enthalpy
	Temp.	Temp.	Temp	Temp	Pres. Ave	Pressure at Td	Pres at Tw	Vapor Pressu	Humidity	Moisture	Moisture	Volume	Moist Air	Heat Cont.
	Td	Td	Tw	Tw	Pb	Ps	Ps'	Pv	R	W (H2O)	W*7000	v	w	h
	(Measured)	(Measured)	Calculated	Calculated	(Measured)	Calculated	Calculated	Calculated	(Measured)	Calculated	Calculated	Calculated	Calculated	Calculated
Repository Level														
Temp. Dry Bulb	^o F	^o C	^o F	^o C	inch Hg	inch Hg	inch Hg	inch Hg	% Rel. Hu	lb/lb dry air	Grains/lb air	ft^3/lb dry air	lb/ft^3	Btu/lb air
Empl. Outlet Td 95	95.0	35.0	78.150	25.6	26.2	1.66425	0.97391	0 81638	49.05	0 02000	140.033	16.498	0.06167	44 86015
Empl. Outlet Td 105	105.0	40 6	80.350	26.9	26.2	2.24857	1.04673	0.81671	36.32	0.02001	140.091	16.795	0.06051	47.35939
Empl. Outlet Td 122	122.0	50.0	83.830	28.8	26.2	3.65154	1.17162	0.81662	22.36	0.02001	140.074	17.301	0 05864	51.58977
Empl. Outlet Td 130	130 0	54.4	85.380	29.7	26.2	4 53786	1.23130	0 81698	18.00	0 02002	140.139	17.539	0.05779	53.59214
Empl. Outlet Td 150	150 0	65 6	88.990	31.7	26 2	7.59746	1.38063	0.81653	10.75	0 02001	140.058	18.133	0 05578	58 55941
Empl. Outlet Td 175	175.0	79.4	93.100	33.9	26.2	13.75175	1.56958	0.81659	5 94	0 02001	140.069	18.876	0 05343	64 78627
Empl. Outlet Td 200	200.0	93.3	96.820	36.0	26.2	23 68091	1.75954	0.81652	3 45	0 02001	140.057	19.619	0 05126	71 00933
Empl. Outlet Td 225	225.0	107.2	100.211	37.9	26 2	39.03081	1.94975	0 81624	2 09	0.02000	140.007	20.362	0.04925	77.22613
Empl. Outlet Td 250	250.0	121.1	103.330	39.6	26.2	61.88679	2.14016	0 81635	1 32	0 02000	140.026	21.105	0 04738	83.45436
Empl. Outlet Td 275	275.0	135.0	106.210	41 2	26.2	94 80951	2.33006	0 81649	0.86	0.02001	140.051	21.849	0 04564	89.68364
Empl Outlet Td 286	285 8	141.0	107.390	41.9	26.2	112.89484	2.41197	0 81670	0 72	0.02001	140.089	22.170	0.04493	92 37935
Empl. Outlet Td 325	325.0	162.8	111.370	44.1	26.2	203.59762	2.70685	0.81667	0 40	0 02001	140.084	23.335	0 04250	102.13940
Empl Outlet Td 342	341.6	172 0	112.930	45.0	26 2	256.45355	2 83064	0 81651	0.32	0 02001	140.055	23.829	0 04154	106 26798
Empl. Outlet Td 375	375.0	190 6	115.880	46.6	26.2	395 90840	3.07812	0.81669	0.21	0 02001	140 086	24 822	0 03973	114 59011
Empl. Outlet Td 392	392.0	200.0	117.290	47.4	26.2	486.89536	3.20284	0 81663	0.17	0 02001	140.076	25.327	0.03886	118.82150
	^o F	^o C	^o F	^o C										

Predicted Psychrometric Properties of Ventilation Air in Repository Emplacement Side

Temperature dry bulb and wet bulb at moisture of 160 grains per pound air in emplacement outlet.

