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GUIDE TO ENVIRONMENTAL MONITORING PROGRAMS IN MINES

Northwest Territories Justice and Public Services
Mining Inspection Services

PREFACE

This guide is designed to introduce the mines in the Northwest Territories to Environmental Monitoring Programs.

It is hoped that the basic, simple, and step-by-step presentation will be of value to environmental engineers, technicians, nurses stationed at mine sites, management and union health and safety representatives, and the workers themselves.

This guide also serves as a recommended standard for environmental control in mines in the Northwest Territories. Please bear in mind that the N.W.T. Mining Safety Ordinance and Mine Safety Rules always takes precedence.

Because of the variety of monitoring equipment and materials in use for sampling and testing purposes, the writer leaves the choice to the individual mine personnel to select their preferable equipment and supplies. Any equipment with Bureau of Mines, NOISH, and governmental approval is acceptable to Mining Inspection Services of the N.W.T. It is also our policy to adopt the T.L.V's recognized by the A.C.G.I.H. (American Conference of Governmental Industrial Hygienists).

I sincerely hope that these guidelines will generate more concern and action in fighting against health hazards in the mines in the Northwest Territories.

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Mining Inspector

Dec. 1982

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1. VENTILATION

1.1 Definition

Ventilation is the coursing of air through working areas in such a way as to provide fresh air and to remove or dilute contaminated air.

1.2 Functions

1) To provide fresh air (recommend no less than 18% oxygen).
2) To remove gases
3) To remove dust
4) To regulate temperature
5) To control fire
6) To reduce radiation effects
7) To slow' down decay of material, e.g. timber

1.3 Volume of Air Required for U/G Operations

When estimating the volume of air required to properly ventilate a mine, one should note that:

1. There are no hard and fast rules to do the job.
2. There are several approaches; a mine should select the most appropriate one instead of the most economical one.
3. When planning a ventilation system, allow room for expansion. (It is more expensive to replace or add units later on)
4. A sure way to find out whether the volume of air is adequate is to make air quality tests.

1.4 Estimating Volume Requirement

conversion : 1 m^3/s = 2,119 c.f.m.
1 m3/h = 0.589 c.f.m.
1000 m/h = 54.7 ft/min.

1) (Volume per ton) x t.pd. + Volume for U/G Equipment.

TABLE 1

Mining Method	Volume per ton m3/h
Square set, cut & fill	85
Shrinkage	50
Block caving	70
Cut & fill, High temperature	100
Room & pillar uranium	170-340

2) (Volume per man) x men per shift + volume for U/G Equipment

TABLE 2

Mining Method	Volume per man m3/h
Square set	85
Cut & fill	680
Cut & fill, High temperature	850
Shrinkage, Block caving	1700
Radioactive Mines	2500

*Uranium Mines in Ontario use about 2500 m^3/h per man.

3) Velocity Approach

Types of headings	Recommended Velocity, m/h
Drifts, raises, shafts	750-900
Haulageways, chutes	550-900
Stopes	550-900
Scrams	900-3200
Crushers, u/g enclosures	2700-3600
Loading pockets	900-3600

*One should apply either method (1) or (2) for estimating requirement for the whole mine, and method (3) for 'local ventilation requirement. NOTE: The requirement for diesel engines underground is 130 m^3/h per horsepower in the N.W.T. but for specific units tested by U.S.B.M. the rates established by U.S.B.M. are accepted.

1.5 Air Measurements

1. Low velocity measurements less than 35m per. min Smoke tubes with aspirator, is commonly used unless special low-speed anemometers are available.

Procedures

i) Break both ends of a smoke tube and nsert it in aspirator.

ii) Mark two vertical lines on wall at d stance of 3m. or 6m. apart depends on air velocity.

iii) Stand close to the wall at the upstream point, squeeze the aspirator to generate a smoke cloud and start the stopwatch simultaneously.

iv) stop the stopwatch when the first bit of cloud reaches the downstream line. (If the test is not done by two men, one has to follow the smoke cloud along its course).

v) Record Data; Date
Location
Distance = l m.
Time = t sec.
Area = Asq. m. (average of 3 areas)

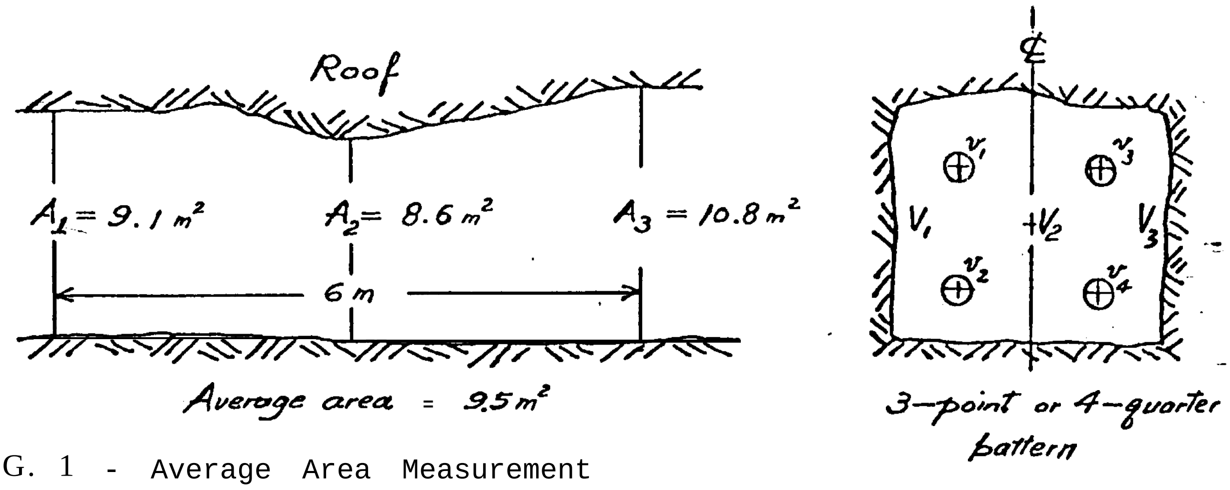

FIG. 1 - Average Area Measurement

vi) Three readings (one near each wall and one in centre) are sufficient.

