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Determination of resistance across development section return stoppings

James Robert Gandy
West Virginia University

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**DETERMINATION OF
RESISTANCE ACROSS DEVELOPMENT
SECTION RETURN STOPPINGS**

**BY
JAMES R. GANDY**

A THESIS

**SUBMITTED TO THE FACULTY OF
DEPARTMENT OF MINING ENGINEERING
COLLEGE OF ENGINEERING AND MINERAL RESOURCES
WEST VIRGINIA UNIVERSITY**

**IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
MASTER OF SCIENCE
IN
ENGINEERING OF MINES**

**SYD S. PENG, CHAIR
A. W. KHAIR
LLOYD ENGLISH**

**MORGANTOWN, WV
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KEYWORDS: MINING, VENTILATION, RESISTANCE

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ABSTRACT

DETERMINATION OF RESISTANCE ACROSS DEVELOPMENT SECTION RETURN STOPPINGS

By James R. Gandy

This thesis describes a ventilation engineering study to determine the resistance across return stoppings on continuous miner development sections. By determining the resistance across return stoppings, one equivalent resistance branch can be created to model leakage across a return stopping line on a development section. This thesis evaluates four types of return stoppings to determine which construction techniques and materials provide the highest resistance, thus allowing minimal leakage from the intake to return entry.

The first phase of the thesis outlines the data gathering process including; station locations, equipment requirements and techniques. Second, the data is used to create a model from which the resistance per stopping is calculated, thus evaluating the stopping performance. Using the ventilation simulation model to obtain leakage resistance branches, the parallel resistance formula provides an equivalent resistance branch.

The equivalent resistance branch results are then used to evaluate leakage at different section locations. Special attention is given to changes in leakage due to changes in pressure differential across return stoppings on development sections.

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INTRODUCTION

1.1 Statement of the Problem

The primary function of mine ventilation is to dilute, render harmless, and carry away dangerous accumulations of gas and dust from the working environment.⁽¹⁾ The ventilation system must be designed to provide a cost efficient means of delivering sufficient quantities of air to ensure a safe working environment while maximizing productivity. For efficient mine ventilation, two problems that require continuous planning are (1) the control of fugitive air (through short-circuiting or leakage) and (2) the necessity to have enough airway capacity to provide the quantity of air needed at all face locations and throughout the mine.

Fugitive air is that quantity of air that enters the system but short-circuits the ventilation network through stoppings, doors, and overcasts. The amount of leakage through stoppings is a function of the pressure difference across the stopping, the resistance that is provided by the construction material and the surrounding roof and ribs.

Leakage is an investment in power consumption (horsepower to move the air by fan) while providing little or no benefit to mine ventilation. Typically, efficient mines are those that can deliver 50% of the air handled by their fans to the working faces.⁽²⁾ Large amounts of

leakage require fans to handle greater quantities of air resulting in increased power costs.

Higher power cost is just one of the problems leakage creates. In a continuous miner development section the air quantity of the last open crosscut usually range from 25,000 to 50,000 cfm, depending the amounts of methane liberated, geological conditions and the mining methods used. Current federal law requires a minimum air velocity of 60 fpm in working places, and respirable dust levels (particles less than 5 microns in size) cannot exceed an average of 2.0 mg/m³ of air per shift. In working areas, methane accumulations shall not exceed 1.0%.⁽¹⁾ The inability to meet these federal requirements causes health, safety and production problems for the mine.

Higher face air requirements and the demand on companies to produce coal in a cost efficient manner require better ventilation practices. To improve these practices, engineering techniques are superior to the in mine, trial-and-error method. By minimizing leakage on continuous miner development sections, the air quantity of the last open crosscut will increase and horsepower consumption at fan installations will be reduced, thus lowering power cost.

Although many companies conduct ventilation surveys at their operations, very little research has been done on the evaluation of resistance across return stoppings. This analysis of the resistance

across continuous miner development section return stoppings is fundamental to the determination of leakage on production sections.

1.2 History

The first experiences with pressure losses in mine ventilation systems were reported by J. A. Saxe, then chief engineer of the Ellsworth Collieries, in 1929.⁽³⁾ A detailed report⁽⁴⁾ on air pressure surveying was published in England in 1931 by J. N. Williamson. Two additional papers published by Williamson⁽⁵⁾⁽⁶⁾ initiated the interest in ventilation surveys in the United States mining industry. R. T. Antz, a Bureau of Mines engineer, made a limited number of ventilation surveys in bituminous coal mines, which produced reliable results.

In order to determine the resistance across return stoppings, data must be gathered from the mine ventilation network. Mine ventilation pressure and air quantity data are essential in the study of ventilation problems, to project future ventilation requirements, and to delineate segments of the system in which conditions are adversely affecting system efficiency.⁽⁷⁾ Pressure and air quantity surveys make it possible to locate areas of excessive resistance and determine the feasibility of correcting existing problems. The data collected from the pressure and quantity surveys can be used to identify airway characteristics such as the coefficient of friction and the resistance of each network branch.

1.3 Purpose

The purpose of this thesis is twofold. The first is to evaluate the resistance across four different types of return stoppings. The second is to find the equivalent resistance that can be assigned to one leakage branch that can be used to represent the leakage for an entire return stopping line.

To achieve the two goals of this thesis, ventilation surveys were conducted on five continuous miner sections at four underground mines. The data was then processed and five network models were constructed. The individual leakage branches were then combined using the parallel resistance formula to develop an equivalent resistance for each stopping line.

BACKGROUND

2.1 Site Location

The data to develop the ventilation models was gathered from four underground mines in northern West Virginia and southwestern Pennsylvania. The mines extract coal from the Pittsburgh #8 seam using longwall mining as the primary mining method. A description of each mine can be found in table 2.1.1.

Table 2.1.1 Mine Description						
Mine	Seam Thickness (ft)	Depth (ft)	Annual Production (MM)	Ventilation Technique	Number of CM Sections	Number of LW Sections
A	6.5-7.0	700	7.3	Exhaust	3	2
B	7.5-8.0	950	4.9	Exhaust	3	1
C	7.5-8.0	650	4.8	Exhaust	3	1
D	6.5-7.0	500	4.5	Exhaust	2	1

Ventilation studies were conducted on five continuous miner development sections at the four mines. Each of the sections was being mined for longwall gate development. Table 2.1.2 gives a layout of each section that was studied.

Table 2.1.2 Section Description				
Section	Mine	Distance (ft)	Number of Entries	Belt Air to Face
4 E	A	5790	3	No
6 Left	B	5310	3	Yes
13 D	C	1350	3	No
12 D	C	5250	3	No
9 Right	D	7130	3	No

2.2 Ventilation Survey

A ventilation survey was conducted on each section. The first step in the planning of the ventilation survey is to set up station locations. The survey area was made up of the entire section (inby the return regulator to the last return stopping in the face area). Figure 2.2.1 shows a typical station layout for a development section ventilation survey. The stations are placed in a manner which will allow cut sequences to be made across the section. The cut sequences divide the section into segments for which the quantities can be balanced so that leakage can be determined. The distance between station cuts ranged from 400 ft -2000 ft. depending on section layout.

In order to have a complete ventilation survey, a wide variety of information must be gathered. To gather the raw data the following equipment was used:

1. Microbarograph
2. Altimeter
3. Sling Psychrometer
4. 25 ft. Tape Measure
5. Vane Anemometer

The microbarograph is used to take a continuous recording of the barometric pressure fluctuations during the ventilation survey. The microbarograph is placed at the base station (usually at the bottom of the man-shaft) to record the changes in barometric pressure. The

Figure 2.2.1 Typical Station Layout

base station instrument provides a reference to which pressures at other stations may be compared and adjusted when computing pressure differences⁽⁸⁾.

An aneroid altimeter was used to determine the pressure at each station. The altimeter records the difference in the vertical component on the static pressure gradient⁽⁸⁾. The altimeter indicates the instantaneous static pressure at each survey station in terms of height of a theoretical air column. Differences found in altimeter readings are the result of the combined effects of the following:

1. Changes in atmospheric pressure due to airway resistance.
2. Changes in the elevation at one station with respect to another or the base station.
3. Variations in temperature.
4. Variations in air velocity and the resultant static and velocity pressures.

Differences in air density due to changing humidity have an effect on barometric pressure. To take this effect into consideration, the station altimeter readings must be adjusted. The determination of humidity requires wet and dry bulb temperature readings, using a sling psychrometer. The value of the vapor pressure is determined from wet and dry bulb temperature values and the barometric pressure⁽⁹⁾.

Air quantity readings were taken at each station on the development section with a vane anemometer. To ensure better accuracy of the air readings, two readings were taken at each location. A full area traverse was used. Vane anemometers register a

velocity within plus or minus-10 percent of the true velocity⁽¹⁰⁾. If the velocity readings differed by more than 20 fpm, additional readings were taken to come within 20 fpm of one of the previous readings. The entry height and width of each reading location was measured and recorded. Sloughage and other obstacles in the traversed plane were measured and entered into the raw data sheet (see Figure 2.2.2 for an example raw data sheet).

2.3 Data Processing

The first step in the raw data computation is to interpret the microbarograph chart from the ventilation survey. The microbarograph records the instantaneous changes in atmospheric pressure on a chart calibrated in feet of elevation versus time. The chart provides a correction for the station altimeter readings.

The raw data from each development section ventilation survey was entered into an “in house” ventilation survey processing program. The program uses the manufacturer’s correction factors for anemometer readings and corrects each station velocity reading. The two velocity readings are averaged for the specific station and multiplied by the corrected area (total area minus sloughage area).

In order to determine the absolute pressure drop relative to the collars of the intake shaft, an altimeter reading is taken at the top of the shaft collar (absolute pressure is set to zero for this point). The data processing program uses the altimeter readings, psychrometer

MINE: _____
DATE: _____
ANEMOMETER NO.: _____
ALTIMETER NO.: _____
TEAM: _____

[illegible]

**NOTE: MARK DIRECTION OF AIR FLOW FOR EACH STATION ON THE MAP.
ELEVATIONS TAKEN FROM MINE MAP**

readings, station elevations, and microbarograph interpretations to calculate the differential pressure from the surface to each underground station in inches of water gauge. The raw data and final output from the ventilation calculation program for each development section ventilation survey can be found in Appendix A.

To find the leakage between each set of stations (cut set) the air quantities must be balanced. Kirchhoff's first law (equation 1) states that the sum of the air quantities leaving a junction or cut must equal the sum of the air quantities entering a junction⁽¹¹⁾. Figure 2.3.1 shows a typical cut sequence balancing operation.

$$\sum Q = 0 \quad (1)$$

Due to the error in anemometer readings the Q_{in} and Q_{out} usually are not equal at cut sequence locations. To balance the numbers the following equations were used:

$$Q_{IN} + Q_{OUT} = Q_{TOTAL} \quad (2)$$

$$\frac{Q_{TOTAL}}{2} = Q_M \quad (3)$$

where Q_M is the midpoint of the Q_{in} and Q_{out}

The final quantity balance can be done by using the following formulas:

$$\frac{Q_M}{Q_B} = CF_B \quad (4)$$

$$\frac{Q_M}{Q_A} = CF_A \quad (5)$$

where Q_B is the summation of the quantities in a given direction below the midpoint

Q_A is the summation of the quantities in a given direction above the midpoint

CF_B is the correction factor for the quantity below the midpoint

CF_A is the correction factor for the quantity above the midpoint

$$Q_{B_N} * CF_B = Q_{B_N \text{ BALANCED}} \quad (6)$$

$$Q_{A_N} * CF_A = Q_{A_N \text{ BALANCED}} \quad (7)$$

where Q_{BN} is the individual quantity branch making up the Q_B

where Q_{AN} is the individual quantity branch making up the Q_A

After each cut set is balanced, the adjacent cut set must be evaluated to determine the leakage. The difference between the balanced quantities in each entry at two adjacent cuts is the leakage, which is taking place for the given segment. For junctions that involve a leakage branch equation 1 can be written as follows:

$$Q_{IN} + LEAKAGE = Q_{OUT} \quad (8)$$

Each individual cut must be balanced with the preceding cut to determine the leakage throughout the ventilation survey.

After a quantity balance has been conducted on the entire section the pressures determined from the ventilation calculation program must be balanced. If an airway is to have a flow of air through it, there must be a difference in pressure potential between one end and the other so that air will go from the area of higher pressure to the area of lower pressure⁽¹²⁾. The initial pressure balancing process involves:

1. Lay out the station locations in the survey.
2. Average the two pressure readings for each location.
3. Place the pressures on their appropriate locations.
4. Check to insure that air will flow in the correct direction due to pressure differential.

Once the raw pressure balance has been conducted, a schematic of the ventilation survey consisting of entry and leakage branches is constructed. The quantity values for each branch are placed in the schematic. A balance check program is then run to insure a proper quantity balance was performed at each junction.

2.4 Ventilation Model

The pressure balance is then refined using a spreadsheet. The resistance values for each branch are determined in a spreadsheet. Table 2.4.1 shows the spreadsheet format for the 13 D section of Mine C. The resistance of the airway is back calculated by using the pressure drop and quantity values from the ventilation survey (equation 9).

$$R = \frac{H}{Q^2} \quad (9)$$

The expected pressure drop for a given airway H_f is calculated from the airway characteristics using the Atkinson equation (equation 10)⁽¹¹⁾. By comparing the raw balanced pressures against the expected pressure drop determined from the airway characteristics (A , P , L , K ,) the pressure balance is fine-tuned.

$$H_f = \frac{KPLQ^2}{5.2A^3} \quad (10)$$

Table 2.4.1 Example of Spreadsheet Model

MINE C13 D SECTION															JCT			ABS PRES	
FROM TO		TYPE	ACTUAL H	QUANTITY	K	LENGTH	AREA	O	N	CF	H=f(K)	RESIST	ACTUAL K	K%					
1	8	0	3.6377110	59663.9	80	987	120	47	1	0	0.147022	10.21892	1979	2474	1	50	525	0.00000	
2	4	0	0.0008840	4800.7	105	505	110	50	1	0	0.000883	0.383569	105	100	2	50	525	-3.84437	
2	6	0	0.0374411	45867.8	85	478	127.1	47	1	0	0.037629	0.177964	85	100	3	50	525	-3.81737	
3	2	0	0.0270040	50668.5	67	449	137.2	47	1	0	0.027029	0.105185	67	100	4	50	525	-3.84525	
4	9	0	0.0011170	4800.7	105	450	105	62	1	0	0.001122	0.484668	105	100	5	50	525	-4.07089	
5	1	1	-4.0708870	53064.4	90	988	120	47	1	0	0.130965	4.070887	-2798	#N/A	6	50	525	-3.88181	
6	11	0	0.0439639	45867.8	80	448	115	46	1	0	0.043858	0.208968	80	100	7	50	525	-3.85203	
7	1	1	-3.8520260	6599.5	100	981	110	50	1	0	0.003087	3.852026	-124799	#N/A	8	50	525	-3.63771	
8	5	0	0.4331760	1017.3	245	166	1	4	1	0	3.237643	4185.683	33	13	9	50	525	-3.84637	
8	7	0	0.2143150	68.1	245	226	1	4	1	0	0.019753	462123.8	2658	1085	10	50	525	-3.78013	
8	16	0	0.0534515	58578.5	70	451	125	50	1	0	0.053332	0.15577	70	100	11	50	525	-3.92577	
9	12	0	0.0014740	6383.6	105	450	116	62	1	0	0.001471	0.361715	105	100	12	50	525	-3.84784	
10	3	0	0.0372400	50668.5	70	450	128	50	1	0	0.037079	0.145055	70	100	13	50	525	-3.74367	
10	9	0	0.0662450	1582.9	245	228	1	4	1	0	10.76625	264.3907	2	1	14	50	525	-3.97280	
10	11	0	0.1456490	3965.7	245	166	1	4	1	0	49.20062	92.61211	1	0	15	50	525	-3.85007	
11	14	0	0.0470305	49833.5	80	451	120	47	1	0	0.046866	0.189381	80	100	16	50	525	-3.69116	
12	15	0	0.0022220	6464.3	105	450	102	62	1	0	0.002218	0.531742	105	100	17	50	525	-4.02001	
13	10	0	0.0364535	56217.1	70	450	138	50	1	0	0.036423	0.115346	70	100					
13	12	0	0.1041725	80.7	245	227	1	4	1	0	0.027861	159958	916	374					
13	14	0	0.2291330	1585	245	166	1	4	1	0	7.859399	912.072	7	3					
14	17	0	0.0472065	51418.5	80	448	121	46	1	0	0.047316	0.178551	80	100					
15	7	0	0.0019600	6531.4	105	450	107	62	1	0	0.001962	0.459456	105	100					
16	13	0	0.0525090	57882.8	70	450	121	46	1	0	0.0527	0.156724	70	100					
16	15	0	0.1589035	67.1	245	227	1	4	1	0	0.019262	352929.9	2021	825					
16	17	0	0.3288485	628.6	245	166	1	4	1	0	1.236174	8322.372	65	27					
17	5	0	0.0508760	52047.1	80	451	120	47	1	0	0.051122	0.187811	80	100					

When the two pressure differences (H_f and H) for the branch are approximately equal, the final resistance is calculated from equation 9. The spreadsheet provides the resistance and airway characteristics for every branch in the schematic. Dummy fan branches were added to the schematic to define the boundary condition for the portion of the mine from the starting point of the section to the mine fan. Leakage branches can be identified by the numeral one, located in the area column. Since leakage branches do not have a physical “area”, a value of “1” is assigned to the area as a placeholder. The number is not used in the program calculations. After all branches have been pressure balanced, the spreadsheet data is downloaded into an operational ventilation model. Figures 2.4.1 - 2.4.5 show the base models for each ventilation survey conducted on the development sections. The branch characteristics for each model can be found in Tables 2.4.2 – 2.4.6, respectively.