File:Lotus\JuraniR\airpsyva 160 grains/lb

	Dry Bulb	Dry Bulb	Wet Bulb	Wet Bulb	Bar.	Sat. Vapor	Sat. Vapor	Partial	Relative	Specific Humidity		Specific	Air Densit	Enthalpy
	Temp.	Temp.	Temp	Temp	Pres. Ave	Pressure at Td	Pres at Tw	Vapor Pressu	Humidity	Moisture	Moisture	Volume	Moist Air	Heat Cont.
	Td	Td	Tw	Tw	Pb	Ps	Ps'	Pv	R	W (H2O)	W*7000	v	w	h
	(Measured)	(Measured)	Calculated	Calculated	(Measured)	Calculated	Calculated	Calculated	(Measured)	Calculated	Calculated	Calculated	Calculated	Calculated
Repository Level														
Temp. Dry Bulb	^o F	^o C	^o F	^o C	inch Hg	inch Hg	inch Hg	inch Hg	% Rel. Hu	lb/lb dry air	Grains/lb air	ft^3/lb dry air	lb/ft^3	Btu/lb air
Empl. Outlet Td 95	95.0	35 0	80.785	27.1	26.2	1.66425	1.06168	0.92909	55.83	0.02287	160.075	16.572	0 06159	48.01752
Empl. Outlet Td 105	105.0	40.6	82.850	28.3	26 2	2.24857	1.13521	0.92899	41.31	0.02287	160.059	16.870	0.06044	50.51784
Empl. Outlet Td 122	122.0	50.0	86.140	30.1	26.2	3.65154	1.26151	0.92882	25.44	0.02286	160.027	17.378	0 05856	54.76772
Empl. Outlet Td 130	130.0	54.4	87.610	30.9	26.2	4.53786	1.32179	0 92918	20.48	0.02287	160.092	17.617	0.05772	56.78035
Empl. Outlet Td 150	150.0	65.6	91.050	32.8	26.2	7.59746	1.47271	0 92913	12.23	0.02287	160.083	18.214	0.05570	61.78475
Empl. Outlet Td 175	175.0	79.4	94.970	35 0	26.2	13.75175	1.66272	0.92904	6.76	0 02287	160.067	18.960	0 05336	68.03944
Empl. Outlet Td 200	200.0	93.3	98.530	37.0	26.2	23.68091	1.85335	0.92874	3.92	0 02286	160.014	19.706	0.05119	74.28796
Empl Outlet Td 225	225.0	107.2	101.795	38 8	26.2	39.03081	2.04453	0.92892	2.38	0.02286	160.046	20.453	0.04918	80.55046
Empl. Outlet Td 250	250.0	121.1	104.800	40.4	26.2	61.88679	2.23534	0.92904	1.50	0.02287	160.067	21.200	0.04732	86.81129
Empl. Outlet Td 275	275.0	135.0	107.580	42.0	26 2	94 80951	2 42538	0.92910	0 98	0 02287	160.077	21.946	0 04558	93.07009
Empl. Outlet Td 286	285.8	141.0	108.720	42 6	26.2	112.89484	2.50726	0 92920	0.82	0.02287	160.096	22.269	0.04486	95.77655
Empl. Outlet Td 325	325.0	162.8	112.572	44.8	26 2	203.59762	2.80181	0 92876	0 46	0 02286	160.017	23.439	0 04244	105.57431
Empl. Outlet Td 342	341.6	172.0	114.090	45.6	26 2	256.45355	2.92583	0.92894	0 36	0.02286	160.049	23.935	0.04148	109.73468
Empl. Outlet Td 375	375.0	190.6	116.955	47.2	26.2	395.90840	3.17282	0 92881	0.23	0.02286	160.026	24.932	0.03967	118.09025
Empl. Outlet Td 392	392.0	200.0	118.330	48.0	26.2	486 89536	3.29760	0.92901	0.19	0 02287	160.062	25.439	0.03881	122.35145
	^o F	^o C	^o F	^o C										

Predicted Psychrometric Properties of Ventilation Air in Repository Emplacement Side

Temperature dry bulb and wet bulb at moisture of 180 grains per pound air in emplacement outlet.

File:Lotus\JuraniR\airpsyva 180 grains/lb

Repository Level Temp. Dry Bulb	Dry Bulb Temp. Td (Measured) ^o F	Dry Bulb Temp. Td (Measured) ^o C	Wet Bulb Temp Tw Calculated ^o F	Wet Bulb Temp Tw Calculated ^o C	Bar. Pres. Ave Pb (Measured) inch Hg	Sat. Vapor Pressure at Td Ps Calculated inch Hg	Sat. Vapor Pres at Tw Ps' Calculated inch Hg	Partial Vapor Pressu Pv Calculated inch Hg	Relative Humidity R (Measured) % Rel. Hu	Specific Humidity Moisture W (H2O) Calculated lb/lb dry air	Specific Humidity Moisture W*7000 Calculated Grains/lb air	Specific Volume v Calculated ft^3/lb dry air	Air Densit Moist Air w Calculated lb/ft^3	Enthalpy Heat Cont. h Calculated Btu/lb air
Empl. Outlet Td 95	95.0	35.0	83.250	28.5	26.2	1.66425	1.14995	1.04060	62.53	0.02573	180.083	16.645	0.06151	51.16955
Empl. Outlet Td 105	105.0	40.6	85.200	29.6	26.2	2.24857	1.22424	1.04035	46.27	0.02572	180.037	16.945	0.06036	53.67806
Empl. Outlet Td 122	122.0	50.0	88.325	31.3	26.2	3.65154	1.35200	1.04038	28.49	0.02572	180.043	17.455	0.05848	57.95564
Empl. Outlet Td 130	130.0	54.4	89.715	32.1	26.2	4.53786	1.41245	1.04032	22.93	0.02572	180.032	17.694	0.05764	59.96653
Empl. Outlet Td 150	150.0	65.6	93.000	33.9	26.2	7.59746	1.56473	1.04059	13.70	0.02573	180.081	18.294	0.05563	65.00596
Empl. Outlet Td 175	175.0	79.4	96.750	36.0	26.2	13.75175	1.75579	1.04053	7.57	0.02572	180.071	19.044	0.05328	71.29365
Empl. Outlet Td 200	200.0	93.3	100.170	37.9	26.2	23.68091	1.94735	1.04048	4.39	0.02572	180.061	19.794	0.05112	77.58138
Empl. Outlet Td 225	225.0	107.2	103.310	39.6	26.2	39.03081	2.13889	1.04049	2.67	0.02572	180.063	20.544	0.04911	83.87124
Empl. Outlet Td 250	250.0	121.1	106.210	41.2	26.2	61.88679	2.33006	1.04067	1.68	0.02573	180.095	21.294	0.04725	90.16588
Empl. Outlet Td 275	275.0	135.0	108.895	42.7	26.2	94.80951	2.52003	1.04046	1.10	0.02572	180.057	22.043	0.04551	96.44892
Empl. Outlet Td 286	285.8	141.0	110.000	43.3	26.2	112.89484	2.60202	1.04066	0.92	0.02573	180.094	22.367	0.04480	99.17217
Empl. Outlet Td 325	325.0	162.8	113.740	45.4	26.2	203.59762	2.89682	1.04057	0.51	0.02573	180.078	23.543	0.04237	109.03121
Empl. Outlet Td 342	341.6	172.0	115.210	46.2	26.2	256.45355	3.02033	1.04026	0.41	0.02572	180.022	24.040	0.04142	113.19769
Empl. Outlet Td 375	375.0	190.6	118.000	47.8	26.2	395.90840	3.26728	1.04038	0.26	0.02572	180.043	25.042	0.03962	121.60393
Empl. Outlet Td 392	392.0	200.0	119.340	48.5	26.2	486.89536	3.39193	1.04063	0.21	0.02573	180.089	25.552	0.03875	125.88879
	^o F	^o C	^o F	^o C										

Predicted Psychrometric Properties of Ventilation Air in Repository Emplacement Side

Temperature dry bulb and wet bulb at moisture of 200 grains per pound air in emplacement outlet.