Calculation:

Airflow $(m^3/h) = A \times \frac{l}{t} \times 3600\ s/h \times 0.90$

l = meters travelled

t = seconds

(90% is correction factor)

2. Moderate-Velocity Measurements - from 35m to 600m per. min.

A) The common instrument used to determine air velocity for this range is the vane type anemometer. Anemometer is a small fan type device geared to a mechanical counter which counts either in feet or meters during any desired time span.

Procedures:

i) Divide the airway into two halves and measure each area separately.

ii) Use extension arm so the body is kept out of airstream being measured.

iii) Set counter to zero.

iv) Take a traverse by moving the anemometer slowly along a plane perpendicular to the airstream. Stop the counter at the end of one minute.

v) Record Date; Date
Location
Anemometer reading, m/min.
Area, A

Calculation

i) Every Anemometer has manufacturers' correction factors for various velocities based on a formula.

$V_T = A + B.V_R$ Where VT = true velocity

A & B are constants

V_R = registered velocity

ii) Usually these corrections are provided in a table form by the manufacturers which is simplified to

$V_T \cdot V_R$ + correction

iii) Airflow (m^3/min) = VT x A

B) Other instruments for moderate-velocity measurements.

a) Velometer with openings to detect air velocity.
b) Velometer with sensor to detect air velocity.

3. High Velocity Measurements - over 600m per min.

a) High Speed Anemometer

b) Pitot Tube and Manometer - With diameter less than 12 mm. the pitot tube (fig. 2) can be inserted through a hole in the ducting or tubing. It is a very useful tool to determine air velocity inside a tubing or ducting close to an intake or exhaust fan.

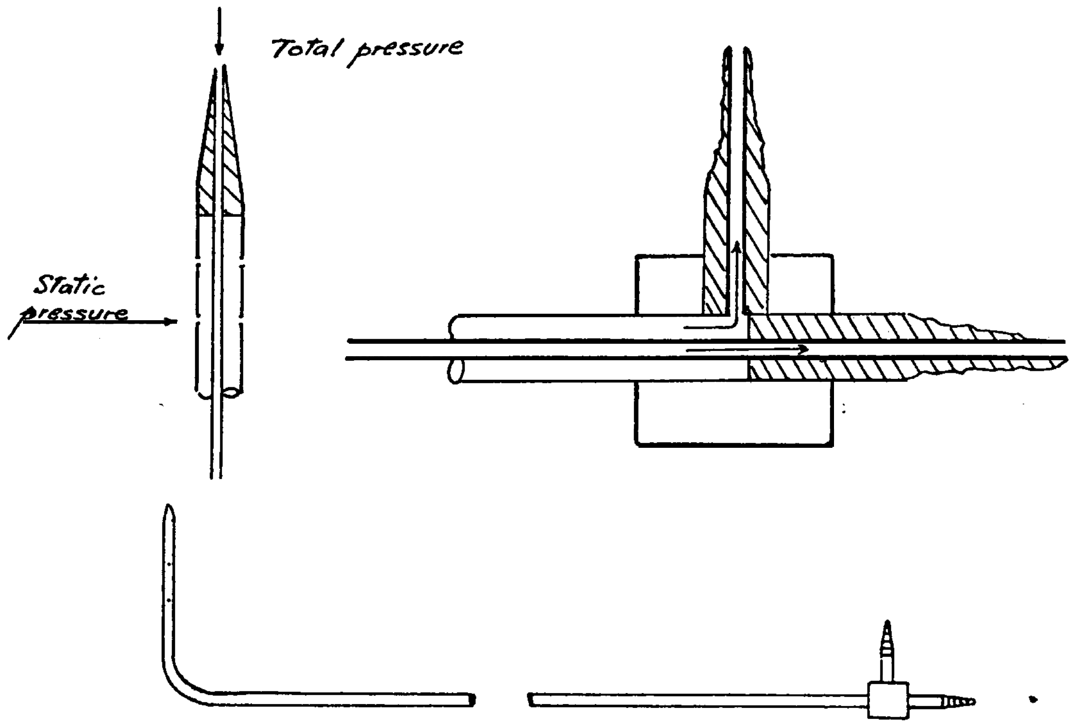

FIG. 2 PITOT TUBE

Procedures

i) Ideally a 5-area, 20-point traverse should be taken to determine the average velocity. This traverse is shown in figure 3(1).

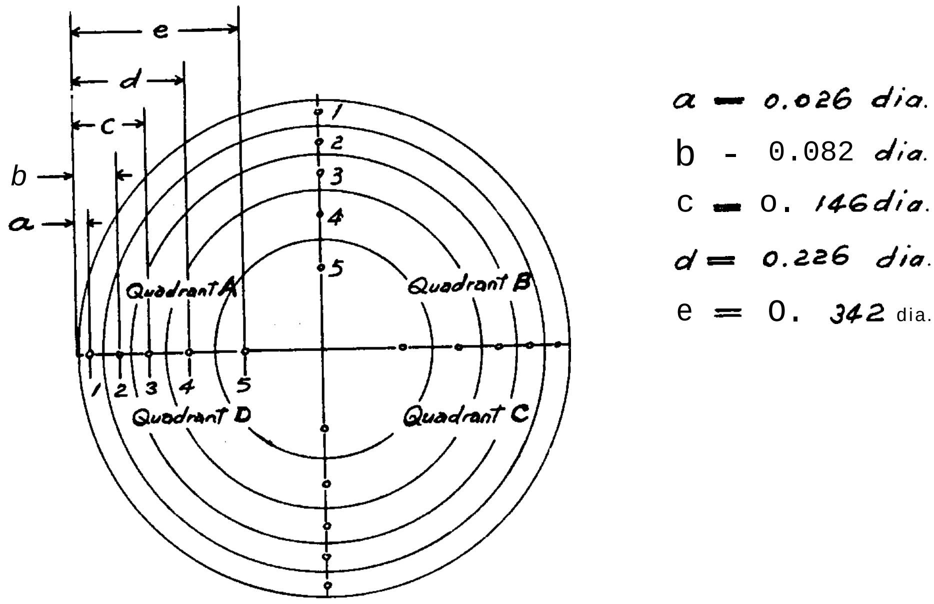

Figure 3. Diagram showing 20-point traverse.

ii) For most ventilation tests, centerline measurements times 0.90 is accurate enough.

iii) Pitot tube and Manometer connections to measure different pressures in an airway is illustrated in the following figure.