Table 2.4.2 Mine A 4 E Section Model Branch Characteristics

---BRANCH-- FROM-TO	AIRFLOW (CFM)	P-LOSS (IN.W.G.)	LENGTH (FT)	AREA (FT^2)	RESISTANCE (KINGERIES)	K	PERIMETER (FT)	# ENTRIES	CUM HL (IN.W.G.)	VELOCITY (FT/MIN)
1-8	45572	5.575	987	120	26.844	80	47	1	5.575	379.8
2-3	380	0.370	225	1	25638.730	245	4	1	6.005	379.7
2-4	155	0.446	164	1	186456.600	245	4	1	6.081	154.6
2-9	44529	0.033	606	125	0.168	60	47	1	5.669	356.2
3-7	15230	0.015	809	106	0.656	100	50	1	6.020	143.7
4-5	29833	0.038	806	106	0.427	70	47	1	6.119	281.4
6-4	29678	0.018	607	124	0.202	70	47	1	6.081	239.3
8-2	45063	0.060	810	114	0.298	60	47	1	5.635	395.3
8-5	79	0.544	166	1	862947.300	245	4	1	6.119	79.4
8-7	430	0.445	226	1	24104.960	245	4	1	6.020	429.8
9-6	86	0.395	164	1	528550.800	245	4	1	6.064	86.4
9-10	1362	0.325	225	1	1751.964	245	4	1	5.994	1361.8
9-12	43080	0.033	599	122	0.178	60	47	1	5.702	353.1
10-3	14851	0.011	606	104	0.518	100	50	1	6.005	142.8
11-10	13489	0.007	599	114	0.389	100	50	1	5.994	118.3
12-11	137	0.285	225	1	151811.400	245	4	1	5.987	137.0
12-13	126	0.343	164	1	215546.000	245	4	1	6.045	126.2
12-15	42817	0.035	601	119	0.193	60	47	1	5.737	359.8
13-6	29591	0.018	599	122	0.208	70	47	1	6.064	242.6
14-11	13352	0.008	601	110	0.432	100	50	1	5.987	121.4
15-14	369	0.242	225	1	17769.790	245	4	1	5.979	368.8
15-16	93	0.292	165	1	339040.100	245	4	1	6.029	92.7
15-18	42356	0.023	449	124	0.128	60	47	1	5.760	341.6
16-13	29465	0.017	601	126	0.191	70	47	1	6.045	233.9
17-14	12983	0.006	449	107	0.352	100	50	1	5.979	121.3
18-17	249	0.213	226	1	34249.670	245	4	1	5.973	249.3
18-19	60	0.258	165	1	723135.500	245	4	1	6.018	59.7
18-21	42047	0.044	571	110	0.247	60	50	1	5.804	382.2
19-16	29372	0.011	452	122	0.123	70	47	1	6.029	240.8

---BRANCH-- FROM-TO	AIRFLOW (CFM)	P-LOSS (IN.W.G.)	LENGTH (FT)	AREA (FT^2)	RESISTANCE (KINGERIES)	K	PERIMETER (FT)	# ENTRIES	CUM HL (IN.W.G.)	VELOCITY (FT/MIN)
20-17	12734	0.006	571	112	0.389	100	50	1	5.973	113.7
21-20	50	0.163	225	1	663291.500	245	4	1	5.967	49.5
21-22	1498	0.198	165	1	883.791	245	4	1	6.002	1498.5
21-24	40499	0.055	835	110	0.334	60	46	1	5.859	368.2
22-19	29313	0.016	569	125	0.184	70	47	1	6.018	234.5
23-20	12684	0.009	833	113	0.553	100	50	1	5.967	112.3
24-23	429	0.099	225	1	5392.993	245	4	1	5.958	428.6
24-25	1409	0.126	165	1	636.560	245	4	1	5.985	1408.6
24-27	38661	0.045	810	118	0.304	70	46	1	5.904	327.6
25-22	27814	0.017	833	134	0.224	70	48	1	6.002	207.6
26-23	12256	0.008	812	114	0.526	100	50	1	5.958	107.5
27-26	59	0.046	225	1	132322.500	245	4	1	5.950	58.8
27-28	87	0.063	165	1	83566.420	245	4	1	5.967	86.5
27-30	38516	0.026	548	122	0.174	60	50	1	5.930	315.7
28-25	26406	0.018	811	125	0.263	70	47	1	5.985	211.2
29-26	12197	0.004	548	126	0.263	100	50	1	5.950	96.8
30-32	38516	0.012	307	129	0.078	60	47	1	5.941	298.6
31-28	26319	0.015	548	117	0.217	70	47	1	5.967	224.9
32-29	12197	0.004	381	107	0.299	100	50	1	5.946	114.0
32-31	26319	0.010	348	113	0.147	70	45	1	5.952	232.9

Table 2.4.3 Mine B 6 Left Section Model Branch Characteristics

---BRANCH-- FROM-TO	AIRFLOW (CFM)	P-LOSS (IN.W.G.)	LENGTH (FT)	AREA (FT^2)	RESISTANCE (KINGERIES)	K	PERIMETER (FT)	# ENTRIES	CUM HL (IN.W.G.)	VELOCITY (FT/MIN)
1-7	21214	1.823	981	110	40.500	100	50	1	1.823	192.9
1-8	35248	1.821	987	120	14.659	80	47	1	1.821	293.7
2-6	21688	0.028	879	113	0.586	100	50	1	1.866	191.9
3-2	5	0.001	225	1	536242.600	245	4	1	1.838	5.1
3-4	83	0.940	164	1	1377900.000	245	4	1	2.777	82.6
3-9	34047	0.035	880	110	0.299	50	47	1	1.872	309.5
4-5	55817	0.032	433	132	0.102	60	47	1	2.809	422.9
6-9	317	0.006	225	1	563.601	245	4	1	1.872	317.4
6-13	21371	0.028	881	111	0.619	100	50	1	1.894	192.5
7-2	21683	0.016	437	108	0.334	100	50	1	1.838	200.8
8-3	34134	0.016	438	114	0.134	50	47	1	1.837	299.4
8-5	645	0.987	166	1	23757.450	245	4	1	2.809	644.7
8-7	469	0.001	226	1	58.603	245	4	1	1.823	469.3
9-10	269	0.826	165	1	114346.800	245	4	1	2.697	268.7
9-12	34095	0.022	880	128	0.190	50	47	1	1.894	266.4
10-4	55735	0.080	882	123	0.257	60	47	1	2.777	453.1
11-10	55466	0.057	880	137	0.186	60	47	1	2.697	404.9
12-11	639	0.746	165	1	18297.650	245	4	1	2.640	638.7
12-13	1476	0.001	224	1	2.604	245	4	1	1.894	1475.7
12-15	31981	0.043	1319	112	0.424	50	47	1	1.937	285.5
13-14	22846	0.040	1320	118	0.773	100	50	1	1.934	193.6
14-15	2098	0.003	225	1	5.704	245	4	1	1.937	2098.0
14-17	20748	0.023	549	100	0.528	100	50	1	1.957	207.5
15-16	189	0.600	165	1	167376.800	245	4	1	2.537	189.4
15-18	33890	0.019	550	115	0.163	50	47	1	1.956	294.7
16-11	54827	0.103	1320	128	0.341	60	47	1	2.640	428.3
17-20	21454	0.023	661	108	0.504	100	50	1	1.980	198.6
18-17	705	0.001	223	1	28.931	245	4	1	1.957	705.4
18-19	409	0.537	166	1	32094.350	245	4	1	2.493	409.1

---BRANCH-- FROM-TO	AIRFLOW (CFM)	P-LOSS (IN.W.G.)	LENGTH (FT)	AREA (FT^2)	RESISTANCE (KINGERIES)	K	PERIMETER (FT)	# ENTRIES	CUM HL (IN.W.G.)	VELOCITY (FT/MIN)
18-21	32775	0.023	661	111	0.218	50	47	1	1.979	295.3
19-16	54638	0.045	550	126	0.149	60	47	1	2.537	433.6
20-23	23496	0.032	880	114	0.571	100	50	1	2.012	206.1
21-20	2042	0.001	226	1	2.878	245	4	1	1.980	2041.9
21-22	426	0.453	166	1	24902.520	245	4	1	2.432	426.4
21-24	30307	0.036	880	104	0.389	55	47	1	2.015	291.4
22-19	54229	0.061	660	120	0.207	60	47	1	2.493	451.9
23-24	2918	0.003	226	1	3.512	245	4	1	2.015	2917.8
23-26	20578	0.029	880	107	0.691	100	50	1	2.041	192.3
24-25	367	0.339	164	1	25133.180	245	4	1	2.354	367.3
24-27	32857	0.026	879	118	0.242	50	47	1	2.041	278.5
25-22	53802	0.078	880	121	0.269	60	47	1	2.432	444.6
26-29	20597	0.011	440	117	0.264	100	50	1	2.052	176.0
27-26	19	0.000	224	1	4340.278	245	4	1	2.041	19.2
27-28	328	0.240	166	1	22283.980	245	4	1	2.281	328.0

Table 2.4.4 Mine C 12 D Section Model Branch Characteristics

---BRANCH-- FROM-TO	AIRFLOW (CFM)	P-LOSS (IN.W.G.)	LENGTH (FT)	AREA (FT^2)	RESISTANCE (KINGERIES)	K	PERIMETER (FT)	# ENTRIES	CUM HL (IN.W.G.)	VELOCITY (FT/MIN)
1-5	59500	3.938	800	120	11.124	80	47	1	3.938	495.8
3-8	48600	0.013	546	138	0.053	55	44	1	4.255	352.2
4-9	14800	0.016	600	95	0.721	107	50	1	4.276	155.8
5-2	1800	0.491	227	1	1514.438	245	4	1	4.429	1800.0
5-7	400	0.672	166	1	41969.000	245	4	1	4.610	400.0
5-28	57300	0.105	1799	138	0.319	55	44	1	4.043	415.2
6-11	33800	0.029	596	116	0.258	80	44	1	4.316	291.4
8-4	14800	0.006	594	105	0.268	107	50	1	4.261	141.0
8-6	33800	0.032	573	112	0.277	80	44	1	4.286	301.8
9-12	15950	0.010	448	104	0.410	107	50	1	4.287	153.4
10-3	48600	0.026	597	139	0.109	55	46	1	4.242	349.6
10-9	1150	0.060	232	1	452.423	245	4	1	4.276	1150.0
10-11	750	0.099	169	1	1765.049	245	4	1	4.316	750.0
11-14	34550	0.026	452	112	0.217	80	44	1	4.342	308.5
12-15	16000	0.013	449	97	0.506	107	50	1	4.300	164.9
13-10	50500	0.024	452	130	0.096	55	44	1	4.216	388.5
13-12	50	0.095	232	1	378720.000	245	4	1	4.287	50.0
13-14	50	0.150	169	1	598640.400	245	4	1	4.342	50.0
14-17	34600	0.033	449	104	0.272	80	44	1	4.374	332.7
15-18	16100	0.024	602	88	0.913	107	50	1	4.323	183.0
16-13	50600	0.028	449	125	0.108	55	44	1	4.192	404.8
16-15	100	0.135	232	1	135159.100	245	4	1	4.300	100.0
16-17	500	0.210	169	1	8387.680	245	4	1	4.374	500.0
17-20	35100	0.041	602	107	0.331	80	44	1	4.415	328.0
18-21	16200	0.021	448	83	0.807	107	50	1	4.345	195.2
19-16	51200	0.030	602	135	0.114	55	44	1	4.165	379.3
19-18	100	0.189	230	1	188731.000	245	4	1	4.323	100.0
19-20	1200	0.280	165	1	1947.313	245	4	1	4.415	1200.0

---BRANCH-- FROM-TO	AIRFLOW (CFM)	P-LOSS (IN.W.G.)	LENGTH (FT)	AREA (FT^2)	RESISTANCE (KINGERIES)	K	PERIMETER (FT)	# ENTRIES	CUM HL (IN.W.G.)	VELOCITY (FT/MIN)
20-23	36300	0.032	448	108	0.242	80	44	1	4.447	336.1
21-24	16700	0.018	451	90	0.639	108	50	1	4.362	185.6
22-19	52500	0.025	448	132	0.091	55	44	1	4.135	397.7
22-21	500	0.235	232	1	9395.120	245	4	1	4.345	500.0
22-23	1600	0.337	168	1	1317.277	245	4	1	4.447	1600.0
23-26	37900	0.040	451	103	0.279	80	44	1	4.487	368.0
24-27	16900	0.016	451	94	0.559	107	50	1	4.378	179.8
25-22	54600	0.032	451	126	0.107	55	45	1	4.110	433.3
25-24	200	0.285	232	1	71178.250	245	4	1	4.362	200.0
25-26	200	0.409	165	1	102307.300	245	4	1	4.487	200.0
26-29	38100	0.024	451	125	0.163	80	46	1	4.511	304.8
27-2	18800	0.051	1799	109	1.433	107	50	1	4.429	172.5
28-25	55000	0.035	451	124	0.115	55	46	1	4.078	443.5
28-27	1900	0.335	229	1	928.875	245	4	1	4.378	1900.0
28-29	400	0.468	163	1	29225.310	245	4	1	4.511	400.0
29-7	38500	0.099	1799	122	0.669	80	44	1	4.610	315.6

Figure 2.4.4 Mine C 13 D Section Model

Table 2.4.5 Mine C 13 D Section Model Branch Characteristics

---BRANCH-- FROM-TO	AIRFLOW (CFM)	P-LOSS (IN.W.G.)	LENGTH (FT)	AREA (FT^2)	RESISTANCE (KINGERIES)	K	PERIMETER (FT)	# ENTRIES	CUM HL (IN.W.G.)	VELOCITY (FT/MIN)
1-8	59664	3.638	987	120	10.219	80	47	1	3.638	497.2
2-4	4801	0.001	505	110	0.384	105	50	1	3.845	43.6
2-6	45868	0.037	478	127.1	0.178	85	47	1	3.882	360.9
3-2	50668	0.027	449	137.2	0.105	67	47	1	3.844	369.3
4-9	4801	0.001	450	105	0.485	105	62	1	3.846	45.7
6-11	45868	0.044	448	115	0.209	80	46	1	3.926	398.9
8-5	1017	0.433	166	1	4185.683	245	4	1	4.071	1017.3
8-7	68	0.214	226	1	462123.800	245	4	1	3.852	68.1
8-16	58578	0.053	451	125	0.156	70	50	1	3.691	468.6
9-12	6384	0.001	450	116	0.362	105	62	1	3.848	55.0
10-3	50668	0.037	450	128	0.145	70	50	1	3.817	395.8
10-9	1583	0.066	228	1	264.391	245	4	1	3.846	1582.9
10-11	3966	0.146	166	1	92.612	245	4	1	3.926	3965.7
11-14	49834	0.047	451	120	0.189	80	47	1	3.973	415.3
12-15	6464	0.002	450	102	0.532	105	62	1	3.850	63.4
13-10	56217	0.036	450	138	0.115	70	50	1	3.780	407.4
13-12	81	0.104	227	1	159958.000	245	4	1	3.848	80.7
13-14	1585	0.229	166	1	912.072	245	4	1	3.973	1585.0
14-17	51419	0.047	448	121	0.179	80	46	1	4.020	424.9
15-7	6531	0.002	450	107	0.459	105	62	1	3.852	61.0
16-13	57883	0.053	450	121	0.157	70	46	1	3.744	478.4
16-15	67	0.159	227	1	352929.900	245	4	1	3.850	67.1
16-17	629	0.329	166	1	8322.372	245	4	1	4.020	628.6

Table 2.4.6 Mine D 9 Right Section Model Branch Characteristics

---BRANCH-- FROM-TO	AIRFLOW (CFM)	P-LOSS (IN.W.G.)	LENGTH (FT)	AREA (FT^2)	RESISTANCE (KINGERIES)	K	PERIMETER (FT)	# ENTRIES	CUM HL (IN.W.G.)	VELOCITY (FT/MIN)
1-17	67182	2.628	987	120	5.822	80	47	1	2.628	559.8
2-3	44992	0.019	414	137	0.096	65	48	1	3.166	328.4
3-4	11419	0.004	453	110	0.327	100	50	1	3.170	103.8
3-6	33572	0.018	477	128	0.158	75	48	1	3.184	262.3
4-10	11419	0.015	1860	116	1.142	100	50	1	3.185	98.4
6-8	33572	0.062	1859	132	0.550	75	47	1	3.246	254.3
8-11	34022	0.067	1851	129	0.582	75	47	1	3.313	263.7
9-2	44992	0.077	1857	144	0.383	65	49	1	3.146	312.4
9-8	450	0.177	234	1	8730.326	245	4	1	3.246	449.8
9-10	4060	0.116	180	1	70.413	245	4	1	3.185	4,059.9
10-13	15479	0.031	1848	111	1.298	100	50	1	3.216	139.5
11-14	39664	0.124	2329	129	0.787	80	47	1	3.437	307.5
12-9	49501	0.105	1850	138	0.430	65	49	1	3.069	358.7
12-11	5642	0.349	231	1	109.767	245	4	1	3.313	5,641.6
12-13	594	0.253	175	1	7154.967	245	4	1	3.216	594.1
13-16	16073	0.058	2333	100	2.239	100	50	1	3.274	160.7
14-7	39716	0.062	1086	126	0.394	80	47	1	3.499	315.2
15-12	55737	0.203	2333	128	0.655	65	47	1	2.964	435.4
15-14	53	0.676	228	1	2435800.000	245	4	1	3.437	52.7
15-16	3647	0.514	169	1	386.159	245	4	1	3.274	3,647.4
16-21	19721	0.016	481	103	0.423	100	50	1	3.290	191.5
17-5	990	0.698	166	1	7111.638	245	4	1	3.325	990.4
17-7	755	0.871	226	1	15302.360	245	4	1	3.499	754.5
17-20	65437	0.062	456	123	0.145	65	47	1	2.690	532.0
20-15	59437	0.071	630	123	0.200	65	47	1	2.760	483.2
20-21	6000	0.601	225	1	166.876	245	4	1	3.290	6,000.0
21-5	25721	0.035	602	103	0.528	100	50	1	3.325	249.7

INVESTIGATION

3.1 Return Stoppings

Stopping workmanship and the materials used in the construction of stoppings play a vital role in the control of leakage. Section leakage also depends on crosscut center distances and the pressure differential across stoppings. Greater crosscut distances reduces the number of stoppings on a development section, thus the leakage is reduced. By increasing the pressure differential across stoppings by a factor (n), the quantity leaking through the stopping is increased by a factor equivalent to the square root of (n). In order to properly evaluate stopping performance, it is necessary to calculate the resistance across a single stopping rather than to assess the leaking air quantity. The resistance method thus takes into account the effects of crosscut distance or pressure differential on the leakage quantity.

For longwall gate development, Bise suggested that design of ventilation systems should allow for a 50% loss of air delivered to the end of each panel due to leakage⁽²⁾. To become proactive with leakage control, stoppings should be constructed of a material and in a fashion that provides a high resistance factor. Table 3.1.1 gives a description of the type of return stoppings that were observed during the five ventilation surveys.

Table 3.1.1 Return Stopping Description									
MINE	SECTION	STOPPING TYPE	STOPPING TYPE	SEALANT MATERIAL	SIDE SEALED	BLOCK CENTERS (FT)	# OF STOPPINGS	TOTAL LEAKAGE (CFM)	LEAKAGE (CFM) PER STOPPING
A	4 E	C	BLOCK	DUPONT	INT. SIDE ONLY	200/275	32	3590.8	112.2
B	6 LEFT	D	BLOCK	B-BOND/TYVEK	BOTH	200	30	3026.9	100.9
C	12 D	B	BLOCK	B-BOND	INT. SIDE ONLY	150	35	5100.0	145.7
C	13 D	B	BLOCK	B-BOND	INT. SIDE ONLY	150	9	7196.6	799.6
D	9 RIGHT	A	METAL	VERSI-FOAM	INT. SIDE ONLY	275	28	6898.6	246.4

The return stoppings were constructed of blocks had dimensions of 6-in. by 8-in. by 16 in. The walls were dry-stacked in a “laid on edge” fashion, 6 in. wide, and each row 8 in. high. Mine D used metal stoppings for return airways. Each mine used a different type of sealant on the stoppings. Mine A used Dupont sealant, which is a glue type sealant on the intake side of the stopping. It should be noted that the quality of the stoppings on the 4- E section was above average compared to the same construction material used in Mine C, which were categorized as average construction. Mine B used B-Bond a mortar based sealant with fibers on both sides of the stopping. Tyvek® was installed on the intake side of the stopping. Tyvek® is a thermoplastic, spun-bonded, olefin sheeting, made by Dupont. For the two sections in Mine C, B-Bond was applied on the intake side of the return stoppings only. To seal the metal stoppings, Mine D used Versi-Foam in the seams of the panels.

A quick and easy way to compare the performance of the various types of stoppings is to determine the leakage per stopping (equation 11).

$$Leakage_{STOPPING} = \frac{Total\ Leakage}{Number\ of\ Stoppings} \quad (11)$$

The total leakage is found by subtracting the quantity reading in by the last return stopping from the return quantity reading at the mouth of the section. It can be seen from Table 3.1.1 that the stoppings in Mine B allowed the least amount of leakage per stopping (100.9 cfm). This

approach is simple, but it does not take into account the pressure differential across the stoppings. It is not sufficiently accurate when conducting ventilation modeling and simulations. Modeling leakage should be based on the resistance that the stopping provides. Leakage through return stoppings can be predicted more accurately if the resistance across the stopping is known.

3.2 Stopping Resistance

The most accurate way to evaluate return stopping performance is to compare the resistance value per stopping. By comparing the resistance, pressure differential will be accounted for. Once the resistance has been determined for a given stopping the effects of pressure differential are reflected in the amount of leakage through the stopping. The resistance per stopping was determined to better compare the four types of stoppings from the mines.