File.Lotus\JuraniR\airpsyva 200 grains/lb

Repository Level Temp. Dry Bulb	Dry Bulb Temp. Td (Measured) ^o F	Dry Bulb Temp. Td (Measured) ^o C	Wet Bulb Temp Tw Calculated ^o F	Wet Bulb Temp Tw Calculated ^o C	Bar. Pres. Ave Pb (Measured) inch Hg	Sat. Vapor Pressure at Td Ps Calculated inch Hg	Sat. Vapor Pres at Tw Ps' Calculated inch Hg	Partial Vapor Pressu Pv Calculated inch Hg	Relative Humidity R (Measured) % Rel. Hu	Specific Humidity Moisture W (H2O) Calculated lb/lb dry air	Specific Humidity Moisture W*7000 Calculated Grains/lb air	Specific Volume v Calculated ft^3/lb dry air	Air Densit Moist Air w Calculated lb/ft^3	Enthalpy Heat Cont. h Calculated Btu/lb air
Empl. Outlet Td 95	95.0	35.0	85.560	29.8	26.2	1.66425	1.23840	1.15076	69.15	0.02857	200.023	16.718	0.06143	54.31070
Empl. Outlet Td 105	105.0	40.6	87.420	30.8	26.2	2.24857	1.31386	1.15100	51.19	0.02858	200.066	17.020	0.06028	56.84613
Empl. Outlet Td 122	122.0	50.0	90.390	32.4	26.2	3.65154	1.44264	1.15091	31.52	0.02858	200.049	17.532	0.05841	61.14211
Empl. Outlet Td 130	130.0	54.4	91.720	33.2	26.2	4.53786	1.50378	1.15113	25.37	0.02858	200.090	17.773	0.05756	63.17145
Empl. Outlet Td 150	150.0	65.6	94.850	34.9	26.2	7.59746	1.65660	1.15091	15.15	0.02858	200.051	18.375	0.05555	68.22242
Empl. Outlet Td 175	175.0	79.4	98.445	36.9	26.2	13.75175	1.84858	1.15090	8.37	0.02858	200.048	19.128	0.05321	74.54349
Empl. Outlet Td 200	200.0	93.3	101.735	38.7	26.2	23.68091	2.04087	1.15098	4.86	0.02858	200.063	19.881	0.05105	80.86745
Empl. Outlet Td 225	225.0	107.2	104.760	40.4	26.2	39.03081	2.23271	1.15086	2.95	0.02858	200.041	20.634	0.04905	87.18537
Empl. Outlet Td 250	250.0	121.1	107.560	42.0	26.2	61.88679	2.42397	1.15087	1.86	0.02858	200.043	21.387	0.04718	93.50713
Empl. Outlet Td 275	275.0	135.0	110.160	43.4	26.2	94.80951	2.61408	1.15069	1.21	0.02857	200.011	22.140	0.04545	99.82322
Empl. Outlet Td 286	285.8	141.0	111.230	44.0	26.2	112.89484	2.69597	1.15078	1.02	0.02858	200.027	22.466	0.04474	102.55684
Empl. Outlet Td 325	325.0	162.8	114.865	46.0	26.2	203.59762	2.99095	1.15103	0.57	0.02858	200.071	23.647	0.04231	112.47645
Empl. Outlet Td 342	341.6	172.0	116.295	46.8	26.2	256.45355	3.11439	1.15075	0.45	0.02857	200.021	24.146	0.04136	116.66537
Empl. Outlet Td 375	375.0	190.6	119.010	48.3	26.2	395.90840	3.36086	1.15067	0.29	0.02857	200.005	25.152	0.03956	125.10809
Empl. Outlet Td 392	392.0	200.0	120.315	49.1	26.2	486.89536	3.48518	1.15075	0.24	0.02857	200.021	25.665	0.03870	129.40944
	^o F	^o C	^o F	^o C										

Predicted Psychrometric Properties of Ventilation Air at Effective Temp 27^C

Temperature dry bulb and wet bulb ......

	Dry Bulb Temp. Td (Measured)	Dry Bulb Temp. Td (Measured)	Wet Bulb Temp Tw Calculated	Wet Bulb Temp Tw Calculated	Bar. Pres. Ave Pb (Measured)	Sat. Vapor Pressure at Td Ps Calculated	Sat. Vapor Pres at Tw Ps' Calculated	Partial Vapor Pressu Pv Calculated	Relative Humidity R (Measured)	Specific Humidity Moisture W (H2O) Calculated	Specific Humidity Moisture W*7000 Calculated	Specific Volume v Calculated	Air Densit Moist Air w Calculated	Enthalpy Heat Cont. h Calculated
Repository Level														
Velocity fpm	^o F	^o C	^o F	^o C	inch Hg	inch Hg	inch Hg	inch Hg	% Rel. Hu	lb/lb dry air	Grains/lb air	ft^3/lb dry air	lb/ft^3	Btu/lb air
50	86.0	30.0	80.000	26.7	26.2	1.25590	1.03484	0.97883	77.94	0.02414	168.979	16.335	0.06263	47.16241
50	95.0	35.0	75.000	23.9	26.2	1.66425	0.87733	0.68993	41.46	0.01682	117.756	16.416	0.06176	41.35077
50	103.0	39.4	70.000	21.1	26.2	2.11928	0.74116	0.43104	20.34	0.01040	72.829	16.485	0.06100	36.23062
50	120.0	48.9	60.000	15.6	26.2	3.45482	0.52310	-0.04288	-1.24	-0.00102	-7.115	16.677	0.05940	27.66773
100	90.0	32.2	80.000	26.7	26.2	1.42513	1.03484	0.94150	66.06	0.02318	162.293	16.430	0.06218	47.11476
100	97.0	36.1	75.000	23.9	26.2	1.76922	0.87733	0.67119	37.94	0.01635	114.473	16.463	0.06154	41.32835
100	105.0	40.6	70.000	21.1	26.2	2.24857	0.74116	0.41224	18.33	0.00994	69.602	16.532	0.06079	36.20961
100	120.0	48.9	60.000	15.6	26.2	3.45482	0.52310	-0.04288	-1.24	-0.00102	-7.115	16.677	0.05940	27.66773
200	93.0	33.9	80.000	26.7	26.2	1.56473	1.03484	0.91349	58.38	0.02247	157.291	16.502	0.06184	47.07879
200	100.0	37.8	75.000	23.9	26.2	1.93742	0.87733	0.64308	33.19	0.01565	109.558	16.534	0.06121	41.29458
200	107.0	41.7	70.000	21.1	26.2	2.38462	0.74116	0.39344	16.50	0.00948	66.381	16.578	0.06057	36.18852
200	120.0	48.9	60.000	15.6	26.2	3.45482	0.52310	-0.04288	-1.24	-0.00102	-7.115	16.677	0.05940	27.66773