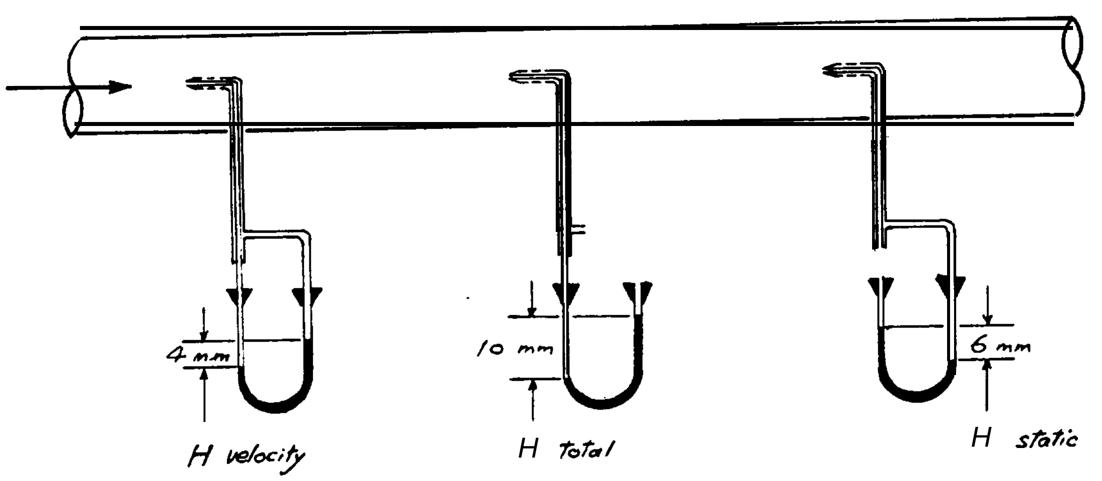

Figure 4. Pitot tube and Manometer connections.

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1. G.E. McElroy - Engineering Factors in the Ventilation of Metal Mines: U.S. Bureau of Mines Bulletin.

Calculation:

A) <u>For Standard Air Density of 1.20 kg/m^3.</u>

i) Velocity (m/min) = 242 $\sqrt{VP}$

Where VP is velocity pressure in mm water.

ii) Corrected velocity = velocity x 0.90

B) <u>For Non-standard Air Density = d_2</u>

i) $v = 242\sqrt{VP} \times \sqrt{\frac{1.20}{d_2}}$ Corrected velocity = velocity x 0.90

ii) Example in Fig. 4 - Vel = 242 $\sqrt{4}$ = 484 m/min.

1.6 Underground Ventilation Survey

1) Daily-routine check by a shift boss or underground supervisor when he visits his men and workings.

a) Check for abnormalities in ventilation, e.g. change of volume or direction of airflow, too dusty or presence of odour.

b) Fans, ductings,

c) Gases, e.g. CO, NO/NO2, CH4, especially in diesel operating areas or area where blasting had taken place earlier.

d) Make correction and/or report to ventilation engineer.

2) **Weekly** - A minimum of one visit to each working area by the ventilation engineer or technician.

a) Check airflow, fans, ductings.

b) Check for gases.,

c) Check for dust condition.

d) Report conditions to U/G supervisors and make recommendation if necessary.

3) Monthly - The ventilation engineer should carry out a survey on total intakes and exhausts, some major airways, main fans, heating systems, fire doors, and other major items concerning ventilation.

4) Semi-annually - A complete ventilation survey should be carried out twice a year, preferably one in summer, one in winter. A copy of full report with a set of level plans and one longitudinal section should be submitted to the Mining Inspection Services.

The Semi-annual Ventilation Survey should include:

a) A brief description of the ventilation and heating/cooling system.

b) A brief description of air distribution.

c) A set of level plans (between 1=1000 and 1=2000 scale depends on the size of the mine) and a longitudinal section.

d) Plottings of all drifts, stopes, raises and manway openings, s-hops, lunchrooms and refuge stations.

e) Amount of airflow and direction in the whole mine.

f) Main fans - make, size, capacity, horsepower, pressure, reversibility.

g) Auxiliary fans - make, type (air driven or electric) pressure, m^3/h delivered.

h) Ductings - material used, size.

i) Ventilation doors, regulators, fire doors, bulkheads, stoppings.

J) Refuge stations and lunchrooms - facilities e.g. air pipe, water pipe, lights, heaters, phones, first aid equipment, fire fighting equipment.

k) Temperature readings and other readings, e.g. pressure and relative humidity (these are optional, mark them on if one finds them useful).

<u>1.7 Ventilation on Surface Plants</u>

1) Crusher house and conveyor - Dilution of dust by ventilation pressurized booth with positive ventilation for operators and pick-up hoods to extract dust are a few of the applications to upgrade air quality.

2) Mill - Special attention should be paid to areas where toxic chemicals are stored, transported, or used, where toxic gases are being generated and also closed-in areas where very little air circulation takes place.

3) Mechanical Shops - Ventilation is mainly used for temperature control. The only area of concern is the welding section where welding fumes have the likelihood to accumulate. Portable ventilators with pick-up hoods are in common use to exhaust fumes, gases and dust particles.

4) Assay Office - Supply of fresh air and removal of dust and toxic gases both in sample preparation area and the laboratory must be maintained properly.

1.8 -References

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4. "Industrial Ventilation, A Manual of Recommended Practice" 16th. Edition, 1980. American Conference of Governmental Industrial Hygienists, P.O. Box 16153 , Lansing, Michigan.

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2. DUST

2. DUST

2.1 Definition

Dust is a particulate contaminant suspended in air.

2.2 Natural Sources

1. Wind and water erosion.
2. Volcanic action.

Clean country air in cold weather contains up to $0.2 mg/m^3$ of dust.

2.3 Source in Mining Industry

1. Blasting
2. Drilling
3. Loading and Unloading
4. Crushing, screening
5. Transportation of rock
6. Transportation of chemicals or other products in powdery forms .
7. Wood dust in dry atmosphere

2.4 Classification of Dusts

1. Nuisance dusts = Any particulate matter when in high enough concentration in the air would irritate skin, eyes and the respiratory system. Examples are calcium, silicate, cellulose portland cement, gypsum, limestone, silicon, starch, zinc oxide dust.

2. Toxic dusts = Dusts which are poisonous to body organs, tissue, etc. Examples are metallic compounds of lead, cadmium, arsenic, mercury, tungsten, etc.