Airways are said to be connected in parallel when the total airflow is divided among them.⁽¹¹⁾ The leakage across a stopping line can be considered a collection of parallel airways. In the model, the leakage between sets are represented as leakage branches that combine the leakage of several stoppings. Before the resistance per individual stopping can be calculated, an equivalent resistance must be calculated which represents the combined resistance of all leakage branches. The equivalent resistance branch must always be placed at the midpoint of the section (location of the average differential

pressure across the stopping line). The general equation for the equivalent resistance of parallel airways can be written as follows:

$$\frac{1}{\sqrt{R_{EQ}}} = \frac{1}{\sqrt{R_1}} + \frac{1}{\sqrt{R_2}} + \frac{1}{\sqrt{R_3}} + \dots (12)$$

Equation 12 permits the reduction of any number of parallel leakage branches to a single equivalent leakage branch.

Once the equivalent resistance branch has been determined for each section's return stopping line, the resistance per individual stopping can be calculated. Assuming that the return stoppings throughout the section have the same resistance, equation 12 can be rearranged to ascertain the resistance per stopping (R_s).

$$R_s = N^2 R_{EQ} (13)$$

where N is the number of return stoppings.

The section ventilation model provided the resistance for the leakage branches found during each ventilation survey. Using the resistance for each leakage branch an equivalent resistance could be determined for the development section return stoppings. Tables 3.2.1–3.2.5 display the calculations and results for each section. Resistance is expressed in Kingeries ($R \times 10^{-10}$ in. WG/cfm²) form.

Table 3.2.1 4 E Return Stopping Resistance, Mine A	
Resistance Branch	$\frac{1}{\sqrt{\text{Branch Resistance}}}$
862,947.2	0.00108
186,456.6	0.00232
528,550.7	0.00138
215,546.0	0.00215
339,040.1	0.00172
723,135.5	0.00118
883.8	0.03364
636.6	0.03964
83,566.4	0.00346
Sum of Square Roots	0.087
Equivalent Resistance	133.504
Number of Stoppings	32
Resistance per Stopping	136,708.2

Table 3.2.2 6 Left Return Stopping Resistance, Mine B	
Resistance Branch	$\frac{1}{\sqrt{\text{Branch Resistance}}}$
23,757.4	0.00649
1,377,858.8	0.00085
114,346.8	0.00296
18,297.6	0.00739
167,376.8	0.00244
32,094.3	0.00558
24,902.5	0.00634
25,133.2	0.00631
Sum of Square Roots	0.038
Equivalent Resistance	679.56
Number of Stoppings	30
Resistance per Stopping	611,605.0

Table 3.2.3 12 D Return Stopping Resistance, Mine C	
Resistance Branch	$\frac{1}{\sqrt{\text{Branch Resistance}}}$
41,969.0	0.00488
29,225.3	0.00585
102,307.3	0.00313
1,317.3	0.02755
1,947.3	0.02266
8,387.7	0.01092
598,640.4	0.00129
1,765.1	0.02380
Sum of Square Roots	0.1001
Equivalent Resistance	99.83
Number of Stoppings	30
Resistance per Stopping	89,847.7

Table 3.2.4 13 D Return Stopping Resistance, Mine C	
Resistance Branch	$\frac{1}{\sqrt{\text{Branch Resistance}}}$
4,185.7	0.01546
8,322.4	0.01096
912.1	0.03311
92.6	0.10391
Sum of Square Roots	0.163
Equivalent Resistance	37.43
Number of Stoppings	9
Resistance per Stopping	3,032.1

Table 3.2.5 9 Right Return Stopping Resistance, Mine D	
Resistance Branch	$\frac{1}{\sqrt{\text{Branch Resistance}}}$
15,302.4	0.00808
2,435,759.0	0.00064
109.8	0.09545
8,730.2	0.01070
Sum of Square Roots	0.115
Equivalent Resistance	75.78
Number of Stoppings	28
Resistance per Stopping	59,412.5

Once the resistance per stopping was found for each section, it was decided to further investigate the low resistance per stopping results for the 13 D section. Discussion with mine personnel lead to the finding of a battery charging station ventilation hole in a return stopping. Since the hole was missed on the ventilation survey, the results for the 13 D return stoppings were dismissed. Using the resistance per stopping process to access the performance of the return stoppings, their ranking (least to highest resistance) is as follows:

Table 3.2.6 Return Stopping Ranking					
Stopping Type	Stopping Material	Sealant Type	Side Sealed	Construction Quality	*Resistance Per Stopping
A	Metal	Versi-Foam	Int. Side	Average	59,400
B	Block	B-Bond	Int. Side	Average	89,900
C	Block	Dupont	Int. Side	Abv. Average	137,000
D	Block	B-Bond/Tyvek	Both	Average	612,000
*Resistance Values are in R x 10 ⁻¹⁰					

From Table 3.2.6 it can be seen that the Type D stoppings in the 6 Left section of Mine B provided the highest resistance, while the Type

A stoppings in the 9 Right section of Mine D provided the least resistance. With the application of Tyvek® and both sides of the stopping sealed, a high resistance to leakage should be expected.

3.3 Equivalent Resistance Test

The function of an equivalent resistance branch is to provide the same leakage for a return stopping line that was found by n leakage branches in a ventilation model. Instead of using a resistance per stopping value, which would mean placing a leakage branch at every return stopping location, the equivalent resistance leakage branch can be placed in the model to account for the total number of return stoppings on the section. In order to test the parallel resistance formula and the equivalent resistance calculation, the equivalent resistance values were substituted into the section models (Figures 3.3.1-3.3.5). A single leakage branch was placed at the midpoint of each return with its respective equivalent resistance. The model for each section was then ran to compare the quantities in the return at both the face area and at the mouth of the section. If the equivalent resistance is correct the quantities at both location should match the quantities in the model that was constructed from the ventilation survey. Tables 3.3.1-3.3.5 provides the branch characteristics for each section equivalent resistance test model. It should be noted that the equivalent resistance for the 6 Left section was determined from the area that had Tyvek® installed on the stoppings.

Figure 3.3.1 4 E Section Equivalent Resistance Test

Table 3.3.1 4 E Section Equivalent Resistance Test Model Branch Characteristics

---BRANCH-- FROM-TO	AIRFLOW (CFM)	P-LOSS (IN.W.G.)	LENGTH (FT)	AREA (FT^2)	RESISTANCE (KINGERIES)	K	PERIMETER (FT)	# ENTRIES	CUM HL (IN.W.G.)	VELOCITY (FT/MIN)
1-8	45579	5.577	987	120	26.844	80	47	1	5.577	379.8
2-3	379	0.368	225	1	25638.730	245	4	1	6.005	378.7
2-9	44772	0.034	606	125	0.168	60	47	1	5.671	358.2
3-7	15211	0.015	809	106	0.656	100	50	1	6.020	143.5
4-5	29939	0.038	806	106	0.427	70	47	1	6.119	282.4
6-4	29939	0.018	607	124	0.202	70	47	1	6.081	241.4
8-2	45150	0.061	810	114	0.298	60	47	1	5.637	396.1
8-7	429	0.443	226	1	24104.960	245	4	1	6.020	428.9
9-10	1357	0.323	225	1	1751.964	245	4	1	5.994	1356.9
9-12	43415	0.034	599	122	0.178	60	47	1	5.705	355.9
10-3	14832	0.011	606	104	0.518	100	50	1	6.005	142.6
11-10	13475	0.007	599	114	0.389	100	50	1	5.994	118.2
12-11	136	0.282	225	1	151811.400	245	4	1	5.987	136.3
12-15	43279	0.036	601	119	0.193	60	47	1	5.741	363.7
13-6	29939	0.019	599	122	0.208	70	47	1	6.063	245.4
14-11	13339	0.008	601	110	0.432	100	50	1	5.987	121.3
15-14	366	0.238	225	1	17769.790	245	4	1	5.979	366.1
15-18	42912	0.024	449	124	0.128	60	47	1	5.764	346.1
16-13	29939	0.017	601	126	0.191	70	47	1	6.044	237.6
17-14	12973	0.006	449	107	0.352	100	50	1	5.979	121.2
18-17	247	0.209	226	1	34249.670	245	4	1	5.973	246.8
18-21	42666	0.045	571	110	0.247	60	50	1	5.809	387.9
19-16	29939	0.011	452	122	0.123	70	47	1	6.027	245.4
20-17	12726	0.006	571	112	0.389	100	50	1	5.973	113.6
21-20	49	0.157	225	1	663291.500	245	4	1	5.967	48.7
21-22	3775	0.190	165	1	133.500	245	4	1	6.000	3774.8
21-24	38842	0.050	835	110	0.334	60	46	1	5.860	353.1
22-19	29939	0.016	569	125	0.184	70	47	1	6.016	239.5

---BRANCH-- FROM-TO	AIRFLOW (CFM)	P-LOSS (IN.W.G.)	LENGTH (FT)	AREA (FT^2)	RESISTANCE (KINGIERIES)	K	PERIMETER (FT)	# ENTRIES	CUM HL (IN.W.G.)	VELOCITY (FT/MIN)
23-20	12678	0.009	833	113	0.553	100	50	1	5.967	112.2
24-23	426	0.098	225	1	5392.993	245	4	1	5.958	426.3
24-27	38416	0.045	810	118	0.304	70	46	1	5.905	325.6
25-22	26165	0.015	833	134	0.224	70	48	1	6.000	195.3
26-23	12251	0.008	812	114	0.526	100	50	1	5.958	107.5
27-26	58	0.045	225	1	132322.500	245	4	1	5.950	58.5
27-28	86	0.062	165	1	83566.420	245	4	1	5.966	85.9
27-30	38271	0.026	548	122	0.174	60	50	1	5.930	313.7
28-25	26165	0.018	811	125	0.263	70	47	1	5.984	209.3
29-26	12193	0.004	548	126	0.263	100	50	1	5.950	96.8
30-32	38271	0.011	307	129	0.078	60	47	1	5.942	296.7
31-28	26079	0.015	548	117	0.217	70	47	1	5.966	222.9
32-29	12193	0.004	381	107	0.299	100	50	1	5.946	114.0
32-31	26079	0.010	348	113	0.147	70	45	1	5.952	230.8

Figure 3.3.2 6 Left Section Equivalent Resistance Test

Table 3.3.2 6 Left Section Equivalent Resistance Test Model Branch Characteristics

---BRANCH-- FROM-TO	AIRFLOW (CFM)	P-LOSS (IN.W.G.)	LENGTH (FT)	AREA (FT^2)	RESISTANCE (KINGERIES)	K	PERIMETER (FT)	# ENTRIES	CUM HL (IN.W.G.)	VELOCITY (FT/MIN)
1-7	21225	1.825	981	110	40.500	100	50	1	1.825	193.0
1-8	35256	1.822	987	120	14.659	80	47	1	1.822	293.8
2-6	21879	0.028	879	113	0.586	100	50	1	1.869	193.6
3-2	7	0.002	225	1	536242.600	245	4	1	1.841	6.7
3-9	34602	0.036	880	110	0.299	50	47	1	1.874	314.6
4-5	56481	0.033	433	132	0.102	60	47	1	2.809	427.9
6-9	307	0.005	225	1	563.601	245	4	1	1.874	307.4
6-13	21572	0.029	881	111	0.619	100	50	1	1.897	194.3
7-2	21872	0.016	437	108	0.334	100	50	1	1.841	202.5
8-3	34609	0.016	438	114	0.134	50	47	1	1.838	303.6
8-7	647	0.002	226	1	58.603	245	4	1	1.825	647.4
9-12	34909	0.023	880	128	0.190	50	47	1	1.897	272.7
10-4	56481	0.082	882	123	0.257	60	47	1	2.776	459.2
11-10	56481	0.059	880	137	0.186	60	47	1	2.694	412.3
12-13	1226	0.000	224	1	2.604	245	4	1	1.897	1225.6
12-41	33684	0.023	619	112	0.199	50	47	1	1.920	300.7
13-14	22797	0.040	1320	118	0.773	100	50	1	1.938	193.2
14-15	2324	0.003	225	1	5.704	245	4	1	1.941	2323.9
14-17	20473	0.022	549	100	0.528	100	50	1	1.960	204.7
15-18	32882	0.018	550	115	0.163	50	47	1	1.958	285.9
16-42	53355	0.051	697	128	0.180	60	47	1	2.584	416.8
17-20	21162	0.023	661	108	0.504	100	50	1	1.982	195.9
18-17	689	0.001	223	1	28.931	245	4	1	1.960	688.6
18-21	32193	0.023	661	111	0.218	50	47	1	1.981	290.0
19-16	53355	0.042	550	126	0.149	60	47	1	2.532	423.5
20-23	23312	0.031	880	114	0.571	100	50	1	2.013	204.5
21-20	2150	0.001	226	1	2.878	245	4	1	1.982	2150.1
21-24	30043	0.035	880	104	0.389	55	47	1	2.016	288.9

---BRANCH-- FROM-TO	AIRFLOW (CFM)	P-LOSS (IN.W.G.)	LENGTH (FT)	AREA (FT^2)	RESISTANCE (KINGIERIES)	K	PERIMETER (FT)	# ENTRIES	CUM HL (IN.W.G.)	VELOCITY (FT/MIN)
22-19	53355	0.059	660	120	0.207	60	47	1	2.490	444.6
23-24	2789	0.003	226	1	3.512	245	4	1	2.016	2788.9
23-26	20523	0.029	880	107	0.691	100	50	1	2.042	191.8
24-27	32832	0.026	879	118	0.242	50	47	1	2.042	278.2
25-22	53355	0.077	880	121	0.269	60	47	1	2.431	441.0
26-29	20550	0.011	440	117	0.264	100	50	1	2.054	175.6
27-26	26	0.000	224	1	4340.278	245	4	1	2.042	26.4
27-28	328	0.239	166	1	22283.980	245	4	1	2.281	327.5
27-30	32478	0.018	441	105	0.172	50	47	1	2.060	309.3
28-25	53355	0.073	880	123	0.256	60	47	1	2.354	433.8
29-30	43	0.007	225	1	36261.120	245	4	1	2.060	43.0
29-32	20507	0.018	440	100	0.423	100	50	1	2.071	205.1
30-31	506	0.186	166	1	7242.454	245	4	1	2.246	506.4
30-33	32015	0.015	440	110	0.149	50	47	1	2.076	291.0
31-28	53028	0.035	440	124	0.125	60	47	1	2.281	427.6
32-33	735	0.004	225	1	78.228	245	4	1	2.076	734.9
32-35	19772	0.025	770	105	0.639	100	50	1	2.096	188.3
33-34	2331	0.131	165	1	241.734	245	4	1	2.207	2331.0
33-36	30419	0.026	769	108	0.276	50	47	1	2.101	281.7
34-31	52521	0.039	440	119	0.142	60	47	1	2.246	441.4
35-38	19772	0.011	378	108	0.289	100	50	1	2.108	183.1
36-38	30419	0.007	305	125	0.070	50	47	1	2.108	243.3
37-34	50190	0.067	771	116	0.268	60	47	1	2.207	432.7
38-37	50190	0.032	345	114	0.126	60	47	1	2.139	440.3
41-15	30558	0.021	700	112	0.225	50	47	1	1.941	272.8
41-42	3126	0.664	165	1	679.600	245	4	1	2.584	3125.8
42-11	56481	0.051	623	128	0.161	60	47	1	2.635	441.3

Figure 3.3.3 12 D Section Equivalent Resistance Test

Table 3.3.3 12 D Section Equivalent Resistance Test Model Branch Characteristics

---BRANCH-- FROM-TO	AIRFLOW (CFM)	P-LOSS (IN.W.G.)	LENGTH (FT)	AREA (FT^2)	RESISTANCE (KINGERIES)	K	PERIMETER (FT)	# ENTRIES	CUM HL (IN.W.G.)	VELOCITY (FT/MIN)
1-5	59497	3.938	800	120	11.124	80	47	1	3.938	495.8
3-8	48382	0.012	546	138	0.053	55	44	1	4.255	350.6
4-9	14797	0.016	600	95	0.721	107	50	1	4.277	155.8
5-2	1801	0.491	227	1	1514.438	245	4	1	4.429	1800.8
5-28	57696	0.106	1799	138	0.319	55	44	1	4.044	418.1
6-11	33585	0.029	596	116	0.258	80	44	1	4.315	289.5
8-4	14797	0.006	594	105	0.268	107	50	1	4.261	140.9
8-6	33585	0.031	573	112	0.277	80	44	1	4.286	299.9
9-12	15944	0.010	448	104	0.410	107	50	1	4.287	153.3
10-3	48382	0.025	597	139	0.109	55	46	1	4.242	348.1
10-9	1147	0.059	232	1	452.423	245	4	1	4.277	1146.6
11-14	33585	0.025	452	112	0.217	80	44	1	4.340	299.9
12-15	15994	0.013	449	97	0.506	107	50	1	4.300	164.9
13-10	49529	0.023	452	130	0.096	55	44	1	4.217	381.0
13-12	50	0.093	232	1	378720.000	245	4	1	4.287	49.7
14-17	33585	0.031	449	104	0.272	80	44	1	4.370	322.9
15-18	16093	0.024	602	88	0.913	107	50	1	4.324	182.9
16-13	49579	0.026	449	125	0.108	55	44	1	4.194	396.6
16-15	99	0.133	232	1	135159.100	245	4	1	4.300	99.1
17-20	33585	0.037	602	107	0.331	80	44	1	4.408	313.9
18-21	16192	0.021	448	83	0.807	107	50	1	4.345	195.1
19-16	49678	0.028	602	135	0.114	55	44	1	4.167	368.0
19-18	99	0.185	230	1	188731.000	245	4	1	4.324	98.9
20-31	33585	0.008	131	108	0.071	80	44	1	4.416	311.0
21-24	16688	0.018	451	90	0.639	108	50	1	4.362	185.4
22-21	497	0.232	232	1	9395.120	245	4	1	4.345	496.7
22-30	55103	0.020	321	132	0.065	55	44	1	4.133	417.4
23-26	38911	0.042	451	103	0.279	80	44	1	4.484	377.8

---BRANCH-- FROM-TO	AIRFLOW (CFM)	P-LOSS (IN.W.G.)	LENGTH (FT)	AREA (FT^2)	RESISTANCE (KINGIERIES)	K	PERIMETER (FT)	# ENTRIES	CUM HL (IN.W.G.)	VELOCITY (FT/MIN)
24-27	16888	0.016	451	94	0.559	107	50	1	4.378	179.7
25-22	55599	0.033	451	126	0.107	55	45	1	4.113	441.3
25-24	199	0.283	232	1	71178.250	245	4	1	4.362	199.3
26-29	38911	0.025	451	125	0.163	80	46	1	4.508	311.3
27-2	18785	0.051	1799	109	1.433	107	50	1	4.429	172.3
28-25	55799	0.036	451	124	0.115	55	46	1	4.080	450.0
28-27	1897	0.334	229	1	928.875	245	4	1	4.378	1897.3
29-7	38911	0.101	1799	122	0.669	80	44	1	4.610	318.9
30-19	49777	0.006	127	132	0.026	55	44	1	4.139	377.1
30-31	5326	0.283	166	1	99.800	245	4	1	4.416	5326.0
31-23	38911	0.026	317	108	0.171	80	44	1	4.442	360.3