Tabulated Air Psychrometric Calculation, Given: Td, Tw, and Pb; Refer Mine Ventilation & Air Conditioning, 2nd Ed., pages 596 to 598, by Hartman, Mutmansky & Wang

where Td is temperature dry bulb, ^oF
Tw is temperature wet bulb, ^oF
Pb is barometric pressure, inch Hg

Formulas used to determine characterictics of air:

Sat. Vapor Pressure (at Td), Ps = 0.18079* e^(((17.27*Td)-552.64)/(Td+395.14)), inches Hg

Sat. Vapor Pressure (at Tw), Ps' = 0.18079* e^(((17.27*Tw)-552.64)/(Tw+395.14)), inches Hg

Vapor Pressure, Pv = Ps'-((Pb-Ps')*(Td-Tw))/(2800-1.3*Tw), inches Hg

Relative Humidity, R = (Pv/Ps)*100%

Specific Humidity, W = 0.622*(Pv/(Pb-Pv)), lb/lb dry air
or Grains Specific Humidity, W*7000 = 0.622*(Pv/(Pb-Pv))*7000, grains water vapor/lb dry

Specific Volume, v = 53.35*(460+Td)/((Pb-Pv)*0.491*144), ft^3/lb

Moist Air density, w = (1.325/(460+Td))*(Pb-.378*Ps'), lb/ft^3

Enthalpy, h = 0.24*Td+W*(1060+0.45*Td), Btu/lb dry air

Flexibility and Sizing of Repository Major Fans (Reference Section 7.10 and 7.11)

The major repository fans are recommended to have variable speed motor to cover a wide range of operation during the lifetime of the repository. Ventilation air quantity requirements are satisfied without changing the physical size of fans and without significantly compromising fan efficiency. The maximum flexibility operation of the three major fans are based on the following computer models:

1. **Primary development fan** is potentially at maximum operation during early development phase when maximum active development areas are relatively far from the primary intake and return airways. This is shown in the computer model (Attachment I) under VNETPC output file Repvaoa2. The model shows a primary development fan performance of 268.62 m^3/s (569,110 cfm) at 3.0 kPa (12.06 inches wg) static pressure. Line 16 of next page spreadsheet shows the calculated data for the required air horsepower, motor brake horsepower and system resistance (R) value at this stage.

   Given the system resistance value, the flexibility of an installed fan motor at about 1491 kW (2000 bhp) (line 14, next page spreadsheet) can potentially deliver about 299.53 m^3/s (634,600 cfm) at 3.73 kPa (15.0 inches wg) static pressure. The VA motor capability allowance may be needed to cover occasional blockage of airway during roadheader initial cutting of emplacement drifts and emergency repair of airways, unforseen configuration losses and expended velocity pressure allowances.

2. **Primary emplacement fan** is potentially at maximum operation during late emplacement phase when maximum active emplacement areas are relatively far from the primary intake and return airways. This is shown in the computer model (Attachment II) under VNETPC output file Repvaoa3. The model shows a primary emplacement fan performance of 320.31m^3/s (678,630 cfm) at (9.61 inches wg) static pressure. Line 27, next page spreadsheet shows the calculated data for the required air horsepower, motor brake horsepower and system resistance (R) value at this stage.

   Given the system resistance value, the flexibility of an installed fan motor at about 1491 kW (2000 bhp) motor (line 25, next page spreadsheet) can potentially deliver about 363.34 m^3/s (769,800 cfm) at 3.08 kPa (12.36 inches wg) static pressure. The VA motor capability allowance may be needed to cover occasional blockage of airways, unforseen configuration losses and expended velocity pressure allowances.

3. **Auxiliary Emplacement Exhaust fan** is potentially at maximum operation during late emplacement phase when maximum active emplacement areas are relatively far from the emplacement shaft, the location of the auxiliary emplacement exhaust fan. This is shown in the computer model (Attachment II) under VNETPC output file Repvaoa3. The model shows the auxiliary emplacement exhaust fan performance of 63.78 m^3/s (135,130 cfm) at 10.45 kPa (42 inches wg) static pressure. Line 41, next page spreadsheet shows the calculated data for the required air horsepower, motor brake horsepower and system resistance (R) value at this stage.

   Given the system resistance value, the flexibility of an installed fan at about 932 kW (1250 bhp) motor (line 40, next page spreadsheet) can potentially deliver about 64.8 m^3/s (137,300 cfm) at 10.78 kPa (43.33 inches wg) static pressure. The VA motor capability allowance may be needed to cover occasional blockage of airways, unforseen configuration losses and expended velocity pressure allowances.