3. Allergenic dusts = These dusts can sensitize exposed individuals and cause asthma or eczema.

4. Fibrogenic dusts = Harmful to lungs, e.g. asbestos fibers.

5. Infectious dusts = Dusts containing bacteria. Infectious dust per se is seldom found in mines.

6. Radioactive dusts = Dusts which are injurious because of radiation. Examples are uranium and thorium ores.

7. Explosive dusts = Dusts are combustible when air-borne. Examples are coal dust and sulfide ores.

2.5 Factors Determining Dust Hazard

1. Chemical and mineralogical composition.
2. Particle size (most harmful range is 10 to 0.5 μm).
3. Concentration of dust
4. Exposure time
5. Individual susceptibility

2.6 Quantitative Determination of Dust

The most common dust sampling instruments are the Konimeters and the Gravimetric Samplers. The following table shows the comparison of these two sampling methods.

	M	M
Advantages	1. "Fast" results	1. Representing a whole Shift's Exposure.
	2. Numerous results	2. Respirable size can be obtained by using cyclone.
	3. Ability to measure peak concentration.	3. Compositional analysis possible.
	4. Good for locating source of dust.	4. Gives average concentration.
	5. Individual particle information obtainable.	5. Gives information of personal dust exposure.
		6. Easy to obtain results by weighing.
Dis-advantages	1. Too short sampling periods.	1. Cumbersome
	2. Long process in treating slides & counting dust.	2. Time consuming in sampling.
	3. Easily contaminated (especially when slides have to be shipped out for dust counting.	3. Electrostatic charge when using nylon cyclone.
	4. Limited analysis, No compositional information	4. Error may occur when weighing small mass of dust.
		5. Critical in selecting suitable filter and flow rate.

2 .6.1 Konimeter Dust Sampling

Equipment;

Konimeter with ring
100 glass slides
Microscope (magnification 150 times) with sub-stage lamp.
Crucible Electric Furnace
Electric Hot Plate
Pyrex dropping bottle-pipette and rubber bulbs.
Pyrex 20 cm. diam. pie plate
3 - 60 cc beakers
4 - 125 cc dropping bottles
1 - 250 cc reagent bottle
Rubber tubing, glass tubing, rubber stoppers
Cheese cloth, adhesives
Cone. Hydro-chloric acid
Pure Ethyl Alcohol

Procedures

A. Preparation. of Slide

1) Clean slide with cheese cloth, place a few drops of alcohol to rub the surface.

2) Apply ½ cc of adhesive solution made of vaseline in Xylol on the glass surface.

3) Mark untreated side with a bortz pencil opposite to the number 1 on the ring.

4) Apply a very thin film of glycerine and water (1:1) to the gasket of Konimeter and clean the gasket at the end of the day.

6) Place ring on Konimeter and fasten the cover. Set the ring position in number 1.

7) Prepared slides should be used within a day or two.

B. Taking Samples

1) Samples should be taken close to persons on the lee side, also at entry and exit of workings.

2) Take three readings and obtain the average for each sampling spot.
The ring is numbered from 1 to 29. To obtain three readings for the first sample: use number 1, line between #1 and #2 and number 2, then leave line between #2 and #3 blank. This way, three readings and one space are obtained.

3) Start second sample on number 3 . ..third sample on number 5, etc. The whole ring will give you 14 samples and a total of 42 readings.

4) To take a reading:

a) remove cap from the jet,
b) push the plunger to its locking position,
c) hold the Konimeter at arm's length, head height and the jet at right angle to air current,
d) Push the trigger,
e) turn the gear to advance the slide to next position,
f) replace the cap.

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2. Source of material - "Semi-annual Dust Survey Procedure" 1974 M.A.P.A.O.

C. Treatment of Slide

1) Clean the side of the slide which does not contain the sample with cheesecloth.

2) Place the slide in monel metal slide holder and heat to 620° C in an electric furnace.

3) Remove slide from furnace to cool, then place it horizontally on a glass holder in a pyrex plate. Drop hot H Cl. carefully from a pipette onto the center until the slide is completely covered. (Hot H Cl. solution = 50% vol. pure H Cl. + 50% vol. distilled water).

4) Drain off the acid after 2 minutes. Drop hot double distilled water carefully on the center of slide. Repeat this until 30 c.c. of water has been used.

5) Run pure alcohol from dropping bottle in continous stream over both sides of the slide.

6) Reheat the slide to 565° C. Remove and cool.

7) Put the slide back to its original position in the ring for counting.

D. <u>Counting Dust Particles</u>

1) Use magnification of 150 X. Counting should be done within a day.

2) Insert ring in the ring holder on the stage, the numbers being on top.

3) Locate the circle of dust spots approximately directly below the objective lens.

4) Rack up the condenser to its stop.

5) Rack down the objective to a position just above the slide.

6) The objective is slowly racked up to focus.

7) Rotate the ring to bring number 1 dust spot in view.

8) Adjust illumination and final focus.

9) Rotate the eyepiece so that the centerlines of the grid marked on the eyepiece are horizontal and vertical.

10) Count all particles 5 microns or less in diameter in the two 9 degree sectors. The two parallel lines are 5 microns apart.

11) Rotate the eyepiece 90 degrees and do similar counting.

12) p.p.c.c. = 2x (sum of the counts in all 4 sectors).

13) Concentration equals to average of 3 readings.

2.7 Sampling Recommendations

Substance	T.L.V.	Filter Media	Flow Rate	Analytical Method
Arsenic	(0.05 mg/m^3)	0.8 micron	1.7 l.p.m.	Atomic Absorption
Asbestos	*see notes	0.8 micron	2.0 l.p.m.	Microscopic Count
Cadmium	0.05 mg/m^3	0.8 micron	1.5 l.p.m.	A.A.
Coal	2 mg/m^3	5 micron	1.7 l.p.m.	Gravimetric
Lead	0.15 mg/m^3	0.8 micron	1.5 l.p.m.	A.A.
Nuisance Dust	Total 10 mg/m^3 Respirable 5 mg/m^3	5 micron	1.7 l.p.m.	Gravimetric
Silica	**See Formula	5 micron	1.7 l.p.m.	x-ray Diffraction
Wood Dust	Hard 1 mg/m^3 soft 5 mg/m^3	5 micron	1.7 l.p.m.	Gravimetric
Zinc Oxide Fume	5 mg/m^3	0.8 micron	1.5 l.p.m.	x-ray Diffraction

**T.L.V for Silca = $\frac{10 \text{ mg/m}}{\text{\% respirable quartz} + 2}$ for respirable dust.

$\frac{30 \text{ mg/m}}{\text{\% quartz} + 3}$ for total dust.