Table 3.3.4 13 D Section Equivalent Resistance Test Model Branch Characteristics

---BRANCH-- FROM-TO	AIRFLOW (CFM)	P-LOSS (IN.W.G.)	LENGTH (FT)	AREA (FT^2)	RESISTANCE (KINGERIES)	K	PERIMETER (FT)	# ENTRIES	CUM HL (IN.W.G.)	VELOCITY (FT/MIN)
1-8	59662	3.637	987	120	10.219	80	47	1	3.637	497.2
2-4	4699	0.001	505	110	0.384	105	50	1	3.845	42.7
2-6	45761	0.037	478	127.1	0.178	85	47	1	3.882	360.0
3-2	50459	0.027	449	137.2	0.105	67	47	1	3.845	367.8
4-9	4699	0.001	450	105	0.485	105	62	1	3.847	44.7
6-11	45761	0.044	448	115	0.209	80	46	1	3.926	397.9
8-7	68	0.215	226	1	462123.800	245	4	1	3.852	68.1
8-16	59594	0.055	451	125	0.156	70	50	1	3.693	476.8
9-12	6274	0.001	450	116	0.362	105	62	1	3.848	54.1
10-3	50459	0.037	450	128	0.145	70	50	1	3.818	394.2
10-9	1576	0.066	228	1	264.391	245	4	1	3.847	1575.5
11-24	45761	0.034	387	120	0.163	80	47	1	3.960	381.3
12-15	6353	0.002	450	102	0.532	105	62	1	3.850	62.3
13-12	79	0.100	227	1	159958.000	245	4	1	3.848	78.9
13-23	59448	0.006	64	138	0.016	70	50	1	3.754	430.8
14-17	53174	0.050	448	121	0.179	80	46	1	4.018	439.5
15-7	6420	0.002	450	107	0.459	105	62	1	3.852	60.0
16-13	59527	0.056	450	121	0.157	70	46	1	3.748	492.0
16-15	67	0.157	227	1	352929.900	245	4	1	3.850	66.8
17-5	53174	0.053	451	120	0.188	80	47	1	4.071	443.1
23-10	52035	0.027	386	138	0.099	70	50	1	3.781	377.1
23-24	7414	0.206	166	1	37.400	245	4	1	3.960	7413.6
24-14	53174	0.008	64	120	0.03	80	47	1	3.967	443.1

Figure 3.3.5 9 Right Section Equivalent Resistance Test

Table 3.3.5 9 Right Section Equivalent Resistance Test Model Branch Characteristics

---BRANCH-- FROM-TO	AIRFLOW (CFM)	P-LOSS (IN.W.G.)	LENGTH (FT)	AREA (FT^2)	RESISTANCE (KINGERIES)	K	PERIMETER (FT)	# ENTRIES	CUM HL (IN.W.G.)	VELOCITY (FT/MIN)
1-17	67182	2.628	987	120	5.822	80	47	1	2.628	559.9
2-3	44882	0.019	414	137	0.096	65	48	1	3.166	327.6
3-4	11420	0.004	453	110	0.327	100	50	1	3.170	103.8
3-6	33461	0.018	477	128	0.158	75	48	1	3.184	261.4
4-10	11420	0.015	1860	116	1.142	100	50	1	3.185	98.4
6-8	33461	0.062	1859	132	0.550	75	47	1	3.245	253.5
8-11	33461	0.065	1851	129	0.582	75	47	1	3.310	259.4
9-2	44882	0.077	1857	144	0.383	65	49	1	3.147	311.7
9-10	4052	0.116	180	1	70.413	245	4	1	3.185	4051.7
10-13	15472	0.031	1848	111	1.298	100	50	1	3.216	139.4
11-22	33461	0.011	298	129	0.101	80	47	1	3.322	259.4
12-9	48933	0.103	1850	138	0.430	65	49	1	3.070	354.6
12-13	591	0.250	175	1	7154.967	245	4	1	3.216	590.7
13-16	16063	0.058	2333	100	2.239	100	50	1	3.274	160.6
14-7	40500	0.065	1086	126	0.394	80	47	1	3.499	321.4
15-16	3636	0.511	169	1	386.159	245	4	1	3.274	3636.2
15-23	56562	0.183	2035	128	0.571	65	47	1	2.946	441.9
16-21	19699	0.016	481	103	0.423	100	50	1	3.290	191.2
17-5	990	0.698	166	1	7111.638	245	4	1	3.325	990.4
17-20	66192	0.063	456	123	0.145	65	47	1	2.691	538.1
20-15	60199	0.072	630	123	0.200	65	47	1	2.763	489.4
20-21	5993	0.599	225	1	166.876	245	4	1	3.290	5993.1
21-5	25692	0.035	602	103	0.528	100	50	1	3.325	249.4
22-14	40500	0.113	2031	129	0.686	80	47	1	3.434	314.0
23-12	49524	0.021	298	128	0.084	65	47	1	2.967	386.9
23-22	7039	0.376	231	1	75.800	245	4	1	3.322	7038.7

As can be seen from Figures 3.3.1-3.3.5 compared to figures 2.4.1-2.4.5 the equivalent resistance test was within ± 200 cfm of the return face reading and mouth of section return reading determined in the original ventilation model for each section. Therefore by substituting an equivalent resistance branch, calculated from the parallel resistance formula, an accurate prediction of leakage can be made in ventilation simulations. The equivalent resistance branch eliminates the need to include a leakage branch at every return stopping for a given development section.

3.4 Uses of Equivalent Resistance Branches

Ventilation simulations are conducted to predict future requirements of the ventilation system. The worst case situations (most difficult position of mining activity on a fan) are modeled to determine the following:

1. The amount of headings that will be required.
2. The need for shafts, shaft location and diameters.
3. The type of fans needed to provide an adequate amount of air.
4. The most cost efficient way to ventilate future projects.

To accurately predict the ventilation requirements of the system, development section return stopping leakage must be modeled. Knowing the resistance per stopping for the various types of stoppings enables one to construct equivalent resistance tables for leakage prediction. Using Equation 13 to determine the equivalent resistance for n number of stoppings, one can develop a table for each type of

return stopping. From the resistance per stopping and the number of stoppings that are being modeled, an equivalent resistance can be determined. Tables 3.4.1-3.4.4 were developed to aid in determining the equivalent resistance for n number of stoppings. To use the charts for development section return stoppings the following procedures should be followed:

1. Determine the distance the section will be advanced by use of timing maps.
2. Determine the number of crosscuts for the section (include track chutes).
3. Determine what type of stoppings will be built.
4. From the appropriate stopping chart, find the equivalent resistance that corresponds to the total number of stoppings.
5. To use the equivalent resistance value in simulations, connect the entries in question with a leakage branch, i.e. track to return leakage, at the mid-point of the two branches. It should be noted that the equivalent resistance branch must always be located at the mid-point of the section.
6. Give the leakage branch the resistance value that was obtained from the equivalent resistance chart.

The equivalent resistance process allows leakage to be modeled in accordance with the changes in fan pressure and mine development thus simulating leakage through the return stoppings. The relationship between the equivalent resistance and number of return stoppings for each type of stopping is shown in Figures 3.4.1-3.4.4.

Table 3.4.1 Type A (Metal With Versi-Foam) Equivalent Resistance

RESISTANCE PER STOPPING (X 10 E-10) = 59,412.5			
# OF STOPPINGS	EQUIVALENT RESISTANCE (X 10 E-10)		# OF STOPPINGS EQUIVALENT RESISTANCE (X 10 E-10)
1	59,412.50		51 22.84
2	14,853.13		52 21.97
3	6,601.39		53 21.15
4	3,713.28		54 20.37
5	2,376.50		55 19.64
6	1,650.35		56 18.95
7	1,212.50		57 18.29
8	928.32		58 17.66
9	733.49		59 17.07
10	594.13		60 16.50
11	491.01		61 15.97
12	412.59		62 15.46
13	351.55		63 14.97
14	303.13		64 14.51
15	264.06		65 14.06
16	232.08		66 13.64
17	205.58		67 13.24
18	183.37		68 12.85
19	164.58		69 12.48
20	148.53		70 12.13
21	134.72		71 11.79
22	122.75		72 11.46
23	112.31		73 11.15
24	103.15		74 10.85
25	95.06		75 10.56
26	87.89		76 10.29
27	81.50		77 10.02
28	75.78		78 9.77
29	70.65		79 9.52
30	66.01		80 9.28
31	61.82		81 9.06
32	58.02		82 8.84
33	54.56		83 8.62
34	51.39		84 8.42
35	48.50		85 8.22
36	45.84		86 8.03
37	43.40		87 7.85
38	41.14		88 7.67
39	39.06		89 7.50
40	37.13		90 7.33
41	35.34		91 7.17
42	33.68		92 7.02
43	32.13		93 6.87
44	30.69		94 6.72
45	29.34		95 6.58
46	28.08		96 6.45
47	26.90		97 6.31
48	25.79		98 6.19
49	24.74		99 6.06
50	23.77		100 5.94

Figure 3.4.1 Type A Equivalent Resistance

Table 3.4.2 Type B (Block With B-Bond Average) Equivalent Resistance

RESISTANCE PER STOPPING (X 10 E-10) = 89,847.7			
# OF STOPPINGS	EQUIVALENT RESISTANCE (X 10 E-10)	# OF STOPPINGS	EQUIVALENT RESISTANCE (X 10 E-10)
1	89,847.70	51	34.54
2	22,461.93	52	33.23
3	9,983.08	53	31.99
4	5,615.48	54	30.81
5	3,593.91	55	29.70
6	2,495.77	56	28.65
7	1,833.63	57	27.65
8	1,403.87	58	26.71
9	1,109.23	59	25.81
10	898.48	60	24.96
11	742.54	61	24.15
12	623.94	62	23.37
13	531.64	63	22.64
14	458.41	64	21.94
15	399.32	65	21.27
16	350.97	66	20.63
17	310.89	67	20.02
18	277.31	68	19.43
19	248.89	69	18.87
20	224.62	70	18.34
21	203.74	71	17.82
22	185.64	72	17.33
23	169.84	73	16.86
24	155.99	74	16.41
25	143.76	75	15.97
26	132.91	76	15.56
27	123.25	77	15.15
28	114.60	78	14.77
29	106.83	79	14.40
30	99.83	80	14.04
31	93.49	81	13.69
32	87.74	82	13.36
33	82.50	83	13.04
34	77.72	84	12.73
35	73.35	85	12.44
36	69.33	86	12.15
37	65.63	87	11.87
38	62.22	88	11.60
39	59.07	89	11.34
40	56.15	90	11.09
41	53.45	91	10.85
42	50.93	92	10.62
43	48.59	93	10.39
44	46.41	94	10.17
45	44.37	95	9.96
46	42.46	96	9.75
47	40.67	97	9.55
48	39.00	98	9.36
49	37.42	99	9.17
50	35.94	100	8.98

Figure 3.4.2 Type B Equivalent Resistance

Table 3.4.3 Type C (Block With Dupont Above Average) Equivalent Resistance

RESISTANCE PER STOPPING (X 10 E-10) = 136,708.2			
# OF STOPPINGS	EQUIVALENT RESISTANCE (X 10 E-10)	# OF STOPPINGS	EQUIVALENT RESISTANCE (X 10 E-10)
1	136,708.20	51	52.56
2	34,177.05	52	50.56
3	15,189.80	53	48.67
4	8,544.26	54	46.88
5	5,468.33	55	45.19
6	3,797.45	56	43.59
7	2,789.96	57	42.08
8	2,136.07	58	40.64
9	1,687.76	59	39.27
10	1,367.08	60	37.97
11	1,129.82	61	36.74
12	949.36	62	35.56
13	808.92	63	34.44
14	697.49	64	33.38
15	607.59	65	32.36
16	534.02	66	31.38
17	473.04	67	30.45
18	421.94	68	29.56
19	378.69	69	28.71
20	341.77	70	27.90
21	310.00	71	27.12
22	282.45	72	26.37
23	258.43	73	25.65
24	237.34	74	24.96
25	218.73	75	24.30
26	202.23	76	23.67
27	187.53	77	23.06
28	174.37	78	22.47
29	162.55	79	21.90
30	151.90	80	21.36
31	142.26	81	20.84
32	133.50	82	20.33
33	125.54	83	19.84
34	118.26	84	19.37
35	111.60	85	18.92
36	105.48	86	18.48
37	99.86	87	18.06
38	94.67	88	17.65
39	89.88	89	17.26
40	85.44	90	16.88
41	81.33	91	16.51
42	77.50	92	16.15
43	73.94	93	15.81
44	70.61	94	15.47
45	67.51	95	15.15
46	64.61	96	14.83
47	61.89	97	14.53
48	59.34	98	14.23
49	56.94	99	13.95
50	54.68	100	13.67

Figure 3.4.3 Type C Equivalent Resistance

Table 3.4.4 Type D (Block With B-Bond/Tyvek) Equivalent Resistance

RESISTANCE PER STOPPING (X 10 E-10) = 611,605.0			
# OF STOPPINGS	EQUIVALENT RESISTANCE (X 10 E-10)	# OF STOPPINGS	EQUIVALENT RESISTANCE (X 10 E-10)
1	611,605.00	51	235.14
2	152,901.25	52	226.19
3	67,956.11	53	217.73
4	38,225.31	54	209.74
5	24,464.20	55	202.18
6	16,989.03	56	195.03
7	12,481.73	57	188.24
8	9,556.33	58	181.81
9	7,550.68	59	175.70
10	6,116.05	60	169.89
11	5,054.59	61	164.37
12	4,247.26	62	159.11
13	3,618.96	63	154.10
14	3,120.43	64	149.32
15	2,718.24	65	144.76
16	2,389.08	66	140.41
17	2,116.28	67	136.25
18	1,887.67	68	132.27
19	1,694.20	69	128.46
20	1,529.01	70	124.82
21	1,386.86	71	121.33
22	1,263.65	72	117.98
23	1,156.15	73	114.77
24	1,061.81	74	111.69
25	978.57	75	108.73
26	904.74	76	105.89
27	838.96	77	103.15
28	780.11	78	100.53
29	727.24	79	98.00
30	679.56	80	95.56
31	636.43	81	93.22
32	597.27	82	90.96
33	561.62	83	88.78
34	529.07	84	86.68
35	499.27	85	84.65
36	471.92	86	82.69
37	446.75	87	80.80
38	423.55	88	78.98
39	402.11	89	77.21
40	382.25	90	75.51
41	363.83	91	73.86
42	346.71	92	72.26
43	330.78	93	70.71
44	315.91	94	69.22
45	302.03	95	67.77
46	289.04	96	66.36
47	276.87	97	65.00
48	265.45	98	63.68
49	254.73	99	62.40
50	244.64	100	61.16

Figure 3.4.4 Type D Equivalent Resistance

CONCLUSION

4.1 Conclusion

Mine ventilation is an important aspect of the total mining system. The primary function of mine ventilation is to provide a safe working environment. The ventilation system must also be designed in a manner to minimize operating cost and capital investment. To control the capital investment on shafts, additional fans, and entry development, a proper ventilation system design is essential. An aid in the design of future projections is ventilation simulations. Although ventilation simulations can help in the determination of ventilation requirements, they are only as accurate as the assumed parameters used to run the simulations. The leakage that is assumed in ventilation modeling should be determined as accurately as possible.

Leakage is can cause excessive power cost with little or no benefit. Controlling leakage will minimize fan work thus reducing power cost. Reducing leakage is also important to achieve required last open break quantities. Depending on the mining environment, high face quantities may be necessary for dust and methane dilution. Minimizing leakage makes these high quantities more easily attainable.

In order to predict leakage, stopping performance must be evaluated. This evaluation involves the determination of resistance across development section return stoppings. Leakage across

stoppings is dependent upon pressure differential and resistance across the stopping. To determine the resistance across stoppings, a detailed ventilation survey must be conducted on the continuous miner development section. Once the survey data has been compiled a model of the section can be created. The model provides the branch resistance values for each leakage branch. Using the parallel resistance formula, an equivalent resistance can be calculated to combine the resistance of all stoppings between two entries.

Once the equivalent resistance is determined the resistance per stopping can be calculated. The resistance per stopping value is the best means of stopping performance evaluation. The Type D stoppings (block with B-Bond/Tyvek and plastered on both sides) performed the best. The high resistance value minimized average leakage per stopping to 100 cfm. By knowing the resistance values for each type of stopping, predictions can be made for future projections.

To insure the procedure was correct a test was run to check the equivalent resistance formula. Substituting in the equivalent resistance branch and checking quantities after running the model showed the procedure was a reasonable approach. The quantities were within 99% of the original values taken from the ventilation surveys.

Tables and charts were created for each type of stopping to help in ventilation simulations. The tables and charts permit to model the section as it progresses; i.e. as additional stoppings are built. Simulations can be run to model the effects of using the different types of stoppings on the development section. The tables provide the proper equivalent resistance for the stopping using the total number of stoppings as the determining factor. This allows for proper leakage simulation, and enables a more precise model to be constructed.

Accurate simulations can assist in ventilation system planning. The reduction of leakage can save on operating cost and capital investment by the following:

- Increasing the air quantity available on the development section.
- Significantly reducing power cost by operating fans at lower pressures.
- Construction of ventilation shafts may be delayed by extending the distance between shafts or possibly eliminating the need for shafts, thus reducing the capital expenditure for shaft construction.
- The number of entries in mains and submains development may be reduced which would help improve lead time on continuous miner sections.

BIBLIOGRAPHY

1. Anon., 1997, Code of Federal Regulations, Title 30, Mineral Resources, U.S. Government Printing Office, Washington D.C., July (updated annually).
2. Bise, C.J. , "Mining Engineering Analysis", Littleton, Colorado, Society of Mining Engineers, 1986.
3. Saxe, J.A. "Modern Mine Ventilation and the Use of the Altimeter", Mining Congress Journal, vol. 15, 1929, pp. 552-54.
4. Williamson, J.N., Ritson, J.A.S., Cooke, W.E., "Air Pressure Surveying in Mines", Trans. Inst. Mining Engineer, vol. 81, 1931, pp. 313-39.
5. Williamson, J.N., "How to Measure Pressure Losses in Ventilation", Coal Age, vol. 37, 1932, pp. 297-8.
6. Williamson, J.N., "How to Make Air Survey and Calculate Results", Coal Age, vol. 37, 1932, pp. 331-3.
7. Mancha, R. "Survey of Underground Mine Pressure", Transactions of A.I.M.E., vol. 168, 1946, pp. 106-18.
8. McElroy, G.E. and Kingery, D.S., 1957, "Making Ventilation-Pressure Surveys with Altimeters," USBM, I.C., No. 7809.
9. Hall, C.J., "Mine Ventilation Engineering", New York, Society of Mining Engineers, 1981.
10. Kingery, D.S., 1960, "Introduction to Mine Ventilating Principles and Practices," USBM Bulletin 589, USBM.
11. Hartman, H.L., "Mine Ventilation and Air Conditioning, John Wiley and Sons, Inc., New York, 1982.
12. Stefanko, R. "Coal Mining Technology Theory and Practice", New York, Society of Mining Engineers, 1983.