Installed Fan BHP Table for Flexibility Reference

1	File:Repva2											
2												
3								Predicting flexibility of repository operation				
4	Output Based on VNETPC Model File REPVA0A2 & REPVAOA3							at maximum installed motor brakehorsepower (BHP).				
5	Surface and	q	Hf	ahp	bhp		@Potential		q	H @	AHP @	BHP @
6	UG fans	VNET Model	VNET Model	VNET Model	VNET Model		System	,	Predicted	Predicted	Predicted	Predicted
7	Design Maximum		Fan Head		hp @ 75%E		Resistance (R)		Flexibility	Fan Head	Flexibility	Flexibility
8	Prediction											hp @ 75%E
9		Air Quantity	Static Pressure	ahp=qH/6345	bhp=ahp/0.75		R=H/(q/100000)^2			H=R(q/100000)^2	ahp=qH/6345	bhp=ahp/0.75
10		cfm	inches WG	hp	bhp		R		cfm	Inches Wg	hp	bhp
11												
12							0.3724		675000	16.97	1805	2406
13							0.3724		650000	15.73	1612	2149
14							0.3724		634600	15.00	1500	2000
15							0.3724		600000	13.40	1268	1690
16	Primary Fan	569110	12.06	1082	1442		0.3724		569110	12.06	1082	1442
17	Development						0.3724		550000	11.26	976	1302
18	Area						0.3724		500000	9.31	734	978
19	Vnetpc file:REPVA0A2						0.3724		400000	5.96	376	501
20	Development						0.3724		300000	3.35	158	211
21	Shaft											
22												
23							0.2086		800000	13.35	1684	2245
24							0.2086		750000	11.74	1387	1850
25							0.2086		769800	12.36	1500	2000
26							0.2086		700000	10.22	1128	1504
27	Primary Fan	678630	9.609	1028	1370		0.2086		678630	9.61	1028	1370
28	Emplacement						0.2086		650000	8.82	903	1204
29	Area						0.2086		600000	7.51	710	947
30	Vnetpc file:REPVA0A3						0.2086		550000	6.31	547	729
31	(Empl. Shaft)						0.2086		500000	5.22	411	548
32							0.2086		400000	3.34	210	281
33												
34												
35							22.9829		180000	74.46	2112	2817
36							22.9829		170000	66.42	1780	2373
37							22.9829		160000	58.84	1484	1978
38							22.9829		150000	51.71	1222	1630
39							22.9829		140000	45.05	994	1325
40							22.9829		137300	43.33	938	1250
41	Auxiliary Fan	135130	41.967	894	1192		22.9829		135130	41.97	894	1192
42	Exhaust Duct						22.9829		130000	38.84	796	1061
43	Vnetpc file REPVA0A3						22.9829		120000	33.10	626	835
44	(Exhaust Main)						22.9829		110000	27.81	482	643
45							22.9829		100000	22.98	362	483
46							22.9829		90000	18.62	264	352
47							22.9829		80000	14.71	185	247
48												

M&O/MK/RSJURANI/Date:07-Aug-97

Comparative Performances of the 1.52, 1.67 and 1.83 m (60", 66", and 72") diameter ventilation pipes for emplacement exhaust ducts

Two similar size ducts (100% backup system) are considered for installation along the exhaust main drift. The return air from the emplacement drifts will be isolated from human contact along the exhaust main drift by containing the return air through these twin insulated pipes. The pipe size is based on the following factors: a) Physical occupancy of the two insulated parallel ducts along the exhaust main; b) Energy usage to handle the required air quantity at potential maximum 47.2 m^3/s (100,000 cfm) through any single emplacement drift; and c) Structural stability [pipe wall thickness = 6.53 mm (1/4 inch) plate] to hold relatively high negative pressures greater than 12.4 kPa (50 inches wg). The metal pipe/duct will be smooth lined ("K" factor = 0.002 kg/m^3 = 11×10^{-10} $lb.min^2/ft^4$) (Reference 5.6) to be installed in welded or flanged joints and can be assumed to have negligible leakages along joints. Leakages are still expected through the numerous valves regulating the emplacement air into the pipe.