*Amosite	0.5 fiber	5μm/cc	
Chrysotile	2 "	"	
Crocidolite	0.2 "	"	
Other Forms	2 "	"	

2.8 Dust Monitoring Program

1. Designate Survey Stations:
   U/G - All working areas including stopes, drifts, raises, u/g crusher, etc.

   Pit - Drill Cabinets, operator booths, etc.

   Mill - Crusher areas, conveyors, transferring points and areas where dust may be generated.

   Shops - Welding area, carpenter shops, sample preparation room, assay office, ore loading area, etc.

2. If doing personal dust sampling, designate people according to his occupation, i.e. stoPe driller, trammer, mucking machine operator, etc.

3. A complete dust survey should be done at least semi-annually. Detailed reports should be submitted to Mining Inspection Services.

4. Stations or occupations showing high dust levels should be sampled more frequently. It is recommended that some stations should be designated to be sampled monthly for this purpose. Quarterly reports summing up the test results for the previous three months should be submitted to Mining Inspection Services.

2.9 References

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3. GASES

3.1 INHALATION-EXHALATION

3.2 LIST OF CERTAIN GASES ENCOUNTERED IN MINING INDUSTRY

3.3 DIESEL EMISSIONS

3.4 ENVIRONMENTAL REGULATIONS FOR USE OF DIESELS UNDERGROUND

3. GASES

3.1 Inhalation-Exhalation in Human Breathing

Activity	Resp. Rate/ Min.	(litre) Air inhaled per resp.	(m^3/h) Volume Inhaled	(m^3/h)* Oxygen Consumed	$\frac{CO_2 \text{ Liberate}}{O_2 \text{ Consumed}}$
At rest	12-18	0.4-0.7	0.3-0.9	0.02	75%
Moderate	30	1.5-2.0	2.7-3.6	0.12	90%
Very Vigorous	40	2.5	6.0	0.17	100%

*Actual volume of oxygen consumed per inhalation is approximately 4% of the total. Exhaled air contains approximately 16% O_2, 79% N_2, and 5% CO_2.

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1. Sources - J.J. Forbes and G.W. Grove, "Mine Gases and Methods for Detecting Them", U.S. Bureau of Mines, Circ. 33 (1954)

3.2 List of Certain Gases Encountered in Mining Industry.

NAME	S.G. AIR=1	PHYSICAL PROPERTIES	HARMFUL EFFECT	SOURCE	DETECTION	ALLOW CONC.	FATAL CONC.
Oxygen, O	1.11	Odorless Colorless Tasteless	Non-toxic	Normal air	Open flame detector	19% min.	< 6%
Nitrogen, N	0.97	Odorless Colorless Tasteless Suffocating	Asphyxiating	Normal air strata	Extinguishes flame	80%	
Carbon Dioxide, CO_2	1.53	Odorless Colorless Slight acid taste, Suffocating	Asphyxiating	Breathing Strata Fire Blasting Any Combustion	Extinguishes flame, Drager tub	0.5%	18%
Carbon Monoxide, CO	0.97	Odorless Colourless Tasteless	Toxic Explosive	Blasting I-C Engine Incomplete Combustion	Detector Drager tube	50 p.p.m	300 p.p.m Explosive range 12-74%
Methane, CH_4	0.55	Odorless Colourless Tasteless	Explosive, Asphyxiating	Strata Blasting I-C Engine Organic decay	Safety lamp, Detector, Explosive Gas Meter	1% recommended	Explosive range 5-15%

3.2 List of Certain Gases Encountered in Mining Industry.

NAME	S.G. AIR=1	PHYSICAL PROPERTIES	HARMFUL EFFECT	SOURCE	DETECTION	ALLOW. CONC.	FATAL CONC.
Nitrogen Oxides, N02	1.59	Irritating odor, Red Brown	Toxic	Blasting, I-C Engine	Odor, Colour	3 p.p.m.	50 p.p.m.
NO	1.04	Bitter Taste		Incomplete Combustion	Detector, Drager tub	25 p.p.m.	
Hydrogen Sulphide, H_2S	1.19	Rotten egg odor, Colorless Acid taste	Toxic Explosive	Strata Water, Strata gas Blasting	Odor, Detector, Drager tub	10 p.p.m.	0.1% Explosive Range 4-46%
Sulphur Dioxide, SO_2	2.26	Irritating odor Colorless Acid taste	Toxic"	Combustion of Sulphide ore, I-C Engine Fire Blasting	Sulphur Odor, Detector, Drager tub	2 p.p.m.	0.1%
Hydrogen, H	0.07	Odorless Colorless Tasteless	Explosive Toxic	Acid water Blasting Batteries	Explosive Gas Meter		Explosive Range 4-74%

3.2 List of Certain Gases Encountered in Mining Industry

NAME	S.G. AIR=1	PHYSICAL PROPERTIES	HARMFUL EFFECT	SOURCE	DETECTION	ALLOW CONC.	FATAL CONC.
Aldehyde, $H_xC_yO_z$	1.17	Irritating odor, Colorless Acid taste	Toxic	I-C Engine	Odor, Drager tube	5 p.p.m.	-
Radon, Rn	7.67	Odorless Colorless Tasteless	Radioactive	Strata	Radiation detector counter	*See chapter on Radiation	-

SOURCES: J.J. Forbes and G.W. Grove, "Mine Gases and Methods of Detecting them".