**APPENDIX A
MINE A 4 E SECTION
VENTILATION SURVEY DATA**

MINE A 4E SECTION LEAKAGE SURVEY 7-2-98
TEAM A: GANDY, KOTCH
Anemometer 42972B

STATION	** ALTIMETER **			%	TEMP-F		DENS.	*** VELOCITIES ***				COR	*** AREA ***			CORRECT	QUANTITY	NOTES	ENTRY
	TIME BASE	1ST	2ND	ELEV CH4	WET	DRY	RATIO	1ST	2ND	3RD	4TH	AVG	HGHT	WIDTH	SLO	AREA			
BASE	09:00 1582	1582	1583	454 .00	61	65	1.037	0	0	0	0	0	.00	.00	0	.0	.0	UG BASE	
BASE	09:00 1582	1582	1583	454 .00	61	65	1.037	0	0	0	0	0	.00	.00	0	.0	.0	UG BASE	
6RET	09:39 1585	1692	1693	457 .00	63	64	1.035	298	286	0	0	302	6.80	15.00	1	101.0	30483.6	6 BLK RETURN	
6TRK	09:45 1585	1668	1668	457 .00	61	63	1.033	393	399	0	0	396	7.60	15.10	2	112.8	44694.0	6 BLK TRACK	
6BLT	09:56 1584	1687	1685	457 .00	63	64	1.035	145	144	122	128	152	7.60	15.50	13	104.8	15968.2	6 BLK BELT	
10RET	10:07 1581	1691	1690	457 .00	63	64	1.035	252	248	0	0	264	7.70	15.40	0	118.6	31262.0	10 BLK RETURN	
10TRK	10:12 1581	1669	1669	457 .00	61	63	1.033	354	348	0	0	355	8.30	15.30	2	125.0	44428.3	10 BLK TRACK	
10BLT	10:16 1581	1683	1682	457 .00	62	64	1.035	129	132	122	119	143	7.40	15.30	12	101.2	14437.2	10 BLK BELT	
13RET	10:26 1578	1684	1684	454 .00	63	63	1.033	258	242	0	0	264	7.80	15.20	1	117.6	30993.1	13 BLK RETURN	
13TRK	10:32 1578	1666	1666	456 .00	62	63	1.033	338	338	0	0	344	8.10	15.20	1	122.1	41964.9	13 BLK TRACK	
13BLT	10:36 1578	1678	1680	457 .00	63	63	1.033	122	121	103	110	131	8.00	16.00	14	114.0	14880.0	13 BLK BELT	
16RET	10:46 1578	1700	1696	464 .00	63	63	1.033	242	234	0	0	253	8.30	15.60	4	125.5	31712.2	16 BLK RETURN	
16TRK	10:51 1580	1683	1681	465 .00	62	63	1.033	347	357	0	0	356	7.80	15.40	1	119.1	42450.0	16 BLK TRACK	
16BLT	10:56 1578	1691	1690	466 .00	63	63	1.033	112	104	112	116	127	8.10	15.30	14	109.9	14001.6	16 BLK BELT	
19RET	11:09 1575	1683	1684	457 .00	64	64	1.036	268	252	0	0	273	7.90	16.10	6	121.2	33051.8	19 BLK RETURN	
19TRK	11:14 1572	1672	1672	459 .00	62	63	1.033	339	344	0	0	347	7.80	15.20	0	118.6	41118.8	19 BLK TRACK	
19BLT	11:19 1572	1685	1685	461 .00	63	63	1.033	118	125	126	123	140	7.60	15.50	15	102.8	14392.0	19 BLK BELT	
21RET	11:31 1570	1684	1684	460 .00	63	63	1.033	227	225	0	0	242	8.40	15.30	4	124.5	30111.2	21 BLK RETURN	
21TRK	12:00 1571	1669	1670	460 .00	62	63	1.033	369	358	0	0	367	7.10	15.20	0	107.9	39587.0	21 BLK TRACK	
21BLT	12:04 1574	1678	1676	461 .00	63	64	1.035	116	114	101	109	126	8.00	15.10	13	107.8	13616.8	21 BLK BELT	
23RET	12:15 1574	1686	1687	467 .00	63	63	1.033	222	232	0	0	243	8.80	15.70	4	134.2	32564.3	23 BLK RETURN	
23TRK	12:20 1574	1679	1681	464 .00	62	63	1.033	319	317	0	0	325	8.50	15.20	0	129.2	42048.7	23 BLK TRACK	
23BLT	12:27 1575	1683	1684	461 .00	63	63	1.033	113	115	93	92	119	8.20	15.00	13	110.0	13113.2	23 BLK BELT	
26RET	12:38 1575	1689	1690	467 .00	63	64	1.035	225	219	0	0	238	8.10	15.30	0	123.9	29517.9	26 BLK RETURN	
26TRK	12:43 1575	1681	1682	463 .00	63	63	1.033	319	308	0	0	321	7.90	15.10	1	118.3	38014.1	26 BLK TRACK	
26BLT	12:48 1575	1684	1684	459 .00	63	63	1.033	105	105	100	112	122	8.00	15.60	14	110.8	13470.9	26 BLK BELT	
29RET	12:58 1578	1686	1686	457 .00	64	64	1.036	222	221	0	0	238	7.80	15.30	2	117.3	27894.9	29 BLK RETURN	
29TRK	13:04 1579	1683	1682	456 .00	63	64	1.035	292	288	0	0	300	8.00	15.20	0	121.6	36480.0	29 BLK TRACK	
29BLT	13:08 1578	1684	1686	455 .00	63	64	1.035	93	96	80	83	103	8.40	16.50	13	125.6	12956.6	29 BLK BELT	
31RET	13:30 1579	1691	1693	456 .00	64	65	1.037	227	231	0	0	245	7.40	15.80	3	113.9	27858.6	31 BLK RETURN	
31TRK	13:36 1578	1688	1687	454 .00	64	64	1.036	280	270	0	0	286	8.20	16.00	2	129.2	36998.2	31 BLK TRACK	
31BLT	13:40 1579	1687	1688	453 .00	63	64	1.035	105	111	83	91	113	7.80	15.60	14	107.7	12184.8	31 BLK BELT	
TOC	15:54 1577	2092	2092	1328 .00	65	79	1.066	0	0	0	0	0	.00	.00	0	.0	.0	TOP OF COLLAR	
BASE	15:58 1577	1593	0	454 .00	63	74	1.055	0	0	0	0	0	.00	.00	0	.0	.0	UG BASE	

BASE ALTIMETER ADJUSTMENTS		
INPUT DATA		ADJUSTMENT
TIMESPAN		
09:00	TO 09:15	0
09:16	TO 09:17	-3
09:18	TO 09:20	-2
09:21	TO 09:23	-1
09:24	TO 09:26	0
09:27	TO 09:32	2
09:33	TO 09:34	3
09:35	TO 09:50	3
09:51	TO 09:52	2
09:53	TO 09:58	2
09:59	TO 10:00	0
10:01	TO 10:22	-1
10:23	TO 10:28	-4
10:29	TO 10:31	-4
10:32	TO 10:33	-4
10:34	TO 10:40	-4
10:41	TO 10:50	-4
10:51	TO 10:53	-2
10:54	TO 10:58	-4
10:59	TO 11:08	-6
11:09	TO 11:12	-7
11:13	TO 11:24	-10
11:25	TO 11:27	-12
11:28	TO 11:33	-12
11:34	TO 11:36	-13
11:37	TO 11:48	-13
11:49	TO 11:49	-12
11:50	TO 11:58	-12
11:59	TO 12:00	-11
12:01	TO 12:02	-9

BASE ALTIMETER ADJUSTMENTS		
INPUT DATA		ADJUSTMENT
TIMESPAN		
12:03	TO 12:06	-8
12:07	TO 12:21	-8
12:22	TO 12:23	-7
12:24	TO 12:50	-7
12:51	TO 12:52	-6
12:53	TO 13:00	-4
13:01	TO 13:01	-4
13:02	TO 13:07	-3
13:08	TO 13:10	-4
13:11	TO 13:14	-4
13:15	TO 13:20	-5
13:21	TO 13:24	-4
13:25	TO 13:26	-4
13:27	TO 13:33	-3
13:34	TO 13:37	-4
13:38	TO 13:39	-3
13:40	TO 13:48	-3
13:49	TO 13:50	-4
13:51	TO 13:52	-3
13:53	TO 14:22	-2
14:23	TO 14:24	-3
14:25	TO 15:14	-3
15:15	TO 15:16	-2
15:17	TO 15:23	-2
15:24	TO 15:27	-1
15:28	TO 15:38	0
15:39	TO 15:40	0
15:41	TO 15:42	-1
15:43	TO 15:44	-5
15:45	TO 15:58	-5

MINE A 4E SECTION LEAKAGE SURVEY 7-2-98
TEAM A: GANDY, KOTCH
Anemometer 42972B

INDEX	TYPE	NODE	BASE		ALTIMETER		DENSITY		VELOCITY
			ALT.	RDG	READING	ELEVATION	RATIO		
1		BASE	1582.0		1582.0	454.0	1.0367	.0	
2		BASE	1582.0		1582.0	454.0	1.0367	.0	
2		BASE	1582.0		1583.0	454.0	1.0367	.0	
3		6RET	1585.0		1692.0	457.0	1.0352	301.8	
3		6RET	1585.0		1693.0	457.0	1.0352	301.8	
3		6TRK	1585.0		1668.0	457.0	1.0327	396.4	
3		6TRK	1585.0		1668.0	457.0	1.0327	396.4	
3		6BLT	1584.0		1687.0	457.0	1.0352	152.4	
3		6BLT	1584.0		1685.0	457.0	1.0352	152.4	
3		10RET	1581.0		1691.0	457.0	1.0352	263.6	
3		10RET	1581.0		1690.0	457.0	1.0352	263.6	
3		10TRK	1581.0		1669.0	457.0	1.0327	355.5	
3		10TRK	1581.0		1669.0	457.0	1.0327	355.5	
3		10BLT	1581.0		1683.0	457.0	1.0350	142.6	
3		10BLT	1581.0		1682.0	457.0	1.0350	142.6	
3		13RET	1578.0		1684.0	454.0	1.0333	263.6	
3		13RET	1578.0		1684.0	454.0	1.0333	263.6	
3		13TRK	1578.0		1666.0	456.0	1.0330	343.6	
3		13TRK	1578.0		1666.0	456.0	1.0330	343.6	
3		13BLT	1578.0		1678.0	457.0	1.0333	130.5	
3		13BLT	1578.0		1680.0	457.0	1.0333	130.5	

3	16RET	1578.0	1700.0	464.0	1.0333	252.7
3	16RET	1578.0	1696.0	464.0	1.0333	252.7
3	16TRK	1580.0	1683.0	465.0	1.0330	356.4
3	16TRK	1580.0	1681.0	465.0	1.0330	356.4
3	16BLT	1578.0	1691.0	466.0	1.0333	127.4
3	16BLT	1578.0	1690.0	466.0	1.0333	127.4
3	19RET	1575.0	1683.0	457.0	1.0355	272.7
3	19RET	1575.0	1684.0	457.0	1.0355	272.7
3	19TRK	1572.0	1672.0	459.0	1.0330	346.8
3	19TRK	1572.0	1672.0	459.0	1.0330	346.8
3	19BLT	1572.0	1685.0	461.0	1.0333	140.0
3	19BLT	1572.0	1685.0	461.0	1.0333	140.0
3	21RET	1570.0	1684.0	460.0	1.0333	241.8
3	21RET	1570.0	1684.0	460.0	1.0333	241.8
3	21TRK	1571.0	1669.0	460.0	1.0330	366.8
3	21TRK	1573.0	1670.0	460.0	1.0330	366.8
3	21BLT	1574.0	1678.0	461.0	1.0352	126.3
3	21BLT	1574.0	1676.0	461.0	1.0352	126.3
3	23RET	1574.0	1686.0	467.0	1.0333	242.7
3	23RET	1574.0	1687.0	467.0	1.0333	242.7
3	23TRK	1574.0	1679.0	464.0	1.0330	325.5
3	23TRK	1575.0	1681.0	464.0	1.0330	325.5
3	23BLT	1575.0	1683.0	461.0	1.0333	119.2
3	23BLT	1575.0	1684.0	461.0	1.0333	119.2
3	26RET	1575.0	1689.0	467.0	1.0352	238.2
3	26RET	1575.0	1690.0	467.0	1.0352	238.2

3	26TRK	1575.0	1681.0	463.0	1.0333	321.4
3	26TRK	1575.0	1682.0	463.0	1.0333	321.4
3	26BLT	1575.0	1684.0	459.0	1.0333	121.6
3	26BLT	1575.0	1684.0	459.0	1.0333	121.6
3	29RET	1578.0	1686.0	457.0	1.0355	237.7
3	29RET	1578.0	1686.0	457.0	1.0355	237.7
3	29TRK	1579.0	1683.0	456.0	1.0352	300.0
3	29TRK	1579.0	1682.0	456.0	1.0352	300.0
3	29BLT	1578.0	1684.0	455.0	1.0352	103.2
3	29BLT	1578.0	1686.0	455.0	1.0352	103.2
3	31RET	1579.0	1691.0	456.0	1.0375	244.5
3	31RET	1579.0	1693.0	456.0	1.0375	244.5
3	31TRK	1578.0	1688.0	454.0	1.0355	286.4
3	31TRK	1579.0	1687.0	454.0	1.0355	286.4
3	31BLT	1579.0	1687.0	453.0	1.0352	113.2
3	31BLT	1579.0	1688.0	453.0	1.0352	113.2
3	TOC	1577.0	2092.0	1328.0	1.0656	.0
3	TOC	1577.0	2092.0	1328.0	1.0656	.0
1	BASE	1577.0	1593.0	454.0	1.0547	.0

MINE A 4E SECTION LEAKAGE SURVEY 7-2-98
TEAM A: GANDY, KOTCH
Anemometer 42972B

TYPE STATION		DIFFERENTIAL PRESSURE UNDERGROUND BASE	DIFFERENTIAL PRESSURE SURFACE BASE
2	BASE	0.0	-4.4296710
3	6RET	-1.5160720	-5.9457430
3	6RET	-1.5306890	-5.9603600
3	6TRK	-1.1615390	-5.5912100
3	6TRK	-1.1615390	-5.5912100
3	6BLT	-1.4620030	-5.8916730
3	6BLT	-1.4327630	-5.8624340
3	10RET	-1.5613270	-5.9909980
3	10RET	-1.5467090	-5.9763800
3	10TRK	-1.2365560	-5.6662270
3	10TRK	-1.2365560	-5.6662270
3	10BLT	-1.4476420	-5.8773130
3	10BLT	-1.4330210	-5.8626920
3	13RET	-1.5453970	-5.9750680
3	13RET	-1.5453970	-5.9750680
3	13TRK	-1.2513070	-5.6809770
3	13TRK	-1.2513070	-5.6809770
3	13BLT	-1.4186260	-5.8482970
3	13BLT	-1.4478690	-5.8775400
3	16RET	-1.6377630	-6.0674330

3	16RET	-1.5792970	-6.0089680
3	16TRK	-1.3423160	-5.7719870
3	16TRK	-1.3130750	-5.7427450
3	16BLT	-1.4810930	-5.9107640
3	16BLT	-1.4664750	-5.8961460
3	19RET	-1.5319910	-5.9616620
3	19RET	-1.5466110	-5.9762820
3	19TRK	-1.3840440	-5.8137150
3	19TRK	-1.3840440	-5.8137150
3	19BLT	-1.5517750	-5.9814460
3	19BLT	-1.5517750	-5.9814460
3	21RET	-1.5781480	-6.0078190
3	21RET	-1.5781480	-6.0078190
3	21TRK	-1.3398120	-5.7694830
3	21TRK	-1.3251890	-5.7548590
3	21BLT	-1.4208170	-5.8504880
3	21BLT	-1.3915730	-5.8212440
3	23RET	-1.4497700	-5.8794400
3	23RET	-1.4643890	-5.8940600
3	23TRK	-1.3870750	-5.8167460
3	23TRK	-1.4016960	-5.8313670
3	23BLT	-1.4790510	-5.9087220
3	23BLT	-1.4936720	-5.9233430
3	26RET	-1.4794160	-5.9090870
3	26RET	-1.4940350	-5.9237060
3	26TRK	-1.4160100	-5.8456810
3	26TRK	-1.4306310	-5.8603020

3	26BLT	-1.5219220	-5.9515920
3	26BLT	-1.5219220	-5.9515920
3	29RET	-1.5330360	-5.9627070
3	29RET	-1.5330360	-5.9627070
3	29TRK	-1.4866740	-5.9163450
3	29TRK	-1.4720540	-5.9017240
3	29BLT	-1.5349170	-5.9645870
3	29BLT	-1.5641560	-5.9938270
3	31RET	-1.6053080	-6.0349780
3	31RET	-1.6345440	-6.0642150
3	31TRK	-1.6029970	-6.0326680
3	31TRK	-1.5737580	-6.0034290
3	31BLT	-1.5921940	-6.0218650
3	31BLT	-1.6068130	-6.0364840
3	TOC	4.4296710	.0000005
3	TOC	4.4296710	.0000005
1	BASE	0.0	-.2342578
AVERAGE TIME LAG BETWEEN DUPLICATE STATION READINGS IS 2 MINUTES			