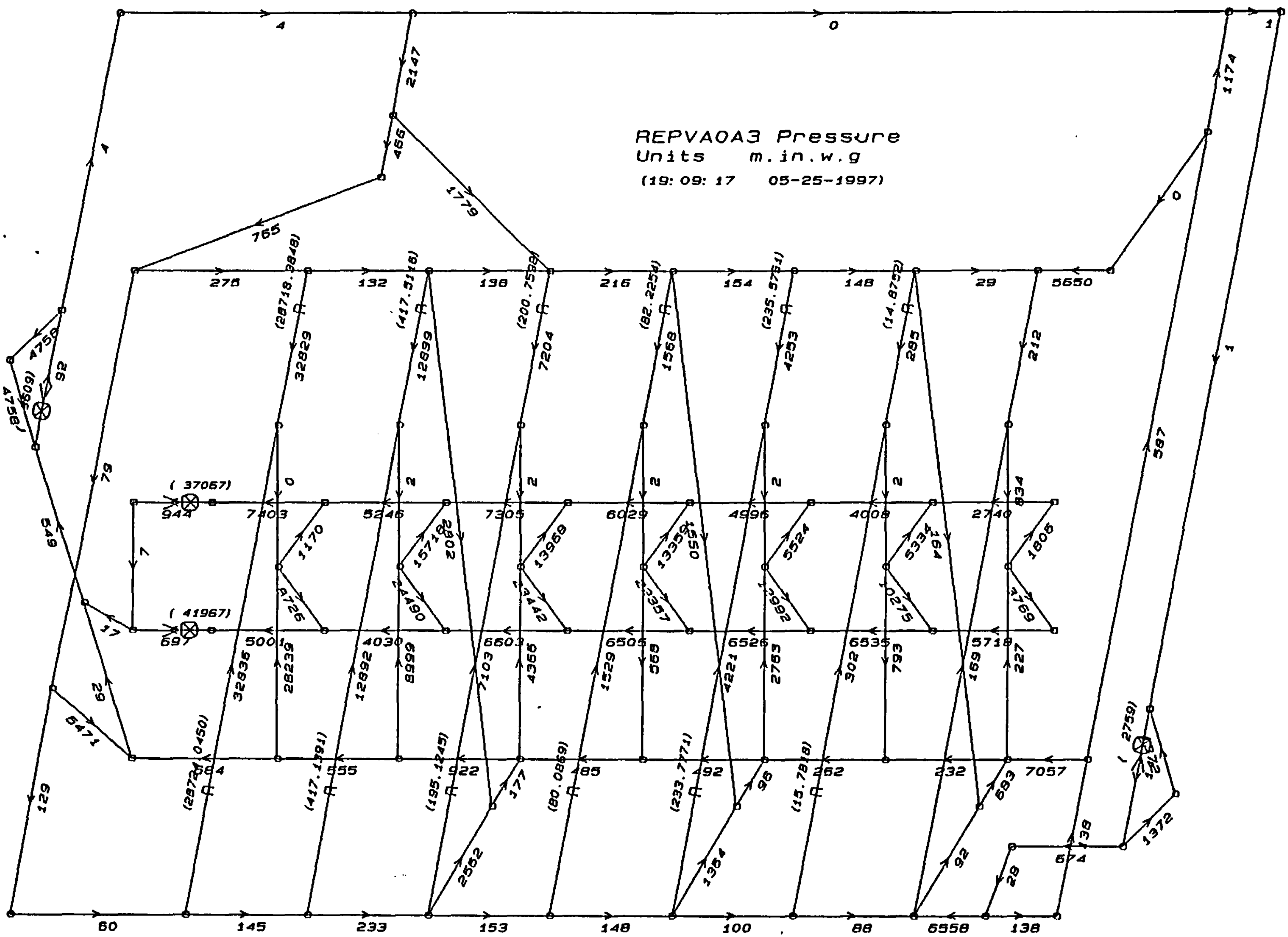
The base case of this comparison is the reference computer generated model during late emplacement phase. This is shown in VNETPC file output Repvaoa3 in Attachment II. The base model uses a 1.83 m (72") inside diameter pipe. To satisfy airflow requirements through the farthest potential emplacement drift, the auxiliary emplacement exhaust fan performance is 63.78 m^3/s (135,130 cfm) at 10.45 kPa (42 inches wg) static pressure. Line 14 of the spreadsheet below shows the calculated data that matches the performance of the fan. As shown in the same spreadsheet, the use of smaller pipes such as the 1.67 and 1.52 m (66 and 60 inches) inside diameter will have considerably higher pressure drop and energy requirements for the repository needs in the next 100 years of operation (Section 4.2.14).

1	PERFORMANCE COMPARISON BETWEEN THE THREE POTENTIAL PIPES 60, 66 AND 72 INCHES DIAMETER								
2	FOR EMPLACEMENT EXHAUST MAIN DUCT								
3	File:Repva2								
4									
5					Resistance	Length	Pressure	ahp	bhp
6	*Duct Diameter*	Perimeter	Area	k factor	for 13070 ft		Drop	H(q/6345	@ eff = 75%
7	d	P	A	k	R	L	H		
8	inches	(ft)	Ft^2			ft	@q =135000 cfm		
9		3.1416(d/12)	3.1416(d^2)/4						
10					kLP/5.2A^3		H=R(q 100000)^2		ahp/.75
11									
12	60	15.708	19.635	11	57.371	13070	104.56	2225	2966
13	66	17.279	23.758	11	35.623	13070	64.92	1381	1842
14	72	18.850	28.274	11	23.056	13070	42.02	894	1192
15									