U.S.B.M. Circ. 33., Hartman H.L., "Mine Ventilation and Air Conditioning"

Ronald Press., TLV's for Chem. Sub. and Phy. Agents in the Work Environment with Intended Changes for 1982, ACGIH

3.3 Diesel Emissions

DIESEL FUEL —— *Combustion* ——→ POLLUTANTS

By weight	
C ≃	85%
H2 ≃	14%
S ≃	0.05-0.7%

Complete Combustion	= CO_2, H_2O, SO_2
Incomplete Combustion	= CO. Aldehydes smoke particulate.
Oxides of Nitrogen	= NO, N07

3.4 Environmental Regulations for Use of Diesels Underground.

1. Approval of equipment.
2. Permit to operate equipment in U/G.
3. Properly constructed refueling station.
4. Adequate ventilation - No less than 130 m3/h per brake horse-power, but for specific units tested and approved by U.S.B.M. the ventilation requirements established by U.S.B.M. are adopted.
5. Ventilation to be checked weekly.
6. Gases Tests to be done daily,

	CO	CO_2	NO	NO_2	CH_4
Undiluted Exhaust	2500 ppm	-	(600 ppm)	600 ppm	-
Adjacent to Exhaust	100 ppm	-	100 ppm	25 ppm	-
Atmosphere	50 ppm	0.75%	25 ppm	3 ppm	1.25%

4. RADIATION

4. RADIATION

4.1 Glossary

Alpha Particle = Positively charged particle (two neutrons + Two protons) identical to the nucleus of a helium atom (He++) It has very low penetrating power but produces intense ionization along its path. Radon, Thoron and some of their daughters emit Alpha Particles.

Beta Particle = Positively charged (positron) or negatively charged particle (electron), released during the decay of some radioactive substances. Its mass is 1/7360 times the mass of an Alpha particle. Beta radiation is more penetrating than Alpha radiation, but produces less-dense 'ionization. Beta particles are emitted by various nuclides in the uranium decay series.

Curie = An old unit of radioactivity. New unit is Bacquerel.

1 Curie = 3.7×10^{10} disintegrations per second.

1 Bq = 1 d.p.s.

Dose Equivalent = Product of energy absorbed in the body, organ or tissue due to exposure to radiation and the quality" factor of a given type of radiation.

Dose Equivalent Units

New		Old
1 Sievert (Sv)	=	100 rem
= 1 gray of Gamma	=	100 rad of Gamma
= 0.05 gray of Alpha	=	5 rad of Alpha

Dose Limit

Atomic Radiation Worker = 50 mSv (5 rem) per year.

Member of the Public = 5 mSv (0.5 rem) per year.

<u>Gamma Particle</u> = Highly penetrating ionization radiation. Gamma rays can penetrate right through the body. X-rays are very similar to Gamma rays.

<u>Ionizing Radiation</u> = Radiation such as alpha, beta and Gamma which possess sufficient energy to ionize the atom or molecules of substances through which they pass. Other examples = cosmic rays, x-rays.
Examples of non-ionizing radiation: Ultra Violet light, visible light, e.g. lasers, infra red, microwaves, UHF and VHF.

<u>Isotopes</u> = Nuclides of an element having the same' number of protons (atomic number) but different numbers of neutrons (mass number).

<u>Radioactivity</u> = The phenomenon of the spontaneous transformation of a radionuclide into a different nuclide, causing the emission of radiation.'

<u>Radon</u> = It is a chemically inert gas found by the decay of radium-226. It is exceptionally soluble in water and is often present in very high concentrations in ground water. This can lead to radon release at considerable distances from the parent radioactive ores and may result in high radon concentrations in the atmosphere of some non-uranium mines.

<u>Radon daughter</u> = Radon (Rn-222) decays to ^{218}Po (RaA) with a half life of 3.8 days, emitting an alpha particle. This decay product is called the radon daughter. Collectively RaA, RaB, RaC and RaC', are called short-lived daughters of radon.

<u>Work Level</u> = Any combination of short-lived radon or thoron daughters per litre of air that will result in the ultimate emission of 1,3 x 10^5 million electron-volts of alpha energy.
1 WL = 2.08 x 10-5 joules per cubic meter.

Work level hour = A unit of exposure which is equal to the product of the concentration in working levels and the duration of exposure in hours.

Work level month = A unit of exposure to radon and thoron daughters. 1 WLM= 170 WLH = 4.2 x 10-3 J

4.2 Harmful Effects of Ionizing Radiation

A. Somatic Effects

1) Chronic Exposure = Excessive exposure over a long period of time may cause cancer, although there are uncertainties about dose-response relationships.

2) Acute Exposure = High dosage over 50 Roentgen may cause injury to human tissue, over 200 Rmay cause severe illness due to loss of white blood cells and infection or even death.

B. Genetic Effects

The most notable effects are the production of mutant genes and aberrations in chromosomes. (Chromosomes are the microscopic rod-shaped bodies bearing genes' .

4.3 Radiation Measurement

4.3.1 Instruments

Scintillation counters and Geiger detectors are commonly used in mining industry.

4.3.2 **De-termination** of WL

A. Instrumatation

-Sampling pump, up to 12 L/rein.
-Filter holder
-25 mm millipore AA filter
-Scintillator/scaler for counting

B. Experimental Procedure

1. Load one 25 mm Millipore AA filter into the open-face filter holder.

2. Note time to start. Sample for 5 minutes.

3. Record fiowrate, average L/rein.

4. Remove filter with a pair of tweezers and place it in the counting tray of a scintillator. (Make sure that the side of the filter that was facing the inlet side now faces the scintillator side) .

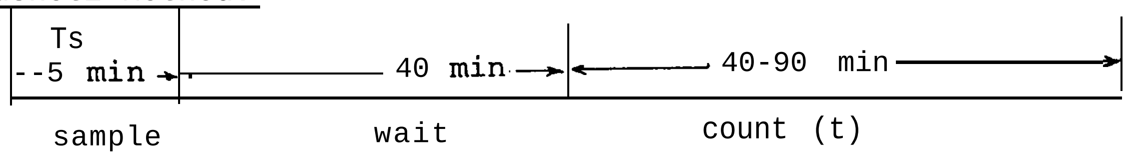
5. Make the countings and calculations according to any of the following three methods:
   a) Kusnetz Method
   b) Modified Tsivoglou Method
   c) Markov Method

6. Background counts can be obtained by counting a blank filter in a scintillator counter..

7. Counter efficiency can be obtained by counting a standard alpha emitter, e.g. Am^{241} or Th^{230} with known disintegration rate.