APPENDIX B
MINE B 6 LEFT SECTION
VENTILATION SURVEY DATA

MINE B 6 LEFT LEAKAGE SURVEY 8-14-98
TEAM A: GANDY, SHUMAKER
Anemometer 42972B

STATION	** ALTIMETER **				%	TEMP-F				DENS.	**** VELOCITIES ****				COR	**** AREA ****				QUANTITY	NOTES	ENTRY
	TIME	BASE	1ST	2ND	ELEV	CH4	WET	DRY	RATIO		1ST	2ND	3RD	4TH		AVG	HGHT	WIDTH	SLO			
BASE	07:45	1184	1184	1182	218	.00	70	74	1.057	0	0	0	0	0	0	0	.00	.00	0	.0	UG BASE	
BASE	07:45	1184	1184	1182	218	.00	70	74	1.057	0	0	0	0	0	0	0	.00	.00	0	.0	UG BASE	
81BLT	08:46	1200	1184	1182	152	.00	73	73	1.056	155	143	180	184	184	185	185	7.50	17.50	23	108.3	19997.8	81 BLK. BELT
81TRK	09:04	1200	1185	1187	153	.00	67	69	1.046	229	232	0	0	0	246	246	7.50	16.80	1	125.0	30738.6	81 BLK. TRACK
81RET	09:11	1207	1196	1195	153	.00	71	72	1.053	478	482	0	0	0	476	476	6.90	15.30	1	104.6	49795.2	81 BLK. RETURN
74RET	09:18	1210	1206	1208	161	.00	71	72	1.053	505	496	0	0	0	496	496	6.60	16.10	1	105.3	52178.9	74 BLK. RETURN
74TRK	09:26	1215	1201	1197	161	.00	67	68	1.044	292	277	0	0	0	295	295	6.80	17.00	1	114.6	33807.0	74 BLK. TRACK
74BLT	09:36	1215	1198	1199	160	.00	73	73	1.056	178	185	189	190	190	205	205	6.80	17.30	20	97.6	20016.2	74 BLK. BELT
70BLT	09:48	1220	1208	1207	166	.00	73	73	1.056	216	211	185	176	176	215	215	7.30	16.40	17	102.7	22131.5	70 BLK. BELT
70TRK	09:58	1224	1218	1217	167	.00	67	70	1.048	254	257	0	0	0	269	269	7.30	17.10	4	120.8	32459.3	70 BLK. TRACK
70RET	10:05	1225	1231	1235	167	.00	71	72	1.053	498	491	0	0	0	490	490	6.60	16.30	1	106.6	52224.2	70 BLK. RET
66RET	10:13	1226	1245	1245	172	.00	71	72	1.053	499	493	0	0	0	491	491	6.80	16.50	1	111.2	54646.9	66 RET. TYVEK
66TRK	10:17	1226	1226	1227	172	.00	68	71	1.050	268	274	0	0	0	283	283	7.10	16.90	1	119.0	33641.7	66 BLK. TRACK
66BLT	10:21	1226	1221	1226	171	.00	73	73	1.056	144	145	0	0	0	163	163	7.00	17.00	22	97.0	15775.3	66 BLK. BELT
58RET	10:36	1226	1246	1244	173	.00	71	71	1.051	497	505	0	0	0	496	496	6.70	16.40	0	109.9	54521.4	58 BLK. RETURN
58TRK	10:41	1226	1221	1221	173	.00	67	69	1.046	241	237	0	225	247	254	254	7.10	17.20	3	119.1	30213.2	58 BLK. TRACK
58BLT	10:49	1226	1217	1217	172	.00	73	73	1.056	226	209	225	227	224	243	243	6.90	16.90	19	97.6	23670.4	58 BLK. BELT
50BLT	11:00	1227	1212	1213	170	.00	73	74	1.058	209	205	205	227	224	233	233	6.80	16.30	19	91.8	21394.5	50 BLK BELT
50TRK	11:11	1227	1217	1220	171	.00	70	71	1.051	273	275	0	0	0	285	285	7.00	16.50	1	114.5	32684.5	50 BLK TRACK
50RET	11:14	1227	1245	1247	171	.00	71	71	1.051	537	531	0	0	0	528	528	6.40	16.40	0	105.0	55378.9	50 BLK RETURN
44RET	11:22	1227	1255	1256	174	.00	71	71	1.051	519	527	0	0	0	517	517	6.50	16.20	1	104.3	53938.0	44 BLK RETURN
44TRK	11:26	1227	1233	1234	174	.00	68	69	1.046	290	292	0	0	0	301	301	6.60	16.50	2	106.9	32167.2	44 BLK TRACK
44BLT	11:30	1227	1230	1235	173	.00	73	73	1.056	194	190	0	0	0	211	211	6.80	16.00	19	89.8	18939.6	44 BLK BELT
39BLT	11:41	1226	1232	1233	180	.00	72	73	1.056	181	183	187	192	192	205	205	7.00	17.60	22	101.2	20769.0	39 BLK BELT
39TRK	11:53	1226	1231	1232	181	.00	69	70	1.049	273	279	0	0	0	287	287	7.00	17.30	3	118.1	33926.9	39 BLK. TRACK
39RET	12:00	1225	1260	1259	181	.00	71	71	1.051	503	513	0	0	0	503	503	6.80	17.00	1	114.6	57627.4	39 BLK. RETURN
27RET	12:10	1225	1265	1264	178	.00	70	70	1.049	481	472	0	0	0	473	473	6.90	17.00	0	117.3	55466.1	27 BLK RETURN
27TRK	12:16	1227	1230	1235	178	.00	73	74	1.058	292	300	295	0	0	305	305	7.00	17.00	1	118.0	36007.9	27 BLK. TRACK
27BLT	12:23	1227	1226	1224	177	.00	73	73	1.056	194	194	0	0	0	213	213	7.40	16.90	19	106.1	22561.9	27 BLK. BELT
19BLT	12:31	1227	1225	1226	182	.00	73	73	1.056	190	184	187	191	191	207	207	7.20	16.30	19	98.4	20387.3	19 BLK. BELT
19TRK	12:45	1227	1232	1229	182	.00	69	71	1.051	272	268	0	0	0	282	282	7.40	16.50	3	119.1	33564.5	19 BLK. TRACK
19RET	12:51	1229	1269	1270	182	.00	71	71	1.051	438	439	0	0	0	437	437	7.80	16.30	0	127.1	55517.8	19 BLK. RETURN
11RET	13:02	1230	1286	1284	191	.00	71	71	1.051	505	512	0	0	0	503	503	6.90	16.40	0	113.2	56957.2	11 BLK. RETURN
11TRK	13:14	1227	1240	1240	191	.00	69	70	1.049	269	267	0	0	0	280	280	7.00	17.20	1	119.4	33432.0	11 BLK. TRACK
11BLT	13:21	1226	1230	1233	190	.00	73	73	1.056	192	206	220	211	225	225	225	7.20	16.60	25	94.5	21245.5	11 BLK. BELT
7BLT	13:32	1226	1235	1235	192	.00	73	73	1.056	197	192	208	215	222	303	303	7.20	16.00	21	94.2	20809.6	7 BLK. BELT
7TRK	13:41	1226	1240	1244	193	.00	69	69	1.047	293	294	0	0	0	303	303	7.20	16.20	2	114.6	34756.8	7 BLK. TRACK
7RET	13:56	1219	1289	1288	193	.00	70	70	1.049	498	504	0	0	0	496	496	6.80	19.30	0	131.2	65120.0	7 BLK. RETURN
TOC	14:26	1224	2050	2051	1196	.00	71	73	1.056	0	0	0	0	0	0	0	.00	.00	0	.0	TOP OF COLLAR	
BASE	14:30	1224	1208	0	218	.00	72	75	1.059	0	0	0	0	0	0	0	.00	.00	0	.0	UG BASE	

BASE ALTIMETER ADJUSTMENTS		
INPUT DATA		ADJUSTMENT
TIMESPAN		
07:45	TO 07:47	0
07:48	TO 07:49	4
07:50	TO 07:51	5
07:52	TO 07:54	6
07:55	TO 07:57	7
07:58	TO 07:59	9
08:00	TO 08:00	11
08:01	TO 08:03	12
08:04	TO 08:07	13
08:08	TO 08:15	13
08:16	TO 08:18	14
08:19	TO 08:22	16
08:23	TO 08:24	17
08:25	TO 09:00	16
09:01	TO 09:01	16
09:02	TO 09:04	16
09:05	TO 09:06	17
09:07	TO 09:09	19
09:10	TO 09:11	23
09:12	TO 09:20	26
09:21	TO 09:22	29
09:23	TO 09:40	31
09:41	TO 09:42	34
09:43	TO 09:51	36
09:52	TO 09:53	39
09:54	TO 09:57	40
09:58	TO 09:59	40
10:00	TO 10:01	40
10:02	TO 10:03	41
10:04	TO 10:06	41
10:07	TO 10:09	41
10:10	TO 10:13	42
10:14	TO 10:16	43
10:17	TO 10:23	42

BASE ALTIMETER ADJUSTMENTS		
INPUT DATA		ADJUSTMENT
TIMESPAN		
10:24	TO 10:27	41
10:28	TO 10:30	42
10:31	TO 10:45	42
10:46	TO 10:48	41
10:49	TO 10:50	42
10:51	TO 11:30	43
11:31	TO 11:33	42
11:34	TO 11:57	42
11:58	TO 11:59	42
12:00	TO 12:05	41
12:06	TO 12:07	40
12:08	TO 12:10	41
12:11	TO 12:50	43
12:51	TO 12:52	45
12:53	TO 12:55	46
12:56	TO 13:01	47
13:02	TO 13:03	46
13:04	TO 13:11	44
13:12	TO 13:13	43
13:14	TO 13:16	43
13:17	TO 13:19	42
13:20	TO 13:21	42
13:22	TO 13:23	43
13:24	TO 13:35	42
13:36	TO 13:38	41
13:39	TO 13:41	42
13:42	TO 13:44	42
13:45	TO 13:48	37
13:49	TO 13:50	36
13:51	TO 14:13	35
14:14	TO 14:16	34
14:17	TO 14:21	34
14:22	TO 14:23	40
14:24	TO 14:32	40

MINE B 6 LEFT LEAKAGE SURVEY 8-14-98
TEAM A: GANDY, SHUMAKER
Anemometer 42972B

INDEX	TYPE	NODE	BASE		ALTIMETER		DENSITY	
			ALT.	RDG	READING	ELEVATION	RATIO	VELOCITY
1		BASE	1184.0		1184.0	218.0	1.0570	.0
2		BASE	1184.0		1184.0	218.0	1.0570	.0
2		BASE	1184.0		1182.0	218.0	1.0570	.0
3		81BLT	1200.0		1184.0	152.0	1.0561	184.7
3		81BLT	1200.0		1182.0	152.0	1.0561	184.7
3		81TRK	1200.0		1185.0	153.0	1.0461	245.9
3		81TRK	1201.0		1187.0	153.0	1.0461	245.9
3		81RET	1207.0		1196.0	153.0	1.0534	476.2
3		81RET	1210.0		1195.0	153.0	1.0534	476.2
3		74RET	1210.0		1206.0	161.0	1.0534	495.7
3		74RET	1210.0		1208.0	161.0	1.0534	495.7
3		74TRK	1215.0		1201.0	161.0	1.0442	295.0
3		74TRK	1215.0		1197.0	161.0	1.0442	295.0
3		74BLT	1215.0		1198.0	160.0	1.0561	205.0
3		74BLT	1215.0		1199.0	160.0	1.0561	205.0
3		70BLT	1220.0		1208.0	166.0	1.0561	215.5
3		70BLT	1220.0		1207.0	166.0	1.0561	215.5
3		70TRK	1224.0		1218.0	167.0	1.0481	268.6
3		70TRK	1224.0		1217.0	167.0	1.0481	268.6
3		70RET	1225.0		1231.0	167.0	1.0534	490.0
3		70RET	1225.0		1235.0	167.0	1.0534	490.0

3	66RET	1226.0	1245.0	172.0	1.0534	491.4
3	66RET	1227.0	1245.0	172.0	1.0534	491.4
3	66TRK	1226.0	1226.0	172.0	1.0504	282.7
3	66TRK	1226.0	1227.0	172.0	1.0504	282.7
3	66BLT	1226.0	1221.0	171.0	1.0561	162.6
3	66BLT	1226.0	1226.0	171.0	1.0561	162.6
3	58RET	1226.0	1246.0	173.0	1.0514	496.2
3	58RET	1226.0	1244.0	173.0	1.0514	496.2
3	58TRK	1226.0	1221.0	173.0	1.0461	253.6
3	58TRK	1226.0	1221.0	173.0	1.0461	253.6
3	58BLT	1226.0	1217.0	172.0	1.0561	242.5
3	58BLT	1227.0	1217.0	172.0	1.0561	242.5
3	50BLT	1227.0	1212.0	170.0	1.0581	233.0
3	50BLT	1227.0	1213.0	170.0	1.0581	233.0
3	50TRK	1227.0	1217.0	171.0	1.0511	285.5
3	50TRK	1227.0	1220.0	171.0	1.0511	285.5
3	50RET	1227.0	1245.0	171.0	1.0514	527.6
3	50RET	1227.0	1247.0	171.0	1.0514	527.6
3	44RET	1227.0	1255.0	174.0	1.0515	517.1
3	44RET	1227.0	1256.0	174.0	1.0515	517.1
3	44TRK	1227.0	1233.0	174.0	1.0465	300.9
3	44TRK	1227.0	1234.0	174.0	1.0465	300.9
3	44BLT	1227.0	1230.0	173.0	1.0561	210.9
3	44BLT	1226.0	1235.0	173.0	1.0561	210.9
3	39BLT	1226.0	1232.0	180.0	1.0557	205.2
3	39BLT	1226.0	1233.0	180.0	1.0557	205.2

3	39TRK	1226.0	1231.0	181.0	1.0488	287.3
3	39TRK	1226.0	1232.0	181.0	1.0488	287.3
3	39RET	1225.0	1260.0	181.0	1.0515	502.9
3	39RET	1225.0	1259.0	181.0	1.0515	502.9
3	27RET	1225.0	1265.0	178.0	1.0491	472.9
3	27RET	1227.0	1264.0	178.0	1.0491	472.9
3	27TRK	1227.0	1230.0	178.0	1.0581	305.2
3	27TRK	1227.0	1235.0	178.0	1.0581	305.2
3	27BLT	1227.0	1226.0	177.0	1.0561	212.7
3	27BLT	1227.0	1224.0	177.0	1.0561	212.7
3	19BLT	1227.0	1225.0	182.0	1.0561	207.3
3	19BLT	1227.0	1226.0	182.0	1.0561	207.3
3	19TRK	1227.0	1232.0	182.0	1.0507	281.8
3	19TRK	1227.0	1229.0	182.0	1.0507	281.8
3	19RET	1229.0	1269.0	182.0	1.0515	436.7
3	19RET	1230.0	1270.0	182.0	1.0515	436.7
3	11RET	1230.0	1286.0	191.0	1.0515	503.3
3	11RET	1228.0	1284.0	191.0	1.0515	503.3
3	11TRK	1227.0	1240.0	191.0	1.0488	280.0
3	11TRK	1227.0	1240.0	191.0	1.0488	280.0
3	11BLT	1226.0	1230.0	190.0	1.0561	224.8
3	11BLT	1227.0	1233.0	190.0	1.0561	224.8
3	7BLT	1226.0	1235.0	192.0	1.0561	220.9
3	7BLT	1226.0	1235.0	192.0	1.0561	220.9
3	7TRK	1226.0	1240.0	193.0	1.0468	303.2
3	7TRK	1226.0	1244.0	193.0	1.0468	303.2
3	7RET	1219.0	1289.0	193.0	1.0491	496.2

3	7RET	1219.0	1288.0	193.0	1.0491	496.2
3	TOC	1224.0	2050.0	1196.0	1.0557	.0
3	TOC	1224.0	2051.0	1196.0	1.0557	.0
1	BASE	1224.0	1208.0	218.0	1.0595	.0

MINE B 6 LEFT LEAKAGE SURVEY 8-14-98
TEAM A: GANDY, SHUMAKER
Anemometer 42972B

TYPE	STATION	DIFFERENTIAL	
		PRESSURE UNDERGROUND BASE	PRESSURE SURFACE BASE
2	BASE	0.0	-1.4610230
3	81BLT	-.6899197	-2.1509430
3	81BLT	-.6601502	-2.1211730
3	81TRK	-.6977578	-2.1587810
3	81TRK	-.7126417	-2.1736650
3	81RET	-.7404281	-2.2014510
3	81RET	-.6809024	-2.1419250
3	74RET	-.7302479	-2.1912710
3	74RET	-.7600048	-2.2210280
3	74TRK	-.5985643	-2.0595870
3	74TRK	-.5390422	-2.0000650
3	74BLT	-.5616372	-2.0226600
3	74BLT	-.5765178	-2.0375410
3	70BLT	-.5511380	-2.0121610
3	70BLT	-.5362597	-1.9972830
3	70TRK	-.6300791	-2.0911020
3	70TRK	-.6152034	-2.0762260
3	70RET	-.7942685	-2.2552910
3	70RET	-.8537552	-2.3147780
3	66RET	-.9167274	-2.3777500

3	66RET	- .9018589	-2.3628820
3	66TRK	- .6463566	-2.1073800
3	66TRK	- .6612300	-2.1222530
3	66BLT	- .5859265	-2.0469490
3	66BLT	- .6602972	-2.1213200
3	58RET	- .9183841	-2.3794070
3	58RET	- .8886470	-2.3496700
3	58TRK	- .5614590	-2.0224820
3	58TRK	- .5614590	-2.0224820
3	58BLT	- .5103875	-1.9714110
3	58BLT	- .4955116	-1.9565350
3	50BLT	- .4483561	-1.9093790
3	50BLT	- .4632331	-1.9242560
3	50TRK	- .5113397	-1.9723630
3	50TRK	- .5559660	-2.0169890
3	50RET	- .9149073	-2.3759300
3	50RET	- .9446438	-2.4056670
3	44RET	-1.0216530	-2.4826760
3	44RET	-1.0365190	-2.4975420
3	44TRK	- .7088836	-2.1699070
3	44TRK	- .7237551	-2.1847780
3	44BLT	- .6755202	-2.1365430
3	44BLT	- .7647508	-2.2257740
3	39BLT	- .6218981	-2.0829210
3	39BLT	- .6367698	-2.0977930
3	39TRK	- .5938991	-2.0549220
3	39TRK	- .6087711	-2.0697940

3	39RET	-1.0275810	-2.4886040
3	39RET	-1.0127160	-2.4737390
3	27RET	-1.1472940	-2.6083170
3	27RET	-1.1027030	-2.5637260
3	27TRK	-.6010246	-2.0620470
3	27TRK	-.6753834	-2.1364060
3	27BLT	-.5597321	-2.0207550
3	27BLT	-.5299847	-1.9910080
3	19BLT	-.4745792	-1.9356020
3	19BLT	-.4894528	-1.9504760
3	19TRK	-.5789608	-2.0399840
3	19TRK	-.5343439	-1.9953670
3	19RET	-1.0914510	-2.5524740
3	19RET	-1.0914510	-2.5524740
3	11RET	-1.1977950	-2.6588180
3	11RET	-1.1977950	-2.6588180
3	11TRK	-.5712402	-2.0322630
3	11TRK	-.5712402	-2.0322630
3	11BLT	-.4506339	-1.9116570
3	11BLT	-.4803779	-1.9414010
3	7BLT	-.4969067	-1.9579300
3	7BLT	-.4969067	-1.9579300
3	7TRK	-.5575604	-2.0185830
3	7TRK	-.6170375	-2.0780610
3	7RET	-1.3786890	-2.8397120
3	7RET	-1.3638320	-2.8248550

3	TOC	1.4683370	.0073141
3	TOC	1.4537090	-.0073143

1	BASE	0.0	.2379505
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AVERAGE TIME LAG BETWEEN DUPLICATE STATION READINGS IS 2 MINUTES