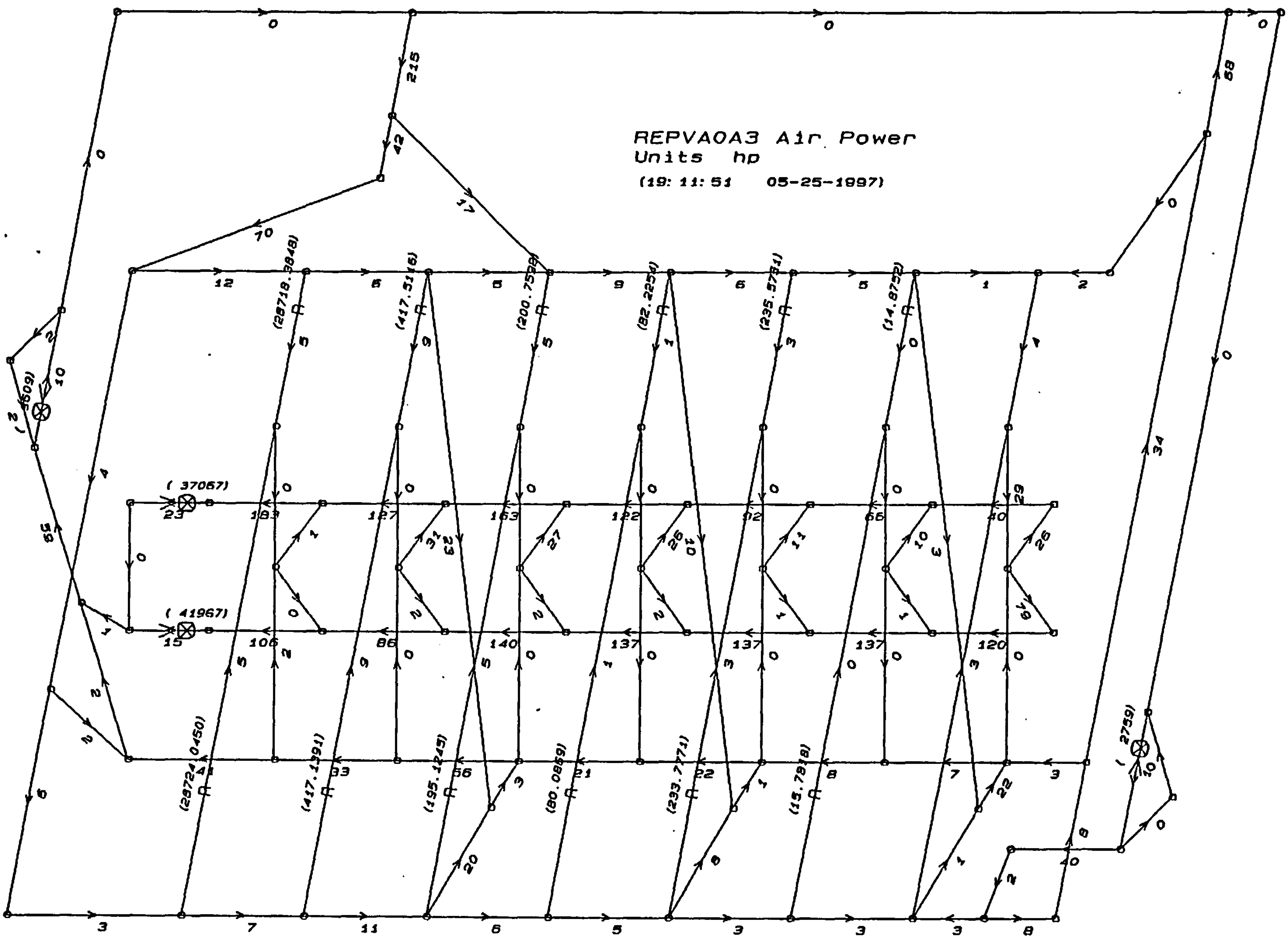
The use of 2.1 m (84 inches) inside diameter duct with potential 0.152 m (6 inches) of insulation was not considered because of the overall diameter size to occupy too much space in the Exhaust Main. The pipe size will hinder the maintenance and operation of the exhaust main drift in normal and abnormal cases.

The comparative performance of the three ducts shows that the 1.83 m (72 inches) diameter pipe is the best choice and is recommended.

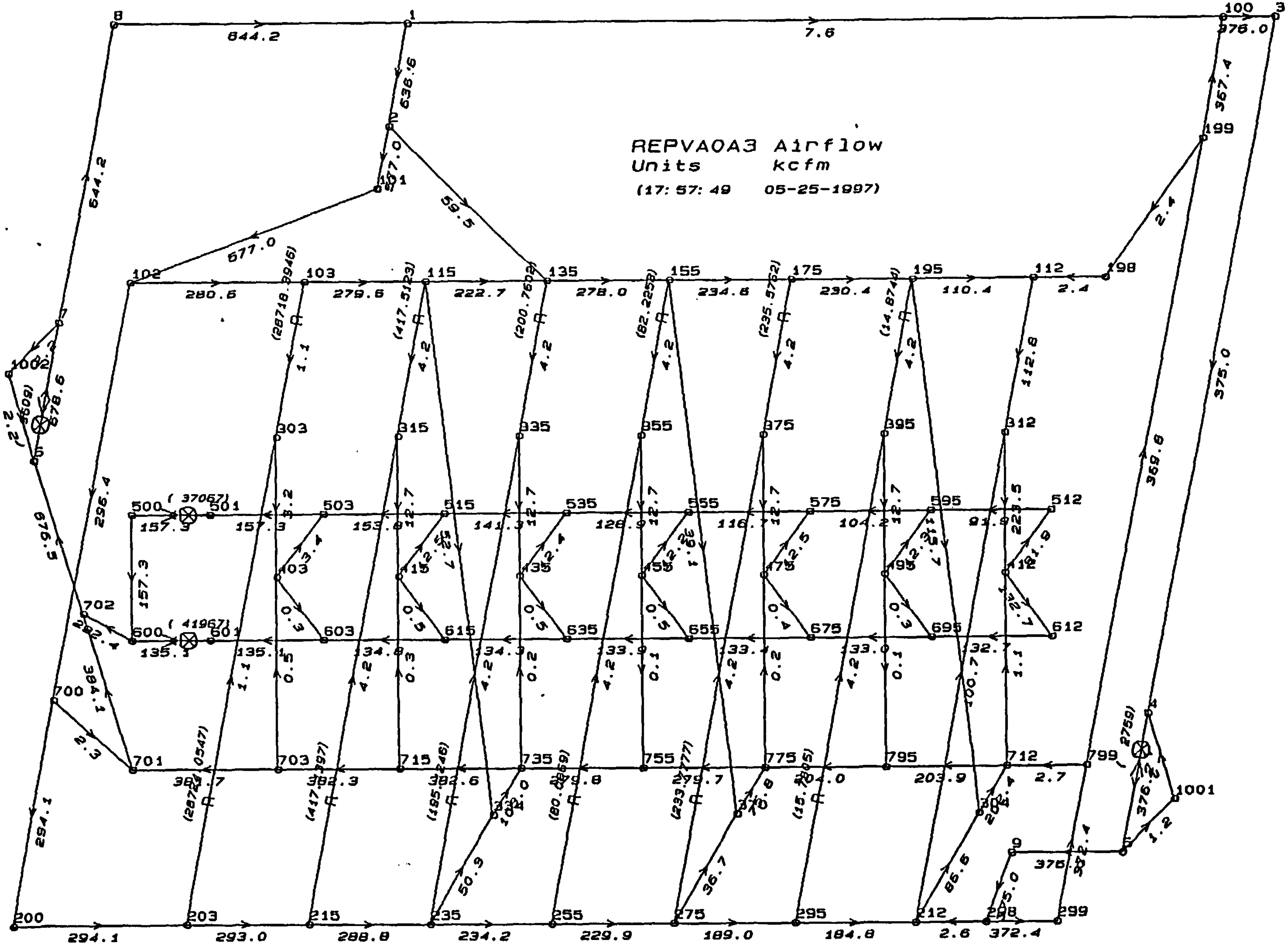
Some information may be obliterated but may be deduced from Attachment II, pages 7 thru 14.