WL Determination Methods

Kusnetz Method:



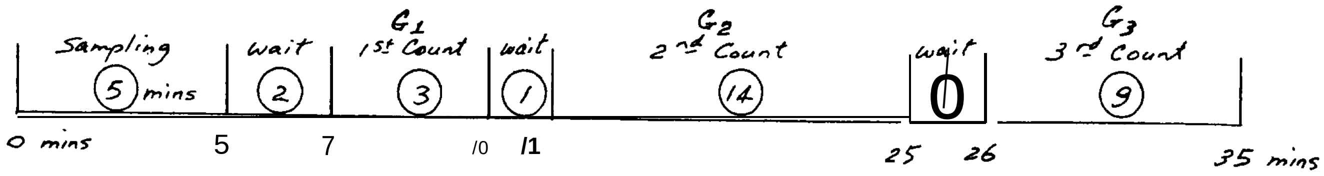
$$WL = \frac{Cr(t) - Cr(B)}{Q \cdot T_s \cdot K \cdot \epsilon} (1 + S_A)$$

C_r (t)	d-count in c.p.m.
C_r (B)	background count c.p.m.
Q	flowrate L/rein
Ts	Sampling time (3-5 rein)
ϵ	α-counter efficiency
K	230 - 2t for $40 \leq t \leq 70$
	195 - 1.5t for $70 \leq t \leq 90$

$$S_A = \frac{C_2 - C_3}{2C_1 + C_2 - C_3}$$ Self-absorbent — usually $\simeq$ zero.

C_1 - front, C_2 - back, C_3 - front covered by new filter.

Modified Tsivogluo Method:



Calculation =

$$C_2 = \frac{1}{\bar{Q} \epsilon} \left[.16894\ G_1 - .082\ G_2 + .07753\ G_3 - .0566\ B \right]$$

$$C_3 = \frac{1}{Q \epsilon} \left[.00122\ G_1 - .02057\ G_2 + .04909\ G_3 - .015749\ B \right]$$

$$C_4 = \frac{1}{Q \epsilon} \left[.02252\ G_1 - .03318\ G_2 - .03771\ G_3 - .0576\ B \right]$$

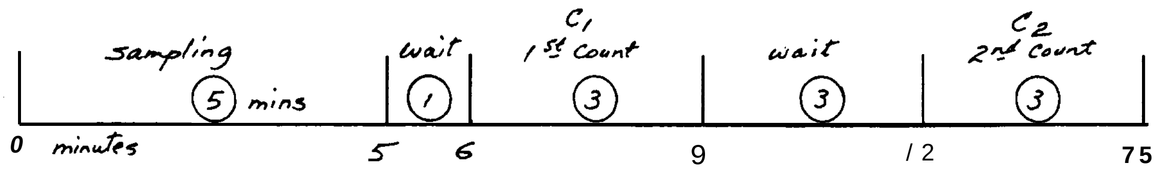
$$WL = .001029\ C_2 + .005077\ C_3 + .003732\ C_4$$

or

$$WL = \frac{1}{1000\ Q \epsilon} \left(.0961\ G_1 - .0650\ G_2 + .1881\ G_3 - 1.071\ B \right)$$

C_2, C_3, C_4 — cone. (pCi/L) of RaA, RaB, RaC

Markov Method:



$$RaA = \frac{.118\ (C_1 - C_2)}{\epsilon \cdot Q}$$

$$WL = \frac{3.1 \times 10^{-4}\ C_2}{\epsilon \cdot Q}$$

4.3.3 Personal Exposure Records

A. The Mine Manager shall keep or cause to be kept a record of concentration of airborne radon daughters in various areas of the mining operation and the time spent by each person in each such area shall be recorded in sufficient detail.

B. The record should include;

- -name of employee
- -date
- -working place and corresponding radon concentration
- -duration in hours

C. Calculation of monthly exposure;

e.g. Mr. A. (Miner)

Date	Workplace	W L	Hours	WLH
1	Stope #1	0.2	7	1.4
2	" "	0.2	8	1.6
3	" "	0.25	4	1.0
3	Station	0.02	3	0.06
4	Stope #2	0.25	8	2.0
5	" "	0.20	7	1.4
6-30	Vacation			

Monthly Total 7.46

"Working Level Months" = $\frac{7.46}{170} = 0.044$

D. Exposure Limit for Radon Exposure

No person is exposed to more than 2.0 "Working Level Months" in any period of 3 consecutive months or to more than 4.0 "Working Level Months" in any period of 12 consecutive months.'

(Schedule C of NWT Mine Saftey Rules)

For Gamma Dose Rate - It is recommended that 750 mR (7.5 mSv) be the allowable concentration of exposure in any period of 3 consecutive months.

(Atomic Energy Control Board)

4.4 References

1. Bigu, J. "Radiation Experiments for Uranium Mine Inspectors - Training Course" Elliot Lake, Ont.

2. Clayton. "Pattys' Industrial Hygiene and Toxicology" 3rd. Edit. 1978, Wiley Interscience Publication.

3. Kirk, B.W. "Introduction to Air Sampling Instrumentation" 2nd. Edit. 1982, Sault College, Ont.

4. Lecture notes from "Uranium Mine Radiation Safety Course" Canadian Institute for Radiation Safety, Elliot Lake, Ont.

5. Thompkins, R.W. "Radiation in Mines" Queens University, Ont.

5. NOISE

5. NOISE

5.1 The Harmful Effect of Noise

1. May cause temporary and permanent damage to hearing when exposed to high level noise over an extended period of time.

2. Interference to speech communication and sound warning signals.

3. Interferes with work performance.

4. Disturbs relaxation and rest.

5. Stress-causing noise may cause heart disease, ulcers and other nerve related problems.

N.B.

1. The normal human ear has a range of hearing that covers 20 to 20,000 Hz at common loudness levels.

2. A person may have experienced no pain before realizing that serious hearing damage has taken place.

5.2 Units for Noise Measurement

The decibel (dB) is a convenient means for describing the level of intensity, power, or pressure of sound above arbitrarily chosen reference values.
The arbitrarily chosen reference power commonly used is 10^{-12}W, and reference pressure is 2×10^{-5} N/m^2.

Some Common Examples:

Source	dB
Rocket	195
Turbo jet engine	160
4 propeller aeroplane	140-150
Large chipping hammer	120
centrifugal fan	100-110
Shouting voice	80-90
Conversational voice	60-70
very soft whisper	30
background in TV & recording studio	20

5.3 The Sound Level Meter

A basic sound level meter weights less than 1 kilogram & consists 'of a microphone, an amphifier, and an indicating meter. Direct dB readings can be obtained a few seconds after the meter is switched on.

There are three frequency-weighting networks (A, B, and C) being used internationally. Each weighting approximates the response characteristics of the human ear for certain sound levels:

dB A - below 55 dB
d B B - 55-85 dB
dB C - above 85 dB

Although sound level meters equipped to measure only dBA is acceptable, when excessive noise is found, more information on other weighting networks and frequency analysis can be helpful to pinpoint the trouble.