APPENDIX C
MINE C 12 D SECTION
VENTILATION SURVEY DATA

MINE C 12D LEAKAGE SURVEY 6-3-98
TEAM A: GANDY, SHUMAKER
Anemometer 42972B

STATION	** ALTIMETER **			%	TEMP-F		DENS.				**** VELOCITIES ****				COR	**** AREA ****			CORRECT	QUANTITY	NOTES	ENTRY
	TIME	BASE	1ST	2ND	ELEV	CH4	WET	DRY	RATIO	1ST	2ND	3RD	4TH	AVG		HGHT	WIDTH	SLO				
BASE	08:36	1817	1817	1818	692	.00	54	61	1.027	0	0	0	0	0	0	.00	.00	0	.0	.0	UG BASE	
BASE	08:36	1817	1817	1818	692	.00	54	61	1.027	0	0	0	0	0	0	.00	.00	0	.0	.0	UG BASE	
40RET	11:02	1843	1691	1691	374	.00	61	64	1.035	269	279	0	0	285	0	7.30	15.90	0	116.1	33132.7	40 BLK. RETURN	
40TRK	11:12	1840	1684	1683	375	.00	57	63	1.032	498	492	0	0	490	0	7.40	15.80	27	89.9	44103.6	40 BLK. TRACK	
40BLT	11:19	1838	1689	1690	376	.00	58	63	1.032	124	111	136	135	144	0	7.20	16.10	20	95.9	13782.2	40 BLK. BELT	
36BLT	11:30	1838	1694	1692	381	.00	59	62	1.030	116	123	107	87	124	0	8.00	17.30	21	117.4	14613.2	36 BLK. BELT	
36TRK	11:38	1838	1685	1686	380	.00	57	63	1.032	382	376	0	0	381	0	8.70	16.20	0	140.9	53685.3	36 BLK. TRACK	
36RET	11:47	1838	1700	1702	379	.00	61	64	1.035	279	268	0	0	285	0	7.30	15.80	1	114.3	32586.9	36 BLK RETURN	
34RET	11:53	1838	1	1	383	.00	99	99	1.122	326	326	0	0	333	0	.10	1.00	0	.1	33.3	34 BLK HOLE	
33RET	11:57	1838	1707	1705	383	.00	61	63	1.033	281	278	0	0	290	0	7.10	15.80	0	112.2	32583.2	33 BLK RETURN	
33BLT	12:05	1838	1695	1697	385	.00	59	62	1.030	101	105	150	148	143	0	8.20	16.10	20	112.0	16036.5	33 BLK BELT	
30BLT	12:17	1836	1706	1709	392	.00	59	63	1.032	133	148	151	158	166	0	7.60	15.70	20	99.3	16466.2	30 BLK BELT	
33TRK	12:27	1839	1700	1700	384	.00	57	63	1.032	438	436	0	0	435	0	7.40	16.20	0	119.9	52176.3	33 BLK TRACK	
30TRK	12:33	1839	1703	1702	391	.00	57	64	1.034	455	458	0	0	454	0	7.20	15.80	0	113.8	51625.4	30 BLK TRACK	
30RET	12:38	1839	1713	1716	390	.00	60	63	1.032	321	320	0	0	328	0	6.60	15.80	0	104.3	34175.4	30 BLK RETURN	
26RET	12:45	1848	1725	1728	399	.00	60	63	1.032	324	316	0	0	327	0	6.70	15.90	0	106.5	34864.4	26 BLK RETURN	
26TRK	12:51	1848	1717	1720	401	.00	57	64	1.034	434	429	0	0	430	0	8.00	15.70	1	124.6	53578.0	26BLK TRACK	
26BLT	12:56	1845	1731	1732	402	.00	61	63	1.033	141	169	136	139	164	0	7.70	15.60	20	100.1	16467.1	26 BLK BELT	
23BLT	13:05	1843	1736	1737	409	.00	61	63	1.033	146	132	157	158	167	0	7.20	15.70	20	93.0	15498.5	23 BLK BELT	
23TRK	13:13	1843	1726	1723	408	.00	57	63	1.032	458	461	0	0	457	0	7.70	15.90	0	122.4	55909.7	23 BLK TRACK	
23RET	13:19	1837	1736	1736	407	.00	61	64	1.035	340	347	0	0	349	0	6.80	15.90	0	108.1	37694.6	23 BLK RETURN	
20RET	13:27	1837	1741	1741	412	.00	61	64	1.035	331	328	0	0	336	0	6.60	15.60	0	103.0	34585.2	20 BLK RETURN	
20TRK	13:32	1837	1726	1726	413	.00	58	63	1.032	513	490	0	0	497	0	7.40	15.70	0	116.2	57702.7	20 BLK TRACK	
20BLT	13:38	1838	1744	1745	417	.00	61	63	1.033	101	85	130	138	130	0	7.50	17.90	21	113.3	14722.5	20 BLK BELT	
17BLT	13:48	1841	1755	1754	422	.00	61	63	1.033	151	140	170	168	176	0	7.50	16.80	20	106.0	18661.6	17 BLK BELT	
17TRK	13:56	1841	1735	1736	420	.00	58	64	1.034	508	509	0	0	503	0	7.20	16.00	2	113.2	56977.3	17 BLK TRACK	
17RET	14:03	1841	1753	1753	419	.00	61	63	1.033	335	321	0	0	335	0	6.80	17.20	1	116.0	38793.9	17 BLK RETURN	
14RET	14:09	1841	1765	1768	429	.00	62	64	1.035	328	323	0	0	332	0	7.30	15.70	1	113.6	37749.5	14 BLK RETURN	
5RET	14:38	1853	1796	1797	457	.00	61	64	1.035	342	325	0	0	340	0	7.30	15.50	1	112.2	38080.0	5 BLK RETURN	
5TRK	14:46	1853	1772	1772	458	.00	58	62	1.030	524	513	0	0	513	0	7.50	15.80	1	117.5	60260.7	5 BLK TRACK	
5BLT	14:49	1854	1802	1801	459	.00	62	65	1.037	188	172	0	0	200	0	7.70	15.80	19	102.7	20532.0	5 BLK BELT	
TOC	15:31	1847	2040	2039	1034	.00	60	71	1.048	0	0	0	0	0	0	.00	.00	0	.0	.0	TOP OF COLLAR	
BASE	15:33	1847	1866	1866	692	.00	58	68	1.042	0	0	0	0	0	0	.00	.00	0	.0	.0	UG BASE	

BASE ALTIMETER ADJUSTMENTS		
INPUT DATA		
TIMESPAN	ADJUSTMENT	
08:36 TO 08:37	0	
08:38 TO 08:40	-1	
08:41 TO 08:42	-1	
08:43 TO 08:44	0	
08:45 TO 08:46	0	
08:47 TO 08:55	0	
08:56 TO 08:58	0	
08:59 TO 09:00	2	
09:01 TO 09:02	4	
09:03 TO 09:04	8	
09:05 TO 09:13	10	
09:14 TO 09:15	10	
09:16 TO 09:17	10	
09:18 TO 09:20	11	
09:21 TO 09:22	12	
09:23 TO 09:25	15	
09:26 TO 09:27	19	
09:28 TO 09:29	21	
09:30 TO 09:39	21	
09:40 TO 09:40	21	
09:41 TO 09:42	21	
09:43 TO 09:44	21	
09:45 TO 09:45	21	
09:46 TO 09:52	21	
09:53 TO 09:54	20	
09:55 TO 09:56	19	
09:57 TO 10:32	19	
10:33 TO 10:35	20	
10:36 TO 10:36	23	
10:37 TO 10:49	26	
10:50 TO 10:51	27	
10:52 TO 11:00	27	
11:01 TO 11:02	26	
11:03 TO 11:12	23	
11:13 TO 11:14	21	
11:15 TO 11:16	21	

BASE ALTIMETER ADJUSTMENTS		
INPUT DATA		
TIMESPAN	ADJUSTMENT	
11:17 TO 11:18	21	
11:19 TO 11:20	21	
11:21 TO 11:34	21	
11:35 TO 11:36	21	
11:37 TO 11:38	21	
11:39 TO 11:40	21	
11:41 TO 11:42	21	
11:43 TO 12:00	21	
12:01 TO 12:02	21	
12:03 TO 12:06	21	
12:07 TO 12:08	20	
12:09 TO 12:10	19	
12:11 TO 12:12	20	
12:13 TO 12:14	21	
12:15 TO 12:16	20	
12:17 TO 12:18	19	
12:19 TO 12:20	20	
12:21 TO 12:23	20	
12:24 TO 12:26	20	
12:27 TO 12:40	22	
12:41 TO 12:41	26	
12:42 TO 12:43	29	
12:44 TO 12:45	31	
12:46 TO 12:50	32	
12:51 TO 12:52	31	
12:53 TO 12:56	28	
12:57 TO 12:59	26	
13:00 TO 13:01	26	
13:02 TO 13:02	26	
13:03 TO 13:05	26	
13:06 TO 13:14	26	
13:15 TO 13:16	25	
13:17 TO 13:18	22	
13:19 TO 13:27	20	
13:28 TO 13:30	20	
13:31 TO 13:32	20	
13:33 TO 13:34	19	

BASE ALTIMETER ADJUSTMENTS		
INPUT DATA		
TIMESPAN	ADJUSTMENT	
13:35 TO 13:36	20	
13:37 TO 13:38	21	
13:39 TO 13:40	22	
13:41 TO 13:41	23	
13:42 TO 13:44	24	
13:45 TO 13:47	24	
13:48 TO 13:49	24	
13:50 TO 14:08	24	
14:09 TO 14:09	24	
14:10 TO 14:11	24	
14:12 TO 14:13	23	

BASE ALTIMETER ADJUSTMENTS		
INPUT DATA		
TIMESPAN	ADJUSTMENT	
14:14 TO 14:15	22	
14:16 TO 14:17	21	
14:18 TO 14:20	22	
14:21 TO 14:22	24	
14:23 TO 14:24	28	
14:25 TO 14:33	31	
14:34 TO 14:35	34	
14:36 TO 14:48	36	
14:49 TO 14:51	37	
14:52 TO 15:17	36	
15:18 TO 15:20	35	
15:21 TO 15:23	30	
15:24 TO 15:34	30	

MINE C 12D LEAKAGE SURVEY 6-3-98
TEAM A: GANDY, SHUMAKER
Anemometer 42972B

INDEX	TYPE	NODE	BASE ALT. RDG	ALTIMETER READING	ELEVATION	DENSITY RATIO	VELOCITY
1		BASE	1817.0	1817.0	692.0	1.0272	.0
2		BASE	1817.0	1817.0	692.0	1.0272	.0
2		BASE	1816.0	1818.0	692.0	1.0272	.0
3		40RET	1843.0	1691.0	374.0	1.0347	285.5
3		40RET	1840.0	1691.0	374.0	1.0347	285.5
3		40TRK	1840.0	1684.0	375.0	1.0318	490.5
3		40TRK	1838.0	1683.0	375.0	1.0318	490.5
3		40BLT	1838.0	1689.0	376.0	1.0320	143.7
3		40BLT	1838.0	1690.0	376.0	1.0320	143.7
3		36BLT	1838.0	1694.0	381.0	1.0303	124.5
3		36BLT	1838.0	1692.0	381.0	1.0303	124.5
3		36TRK	1838.0	1685.0	380.0	1.0318	380.9
3		36TRK	1838.0	1686.0	380.0	1.0318	380.9
3		36RET	1838.0	1700.0	379.0	1.0347	285.0
3		36RET	1838.0	1702.0	379.0	1.0347	285.0
3		34RET	1838.0	1.0	383.0	1.1217	332.7
3		34RET	1838.0	1.0	383.0	1.1217	332.7
3		33RET	1838.0	1707.0	383.0	1.0327	290.5
3		33RET	1838.0	1705.0	383.0	1.0327	290.5
3		33BLT	1838.0	1695.0	385.0	1.0303	143.2
3		33BLT	1837.0	1697.0	385.0	1.0303	143.2

3	30BLT	1836.0	1706.0	392.0	1.0322	165.8
3	30BLT	1837.0	1709.0	392.0	1.0322	165.8
3	33TRK	1839.0	1700.0	384.0	1.0318	435.2
3	33TRK	1839.0	1700.0	384.0	1.0318	435.2
3	30TRK	1839.0	1703.0	391.0	1.0337	453.8
3	30TRK	1839.0	1702.0	391.0	1.0337	453.8
3	30RET	1839.0	1713.0	390.0	1.0325	327.7
3	30RET	1839.0	1716.0	390.0	1.0325	327.7
3	26RET	1848.0	1725.0	399.0	1.0325	327.3
3	26RET	1849.0	1728.0	399.0	1.0325	327.3
3	26TRK	1848.0	1717.0	401.0	1.0337	430.0
3	26TRK	1845.0	1720.0	401.0	1.0337	430.0
3	26BLT	1845.0	1731.0	402.0	1.0327	164.5
3	26BLT	1843.0	1732.0	402.0	1.0327	164.5
3	23BLT	1843.0	1736.0	409.0	1.0327	166.6
3	23BLT	1843.0	1737.0	409.0	1.0327	166.6
3	23TRK	1843.0	1726.0	408.0	1.0318	456.7
3	23TRK	1842.0	1723.0	408.0	1.0318	456.7
3	23RET	1837.0	1736.0	407.0	1.0347	348.6
3	23RET	1837.0	1736.0	407.0	1.0347	348.6
3	20RET	1837.0	1741.0	412.0	1.0347	335.9
3	20RET	1837.0	1741.0	412.0	1.0347	335.9
3	20TRK	1837.0	1726.0	413.0	1.0320	496.7
3	20TRK	1836.0	1726.0	413.0	1.0320	496.7
3	20BLT	1838.0	1744.0	417.0	1.0327	130.0
3	20BLT	1839.0	1745.0	417.0	1.0327	130.0
3	17BLT	1841.0	1755.0	422.0	1.0328	176.1

3	17BLT	1841.0	1754.0	422.0	1.0328	176.1
3	17TRK	1841.0	1735.0	420.0	1.0340	503.3
3	17TRK	1841.0	1736.0	420.0	1.0340	503.3
3	17RET	1841.0	1753.0	419.0	1.0328	334.5
3	17RET	1841.0	1753.0	419.0	1.0328	334.5
3	14RET	1841.0	1765.0	429.0	1.0350	332.3
3	14RET	1841.0	1768.0	429.0	1.0350	332.3
3	5RET	1853.0	1796.0	457.0	1.0347	339.5
3	5RET	1853.0	1797.0	457.0	1.0347	339.5
3	5TRK	1853.0	1772.0	458.0	1.0300	512.9
3	5TRK	1853.0	1772.0	458.0	1.0300	512.9
3	5BLT	1854.0	1802.0	459.0	1.0370	200.0
3	5BLT	1854.0	1801.0	459.0	1.0370	200.0
3	TOC	1847.0	2040.0	1034.0	1.0483	.0
3	TOC	1847.0	2039.0	1034.0	1.0483	.0
1	BASE	1847.0	1866.0	692.0	1.0419	.0

MINE C 12D LEAKAGE SURVEY 6-3-98
TEAM A: GANDY, SHUMAKER
Anemometer 42972B

TYPE	STATION	DIFFERENTIAL	
		PRESSURE UNDERGROUND BASE	PRESSURE SURFACE BASE
2	BASE	0.0	-1.9418400
3	40RET	-2.2560960	-4.1979360
3	40RET	-2.2852100	-4.2270500
3	40TRK	-2.1869120	-4.1287520
3	40TRK	-2.1869120	-4.1287520
3	40BLT	-2.2871780	-4.2290180
3	40BLT	-2.2871780	-4.2290180
3	36BLT	-2.2970000	-4.2388410
3	36BLT	-2.2533310	-4.1951710
3	36TRK	-2.1659100	-4.1077500
3	36TRK	-2.1659100	-4.1077500
3	36RET	-2.3891370	-4.3309770
3	36RET	-2.4036910	-4.3455310
3	34RET	23.4761200	21.5342800
3	34RET	23.4911500	21.5493100
3	33RET	-2.4426490	-4.3844890
3	33RET	-2.3989900	-4.3408300
3	33BLT	-2.2546080	-4.1964480
3	33BLT	-2.2837190	-4.2255590
3	30BLT	-2.3359140	-4.2777540

3	30BLT	-2.3504670	-4.2923070
3	33TRK	-2.3099200	-4.2517600
3	33TRK	-2.2953650	-4.2372050
3	30TRK	-2.2456040	-4.1874440
3	30TRK	-2.2164960	-4.1583370
3	30RET	-2.4160180	-4.3578580
3	30RET	-2.4451190	-4.3869600
3	26RET	-2.3323490	-4.2741890
3	26RET	-2.3468970	-4.2887370
3	26TRK	-2.1782700	-4.1201100
3	26TRK	-2.2510180	-4.1928580
3	26BLT	-2.4247740	-4.3666140
3	26BLT	-2.4538670	-4.3957070
3	23BLT	-2.4277410	-4.3695810
3	23BLT	-2.4277410	-4.3695810
3	23TRK	-2.2893640	-4.2312040
3	23TRK	-2.2457190	-4.1875590
3	23RET	-2.5296940	-4.4715340
3	23RET	-2.5151490	-4.4569890
3	20RET	-2.5324500	-4.4742900
3	20RET	-2.5179060	-4.4597460
3	20TRK	-2.3028280	-4.2446680
3	20TRK	-2.3028280	-4.2446680
3	20BLT	-2.5044720	-4.4463120
3	20BLT	-2.4899290	-4.4317690
3	17BLT	-2.5489720	-4.4908120
3	17BLT	-2.5198920	-4.4617320

3	17TRK	-2.2687690	-4.2106090
3	17TRK	-2.2687690	-4.2106090
3	17RET	-2.5571530	-4.4989930
3	17RET	-2.5426120	-4.4844520
3	14RET	-2.5823100	-4.5241500
3	14RET	-2.6113850	-4.5532250
3	5RET	-2.4644500	-4.4062910
3	5RET	-2.4644500	-4.4062910
3	5TRK	-2.1083820	-4.0502220
3	5TRK	-2.0938470	-4.0356870
3	5BLT	-2.5064210	-4.4482610
3	5BLT	-2.4773650	-4.4192050
3	TOC	1.9273730	-.0144666
3	TOC	1.9563070	.0144669
1	BASE	0.0	-.2757184
AVERAGE TIME LAG BETWEEN DUPLICATE STATION READINGS IS 2 MINUTES			

APPENDIX D
MINE C 13 D SECTION
VENTILATION SURVEY DATA

MINE C 13D LEAKAGE SURVEY 6-16-98
TEAM A: GANDY, SHUMAKER
Anemometer 42972B

STATION	** ALTIMETER **				%	TEMP-F		DENS. ***** VELOCITIES ***** COR				AREA *****				CORRECT	QUANTITY	NOTES	ENTRY
	TIME	BASE	1ST	2ND	ELEV	CH4	WET	DRY	RATIO	1ST	2ND	3RD	4TH	AVG	HGHT	WIDTH	SLO	AREA	
BASE	09:25	1980	1980	1981	692	.00	65	68	1.044	0	0	0	0	0	.00	.00	0	.0	UG BASE
BASE	09:25	1980	1980	1981	692	.00	65	68	1.044	0	0	0	0	0	.00	.00	0	.0	UG BASE
18BLT	10:51	1980	1838	1839	409	.00	66	67	1.042	17	14	0	0	0	7.50	16.00	15	105.0	18 BLK. BLT
18TRK	11:00	1979	1836	1837	409	.00	65	67	1.042	432	428	0	0	429	8.10	16.00	0	129.6	18 BLK. TRK
18RET	11:10	1979	1848	1846	409	.00	66	68	1.044	390	405	397	0	398	6.90	16.10	0	111.1	18 BLK. RETURN
15RET	11:18	1979	1854	1854	414	.00	66	68	1.044	422	425	0	0	422	6.80	16.20	1	109.2	15 BLK. RETURN
15TRK	11:25	1978	1836	1838	414	.00	65	67	1.042	495	494	0	0	490	7.60	16.30	1	122.9	15 BLK. TRK
15BLT	11:31	1977	1842	1844	414	.00	66	67	1.042	43	52	38	34	57	7.70	16.20	17	107.7	15 BLK. BLT
12BLT	11:46	1979	1854	1856	422	.00	66	67	1.042	54	56	17	20	51	8.30	16.10	17	116.6	12 BLK. BLT
12TRK	11:58	1981	1846	1845	422	.00	65	67	1.042	431	420	0	0	424	8.60	16.30	2	138.2	12 BLK. TRK
12RET	12:05	1981	1868	1869	422	.00	66	68	1.044	409	420	0	0	414	7.30	15.90	2	114.1	12 BLK. RETURN
9RET	12:13	1981	1878	1879	431	.00	66	68	1.044	431	433	0	0	430	7.40	15.90	1	116.7	9 BLK. RETURN
9TRK	12:19	1981	1856	1858	431	.00	65	67	1.042	504	499	0	0	497	7.40	15.70	1	115.2	9 BLK. TRK
9BLT	12:26	1981	1872	1872	431	.00	66	67	1.042	37	30	66	60	64	7.40	16.00	17	101.4	9 BLK. BLT
6BLT	12:38	1981	1878	1879	441	.00	66	68	1.044	37	41	48	47	59	7.80	15.80	16	107.2	6 BLK. BLT
6TRK	12:47	1986	1873	1874	441	.00	66	68	1.044	522	522	0	0	516	7.80	15.80	2	121.2	6 BLK. TRK
6RET	12:53	1986	1891	1890	441	.00	65	67	1.042	469	458	0	0	460	7.00	15.80	1	109.6	6 BLK. RETURN
TOC	15:39	2015	2207	2206	1034	.00	69	75	1.059	0	0	0	0	0	.00	.00	0	.0	TOP OF COLLAR
BASE	15:33	2015	2026	2025	692	.00	67	73	1.054	0	0	0	0	0	.00	.00	0	.0	UG BASE

BASE ALTIMETER ADJUSTMENTS		
INPUT DATA		
TIMESPAN	ADJUSTMENT	
09:25 TO 09:34	0	
09:35 TO 09:36	2	
09:37 TO 09:43	2	
09:44 TO 09:45	1	
09:46 TO 10:00	-1	
10:01 TO 10:02	-2	
10:03 TO 10:40	-2	
10:41 TO 10:42	-1	
10:43 TO 10:51	0	
10:52 TO 10:54	1	
10:55 TO 10:58	0	
10:59 TO 11:20	-1	
11:21 TO 11:22	-2	
11:23 TO 11:30	-2	
11:31 TO 11:32	-3	
11:33 TO 11:43	-2	
11:44 TO 11:50	-1	
11:51 TO 11:52	0	
11:53 TO 12:41	1	