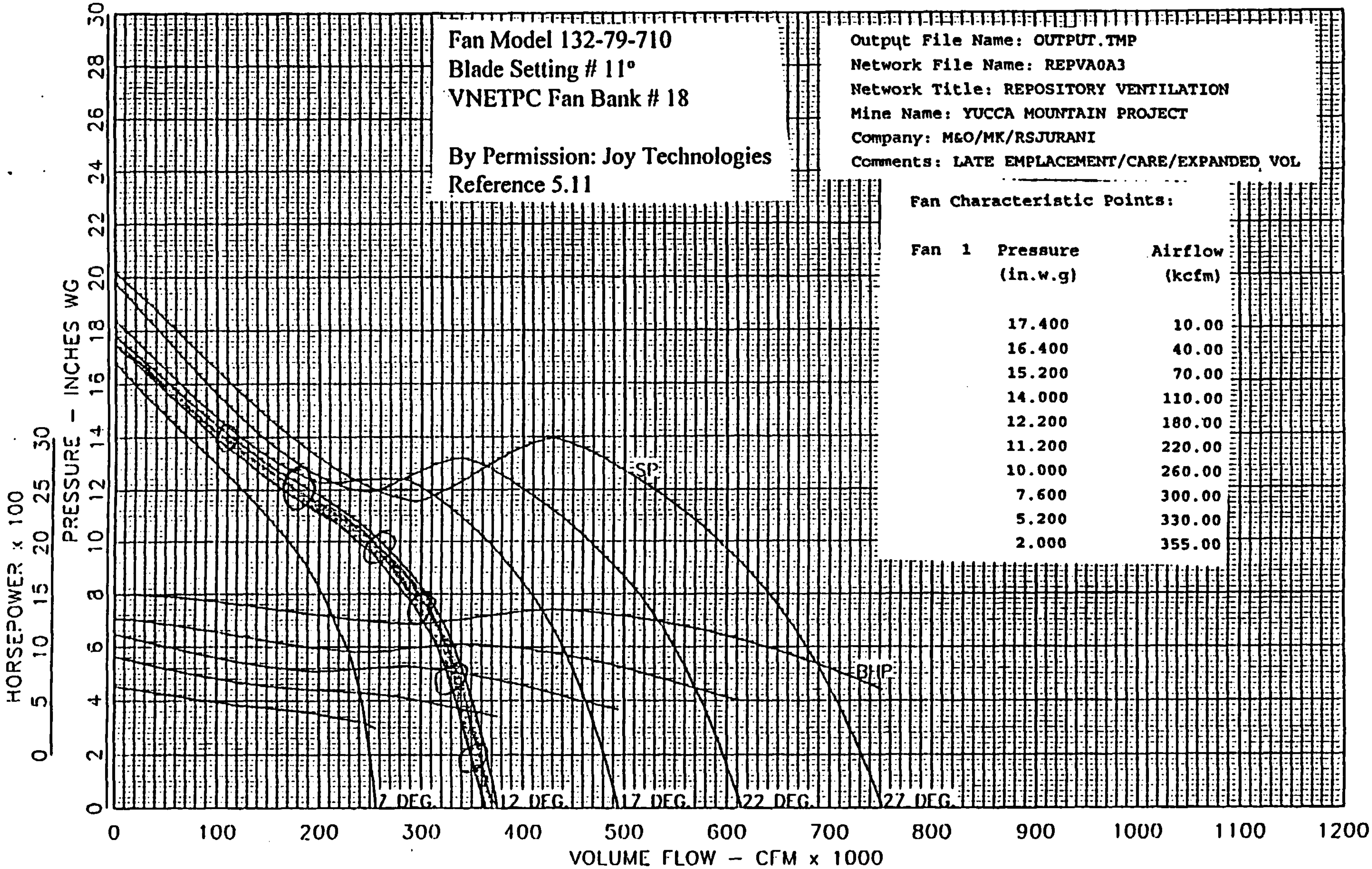


Some information may be obliterated but may be deduced from Attachment II, pages 7 thru 14.



Some information may be obliterated but may be deduced from Attachment II, pages 7 thru 14.




Fan Model 132-79-710
Blade Setting # 11°
VNETPC Fan Bank # 18
By Permission: Joy Technologies
Reference 5.11
Output File Name: OUTPUT.TMP
Network File Name: REPVA0A3
Network Title: REPOSITORY VENTILATION
Mine Name: YUCCA MOUNTAIN PROJECT
Company: M&O/MK/RSJURANI
Comments: LATE EMPLACEMENT/CARE/EXPANDED VOL
Fan Characteristic Points:
Fan 1 Pressure (in.w.g) Airflow (kcfm)
17.400 10.00
16.400 40.00
15.200 70.00
14.000 110.00
12.200 180.00
11.200 220.00
10.000 260.00
7.600 300.00
5.200 330.00
2.000 355.00
SP
BHP
7 DEG.
12 DEG.
17 DEG.
22 DEG.
27 DEG.
HORSEPOWER x 100
PRESSURE - INCHES WG
VOLUME FLOW - CFM x 1000
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
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