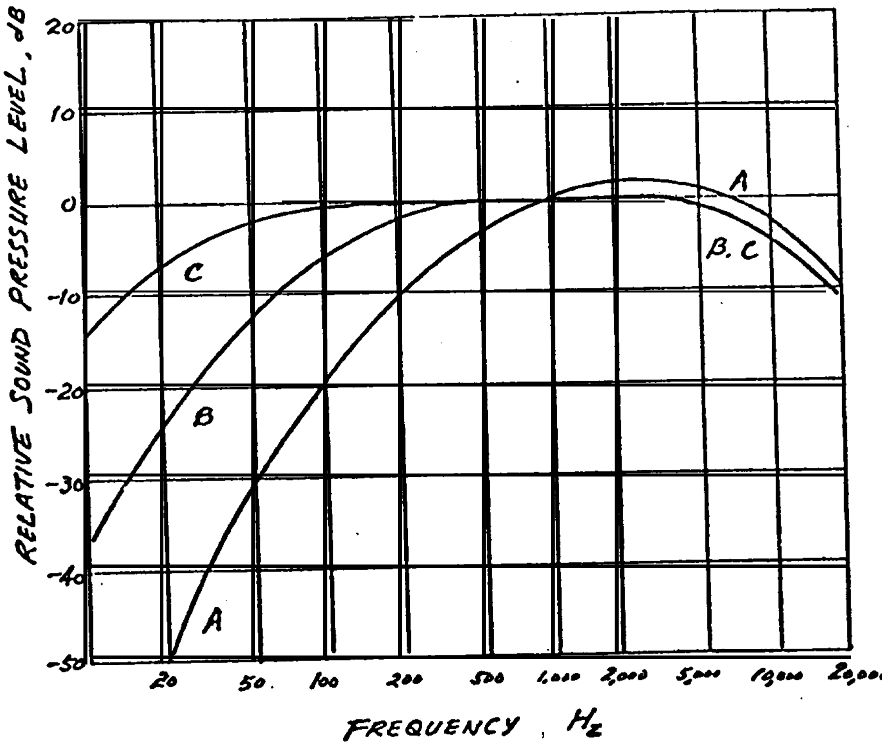


Fig. 9 International Standard A, B, and C weighting curves for sound level meters.

5.4 Permissible Noise Exposure

Time (hours per day)	Sound Level dBA (regardless of frequency)
16	80
8	85
4	90
2	95
1	100
1/2	105
1/4	110
1/8	115

Documentation of the T.L.V. 1982 A.C.G.I.H.

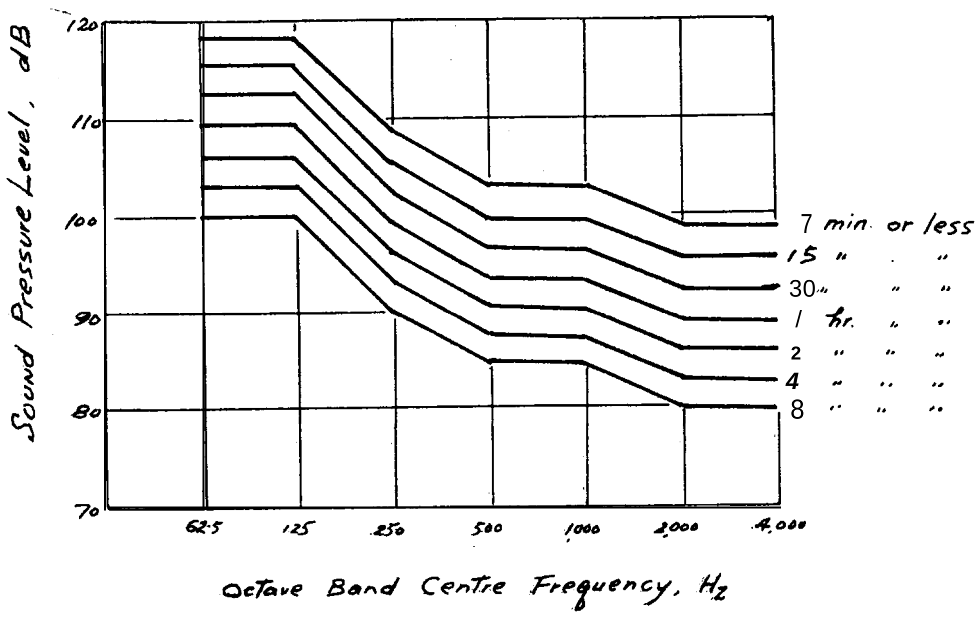


Fig. 10 Sound pressure levels at which hearing conservation should be introduced.

5.5 Hearing Conservation Programs

5.5.1 Noise Level Survey

1. Set up survey stations.
2. Take dBA readings periodically with a sound level meter.
3. post warningsigns at high noise level areas.
4. Provide hearing protective equipment for men exposed to noise hazards.
5. Keep record and send copies to Mining Inspection Services hi-annually.

5.5.2 'Hearing Testing

1. To have pre-employment or initial hearing test for all employees.
2. To check periodically the hearing acuity of persons exposed to "hazardous noises by a qualified and certified audiometric technician..
3. Audiometric tests should "be done inside closed test room or booth.

4. Detailed records should be kept at the property for " future medical references.

5.6 Some Noise Control Principles

1. Control at the Source

   Substitute with quieter equipment, process, or material if feasible.

   - Reduce driving force, e.g. r.p.m.

   " " response, e.g. by damping bracing.

   " " area of vibrating surface.

   " " velocity of fluid flow.

   " " turbulence

   Absorb the sound wave.

2. Set desired criteria level at 85 dB. (all reductions are beneficial, e.g. 3 dB equals a 50% reduction of exposure time.

3. Where control at the source is impractical, operator's booth should be installed and personal hearing protective equipment should be provided.

4. Consider dust and ventilation control when designing enclosures for noise purposes.

5. Use fireproof materials in all installations. Materials which will emit noxious fumes when heated or burnt should not be used in any underground installation.

6. Segregate high noise operation areas.

5.7 References

1. Clayton, "Patty's Industrial Hygiene and Toxicology" 3rd Edit. 1978, Wiley Interscience Publication.

2. "Documentation of the Threshold Limit Values" 4th. Edit. ACGIH.

3. Woods, "Practical Guide to Noise Control"