BASE ALTIMETER ADJUSTMENTS		
INPUT DATA		
TIMESPAN	ADJUSTMENT	
12:42 TO 12:43	4	
12:44 TO 13:13	6	
13:14 TO 13:15	9	
13:16 TO 13:40	11	
13:41 TO 13:41	14	
13:42 TO 13:43	16	
13:44 TO 13:47	19	
13:48 TO 14:06	21	
14:07 TO 14:08	24	
14:09 TO 14:39	26	
14:40 TO 14:40	27	
14:41 TO 14:43	27	
14:44 TO 14:45	28	
14:46 TO 14:53	28	
14:54 TO 14:55	29	
14:56 TO 15:21	31	
15:22 TO 15:23	35	
15:24 TO 15:43	35	

MINE C 13D LEAKAGE SURVEY 6-16-98
TEAM A: GANDY, SHUMAKER
Anemometer 42972B

INDEX	TYPE	NODE	BASE ALT. RDG	ALTIMETER READING	ELEVATION	DENSITY RATIO	VELOCITY
1		BASE	1980.0	1980.0	692.0	1.0438	.0
2		BASE	1980.0	1980.0	692.0	1.0438	.0
2		BASE	1980.0	1981.0	692.0	1.0438	.0
3		18BLT	1980.0	1838.0	409.0	1.0421	.0
3		18BLT	1981.0	1839.0	409.0	1.0421	.0
3		18TRK	1979.0	1836.0	409.0	1.0418	428.6
3		18TRK	1979.0	1837.0	409.0	1.0418	428.6
3		18RET	1979.0	1848.0	409.0	1.0440	397.6
3		18RET	1979.0	1846.0	409.0	1.0440	397.6
3		15RET	1979.0	1854.0	414.0	1.0441	422.4
3		15RET	1979.0	1854.0	414.0	1.0441	422.4
3		15TRK	1978.0	1836.0	414.0	1.0418	490.0
3		15TRK	1978.0	1838.0	414.0	1.0418	490.0
3		15BLT	1977.0	1842.0	414.0	1.0421	56.8
3		15BLT	1978.0	1844.0	414.0	1.0421	56.8
3		12BLT	1979.0	1854.0	422.0	1.0421	50.9
3		12BLT	1979.0	1856.0	422.0	1.0421	50.9
3		12TRK	1981.0	1846.0	422.0	1.0418	424.3
3		12TRK	1981.0	1845.0	422.0	1.0418	424.3
3		12RET	1981.0	1868.0	422.0	1.0441	413.8
3		12RET	1981.0	1869.0	422.0	1.0441	413.8

3	9RET	1981.0	1878.0	431.0	1.0441	430.5
3	9RET	1981.0	1879.0	431.0	1.0441	430.5
3	9TRK	1981.0	1856.0	431.0	1.0418	496.7
3	9TRK	1981.0	1858.0	431.0	1.0418	496.7
3	9BLT	1981.0	1872.0	431.0	1.0421	64.4
3	9BLT	1981.0	1872.0	431.0	1.0421	64.4
3	6BLT	1981.0	1878.0	441.0	1.0441	58.5
3	6BLT	1981.0	1879.0	441.0	1.0441	58.5
3	6TRK	1986.0	1873.0	441.0	1.0441	516.2
3	6TRK	1986.0	1874.0	441.0	1.0441	516.2
3	6RET	1986.0	1891.0	441.0	1.0418	460.5
3	6RET	1986.0	1890.0	441.0	1.0418	460.5
3	TOC	2015.0	2207.0	1034.0	1.0590	.0
3	TOC	2015.0	2206.0	1034.0	1.0590	.0
1	BASE	2015.0	2026.0	692.0	1.0543	.0

MINE C 13D LEAKAGE SURVEY 6-16-98
TEAM A: GANDY, SHUMAKER
Anemometer 42972B

TYPE		STATION	DIFFERENTIAL PRESSURE UNDERGROUND BASE	DIFFERENTIAL PRESSURE SURFACE BASE
2		BASE	0.0	-1.8904630
3		18BLT	-1.8757900	-3.7662530
3		18BLT	-1.8757900	-3.7662530
3		18TRK	-1.8510650	-3.7415270
3		18TRK	-1.8655420	-3.7560040
3		18RET	-2.0174260	-3.9078880
3		18RET	-1.9884770	-3.8789390
3		15RET	-2.0333110	-3.9237740
3		15RET	-2.0333110	-3.9237740
3		15TRK	-1.7925250	-3.6829880
3		15TRK	-1.8214790	-3.7119420
3		15BLT	-1.9073130	-3.7977750
3		15BLT	-1.9217880	-3.8122510
3		12BLT	-1.9404470	-3.8309100
3		12BLT	-1.9693920	-3.8598540
3		12TRK	-1.7861660	-3.6766290
3		12TRK	-1.7716910	-3.6621540
3		12RET	-2.0959940	-3.9864560
3		12RET	-2.1104630	-4.0009250
3		9RET	-2.1147060	-4.0051680

3	9RET	-2.1291720	-4.0196340
3	9TRK	-1.8012280	-3.6916910
3	9TRK	-1.8301720	-3.7206340
3	9BLT	-2.0463000	-3.9367630
3	9BLT	-2.0463000	-3.9367630
3	6BLT	-1.9874900	-3.8779530
3	6BLT	-2.0019560	-3.8924190
3	6TRK	-1.8265930	-3.7170550
3	6TRK	-1.8410610	-3.7315230
3	6RET	-2.0973740	-3.9878370
3	6RET	-2.0829110	-3.9733730
3	TOC	1.8832710	-.0071913
3	TOC	1.8976540	.0071912
1	BASE	0.0	-.1587147

AVERAGE TIME LAG BETWEEN DUPLICATE STATION READINGS IS 2 MINUTES

APPENDIX E
MINE D 9 RIGHT SECTION
VENTILATION SURVEY DATA

MINE D 9 RIGHT SECTION LEAKAGE SURVEY 6-23-98
TEAM A: GANDY, SHUMAKER
Anemometer 42972B

STATION	** ALTIMETER **			%	TEMP-F		***** VELOCITIES *****				***** COR *****		***** AREA *****			QUANTITY	NOTES	ENTRY
	TIME BASE	1ST	2ND	ELEV CH4	WET	DRY	DENS. RATIO	1ST	2ND	3RD	4TH	AVG	HGHT	WIDTH	SLO	AREA		
BASE	09:14 1534	1534	0	524	.00	65	68	1.043	0	0	0	0	.00	.00	0	.0	UG BASE	
BASE	09:14 1534	1534	0	524	.00	65	68	1.043	0	0	0	0	.00	.00	0	.0	UG BASE	
3604BLT	12:14 1555	1655	1655	534	.00	65	66	1.040	143	144	0	0	162	8.00	17.00	25	111.0	32 BLK. BELT
3604RET	12:21 1556	1654	1656	534	.00	64	64	1.036	304	296	0	0	309	7.90	16.00	2	124.4	32 BLK. RETURN
3604TRK	12:27 1557	1640	1641	534	.00	64	65	1.037	406	492	0	0	447	8.10	16.00	1	128.6	32 BLK. TRK
5454BLT	12:35 1557	1633	1635	520	.00	65	66	1.040	118	117	0	0	134	8.50	16.60	25	116.1	46 BLK. BELT
5454TRK	12:39 1557	1627	1628	523	.00	64	66	1.039	353	354	0	0	358	8.60	16.10	1	137.5	46 BLK. TRK
5454RET	12:44 1559	1650	1653	530	.00	64	65	1.037	269	285	0	0	288	7.60	15.90	2	118.8	46 BLK. RETURN
7313RET	12:54 1560	1654	1655	525	.00	66	67	1.042	248	245	0	0	260	7.80	16.70	2	128.3	73+13 RETURN
7313TRK	13:00 1558	1649	1648	524	.00	64	65	1.037	356	347	0	0	356	7.80	16.80	4	127.0	73+13 TRK
7313BLT	13:03 1558	1646	1647	523	.00	65	67	1.042	90	93	0	0	107	7.90	16.50	24	106.3	73+13 BELT
1273BLT	13:34 1565	1658	1659	524	.00	67	67	1.042	199	196	0	0	216	7.70	16.20	24	100.7	12+73 BELT
1273TRK	13:40 1564	1640	1640	526	.00	66	68	1.044	495	491	0	0	489	7.50	15.80	1	117.5	12+73 TRK
1273RET	13:45 1565	1672	1671	528	.00	63	65	1.037	303	305	0	0	313	8.00	16.00	1	127.0	12+73 RETURN
9RREG	13:59 1563	1676	1677	529	.00	63	65	1.037	354	3456	48	47	949	7.10	16.10	1	113.3	9 RIGHT REG.
VPIPE	14:02 1569	1676	1677	529	.00	63	65	1.037	1624	1624	0	0	1570	1.00	.60	0	.6	10" VENT PIPE
OTBREG	14:07 1571	1741	1741	529	.00	63	65	1.037	0	0	0	0	0	.00	.00	0	.0	.8" MAG.
188RET	14:28 1574	1684	1683	528	.00	63	64	1.035	325	331	0	0	335	7.60	16.60	2	124.2	1+88 RET
188TRK	14:31 1574	1648	1647	525	.00	66	68	1.044	578	571	0	0	566	7.30	16.10	2	115.5	1+88 TRACK
188BLT	14:35 1573	1673	1673	524	.00	66	67	1.042	196	203	204	209	221	8.20	15.50	24	103.1	1+88 BELT
BELTREG	14:44 1577	1672	1673	524	.00	67	69	1.046	517	505	0	0	506	7.30	15.70	0	114.6	BELT REG. .9"
OTBYRE	14:50 1584	1747	1747	524	.00	67	69	1.046	0	0	0	0	0	.00	.00	0	.0	OUTBY REG
TOC	15:34 1569	1672	1672	773	.00	70	78	1.065	0	0	0	0	0	.00	.00	0	.0	TOP OF COLLAR
BASE	15:36 1569	1561	1561	524	.00	68	71	1.051	0	0	0	0	0	.00	.00	0	.0	UG BASE

BASE ALTIMETER ADJUSTMENTS		
INPUT DATA		
TIMESPAN	ADJUSTMENT	
09:14 TO 09:15	0	
09:16 TO 09:20	6	
09:21 TO 09:25	9	
09:26 TO 09:31	11	
09:32 TO 09:37	12	
09:38 TO 09:40	14	
09:41 TO 09:51	14	
09:52 TO 09:56	14	
09:57 TO 09:59	17	
10:00 TO 10:07	20	
10:08 TO 10:11	23	
10:12 TO 10:15	26	
10:16 TO 10:20	29	
10:21 TO 10:22	31	
10:23 TO 10:26	32	
10:27 TO 10:30	31	
10:31 TO 10:32	32	
10:33 TO 10:36	33	
10:37 TO 10:39	32	
10:40 TO 10:42	32	
10:43 TO 10:44	33	
10:45 TO 10:52	32	
10:53 TO 10:55	30	
10:56 TO 10:57	28	
10:58 TO 10:59	26	
11:00 TO 11:02	24	
11:03 TO 11:07	24	
11:08 TO 11:10	24	
11:11 TO 11:12	25	
11:13 TO 11:14	27	
11:15 TO 11:18	29	
11:19 TO 11:21	29	
11:22 TO 11:24	29	
11:25 TO 11:26	29	
11:27 TO 11:28	29	

BASE ALTIMETER ADJUSTMENTS		
INPUT DATA		
TIMESPAN	ADJUSTMENT	
11:29 TO 11:32	28	
11:33 TO 11:34	27	
11:35 TO 11:40	26	
11:41 TO 11:41	24	
11:42 TO 11:43	21	
11:44 TO 11:46	19	
11:47 TO 11:50	17	
11:51 TO 11:52	16	
11:53 TO 11:55	17	
11:56 TO 11:58	17	
11:59 TO 12:00	16	
12:01 TO 12:02	18	
12:03 TO 12:08	19	
12:09 TO 12:12	19	
12:13 TO 12:14	21	
12:15 TO 12:19	23	
12:20 TO 12:21	22	
12:22 TO 12:26	22	
12:27 TO 12:29	23	
12:30 TO 12:40	23	
12:41 TO 12:42	24	
12:43 TO 12:52	25	
12:53 TO 12:55	26	
12:56 TO 12:57	25	
12:58 TO 13:05	24	
13:06 TO 13:08	23	
13:09 TO 13:12	23	
13:13 TO 13:14	24	
13:15 TO 13:18	25	
13:19 TO 13:20	26	
13:21 TO 13:22	27	
13:23 TO 13:27	28	
13:28 TO 13:30	29	
13:31 TO 13:36	31	
13:37 TO 13:39	31	
13:40 TO 13:42	30	

BASE ALTIMETER ADJUSTMENTS		
INPUT DATA		
TIMESPAN	ADJUSTMENT	
13:43	TO 13:49	31
13:50	TO 13:52	30
13:53	TO 13:59	29
14:00	TO 14:00	31
14:01	TO 14:02	35
14:03	TO 14:08	37
14:09	TO 14:12	41
14:13	TO 14:20	43
14:21	TO 14:22	44
14:23	TO 14:27	42
14:28	TO 14:32	40
14:33	TO 14:35	39
14:36	TO 14:40	40

BASE ALTIMETER ADJUSTMENTS		
INPUT DATA		
TIMESPAN	ADJUSTMENT	
14:41	TO 14:45	43
14:46	TO 14:49	47
14:50	TO 14:53	50
14:54	TO 14:59	51
15:00	TO 15:01	49
15:02	TO 15:04	45
15:05	TO 15:13	42
15:14	TO 15:16	40
15:17	TO 15:19	39
15:20	TO 15:22	40
15:23	TO 15:25	40
15:26	TO 15:30	40
15:31	TO 15:38	35

MINE D 9 RIGHT LEAKAGE SURVEY 6-23-98
TEAM A: GANDY, SHUMAKER
Anemometer 42972B

INDEX	TYPE	NODE	BASE ALT. RDG	ALTIMETER READING	ELEVATION	DENSITY RATIO	VELOCITY
1		BASE	1534.0	1534.0	524.0	1.0434	.0
2		BASE	1534.0	1534.0	524.0	1.0434	.0
2		BASE	1540.0	.0	524.0	1.0434	.0
3		3604BLT	1555.0	1655.0	534.0	1.0398	161.6
3		3604BLT	1557.0	1655.0	534.0	1.0398	161.6
3		3604RET	1556.0	1654.0	534.0	1.0355	309.1
3		3604RET	1556.0	1656.0	534.0	1.0355	309.1
3		3604TRK	1557.0	1640.0	534.0	1.0375	446.7
3		3604TRK	1557.0	1641.0	534.0	1.0375	446.7
3		5454BLT	1557.0	1633.0	520.0	1.0397	134.2
3		5454BLT	1557.0	1635.0	520.0	1.0397	134.2
3		5454TRK	1557.0	1627.0	523.0	1.0394	357.7
3		5454TRK	1558.0	1628.0	523.0	1.0394	357.7
3		5454RET	1559.0	1650.0	530.0	1.0375	288.2
3		5454RET	1559.0	1653.0	530.0	1.0375	288.2
3		7313RET	1560.0	1654.0	525.0	1.0420	260.5
3		7313RET	1559.0	1655.0	525.0	1.0420	260.5
3		7313TRK	1558.0	1649.0	524.0	1.0375	355.9
3		7313TRK	1558.0	1648.0	524.0	1.0375	355.9
3		7313BLT	1558.0	1646.0	523.0	1.0417	106.8
3		7313BLT	1558.0	1647.0	523.0	1.0417	106.8
3		1273BLT	1565.0	1658.0	524.0	1.0423	215.9

3	1273BLT	1565.0	1659.0	524.0	1.0423	215.9
3	1273TRK	1564.0	1640.0	526.0	1.0440	488.6
3	1273TRK	1564.0	1640.0	526.0	1.0440	488.6
3	1273RET	1565.0	1672.0	528.0	1.0372	312.7
3	1273RET	1565.0	1671.0	528.0	1.0372	312.7
3	9RREG	1563.0	1676.0	529.0	1.0372	948.8
3	9RREG	1569.0	1677.0	529.0	1.0372	948.8
3	VPIPE	1569.0	1676.0	529.0	1.0372	1570.5
3	VPIPE	1571.0	1677.0	529.0	1.0372	1570.5
3	OTBREG	1571.0	1741.0	529.0	1.0372	.0
3	OTBREG	1575.0	1741.0	529.0	1.0372	.0
3	188RET	1574.0	1684.0	528.0	1.0352	334.5
3	188RET	1574.0	1683.0	528.0	1.0352	334.5
3	188TRK	1574.0	1648.0	525.0	1.0440	566.2
3	188TRK	1573.0	1647.0	525.0	1.0440	566.2
3	188BLT	1573.0	1673.0	524.0	1.0420	220.9
3	188BLT	1574.0	1673.0	524.0	1.0420	220.9
3	BELTREG	1577.0	1672.0	524.0	1.0463	505.7
3	BELTREG	1581.0	1673.0	524.0	1.0463	505.7
3	OTBYRE	1584.0	1747.0	524.0	1.0463	.0
3	OTBYRE	1584.0	1747.0	524.0	1.0463	.0
3	TOC	1569.0	1672.0	773.0	1.0651	.0
3	TOC	1569.0	1672.0	773.0	1.0651	.0
1	BASE	1569.0	1561.0	524.0	1.0505	.0

MINE D 9 RIGHT LEAKAGE SURVEY 6-23-98
TEAM A: GANDY, SHUMAKER
Anemometer 42972B

TYPE	STATION	DIFFERENTIAL	
		PRESSURE UNDERGROUND BASE	PRESSURE SURFACE BASE
2	BASE	0.0	-1.8701340
3	3604BLT	-1.3216000	-3.1917350
3	3604BLT	-1.3801620	-3.2502960
3	3604RET	-1.2874140	-3.1575490
3	3604RET	-1.4045370	-3.2746710
3	3604TRK	-1.0618720	-2.9320070
3	3604TRK	-1.1643810	-3.0345160
3	5454BLT	-1.1683070	-3.0384410
3	5454BLT	-1.2854730	-3.1556080
3	5454TRK	-1.0314430	-2.9015770
3	5454TRK	-1.1193280	-2.9894630
3	5454RET	-1.2425030	-3.1126380
3	5454RET	-1.3742740	-3.2444090
3	7313RET	-1.3579240	-3.2280580
3	7313RET	-1.4750470	-3.3451820
3	7313TRK	-1.3245280	-3.1946630
3	7313TRK	-1.3977380	-3.2678730
3	7313BLT	-1.3018900	-3.1720240
3	7313BLT	-1.4043880	-3.2745220
3	1273BLT	-1.3585580	-3.2286930

3	1273BLT	-1.4610340	-3.3311690
3	1273TRK	-1.0700280	-2.9401630
3	1273TRK	-1.1578940	-3.0280280
3	1273RET	-1.5035100	-3.3736440
3	1273RET	-1.5766900	-3.4468240
3	9RREG	-1.5270450	-3.3971800
3	9RREG	-1.5416800	-3.4118140
3	VPIPE	-1.3415970	-3.2117310
3	VPIPE	-1.4147700	-3.2849040
3	OTBREG	-2.4145480	-4.2846830
3	OTBREG	-2.4437840	-4.3139180
3	188RET	-1.5460950	-3.4162290
3	188RET	-1.6192590	-3.4893940
3	188TRK	-1.0495190	-2.9196530
3	188TRK	-1.1373730	-3.0075070
3	188BLT	-1.4605170	-3.3306510
3	188BLT	-1.5336950	-3.4038290
3	BELTREG	-1.3744490	-3.2445840
3	BELTREG	-1.4183560	-3.2884910
3	OTBYRE	-2.3824340	-4.2525680
3	OTBYRE	-2.4701310	-4.3402650
3	TOC	1.9140420	.0439074
3	TOC	1.8262270	-.0439078
1	BASE	0.0	.1173208
AVERAGE TIME LAG BETWEEN DUPLICATE STATION READINGS IS 2 MINUTES			