Radon Gas

1. Introduction

The subject of Radon in mines can be very emotive and, in some cases, the dangers have been overstated. However, it does represent a potential threat to those who explore abandoned mines and you should be aware of what it is. Levels of Radon in working mines are constantly monitored but this is not the case for the majority of abandoned mines. Although readings have been taken in a several abandoned mines throughout the UK, the Radon levels have been found to vary from minimal to extremely high.

The concentration of Radon in mines varies tremendously according to the country rock and area of the UK. It has been found, however, that it is particularly bad in granite, limestone or shale. Ventilation is also an important factor, since mines with a poor air flow tend to allow a greater concentration of Radon to build up. Similarly, where atmospheric pressure is low, Radon is drawn out of the rock at a greater rate. Radon is heavier than air and will thus concentrate in pockets just above the floor or water level. One unexplained anomaly is that Radon levels in mines seem to be lower in winter.

No abandoned mine can ever be given a complete 'bill of health' and there will always be a risk factor. Most mines may have a raised radon concentration at some time during the year, although certain sites are only likely to be at background level.

2. Radon and Its Effects

Radon is a radioactive gas with two isotopes :-

- ^{220}Radon has a half life of 54.5 seconds with alpha radiation of 6.28 MeV per atom.
- ^{222}Radon has a half life of 3.8 days with alpha radiation of 5.49 MeV per atom.

It is formed by the radioactive decay of Radium, Actinium and Thorium, as well as being a disintegration product of ^{238}Uranium. In the latter process, ^{226}Radium and ^{222}Radon are formed. Radon itself decays to minute radioactive particles, termed 'Radon Daughters', which float in the air and only have a half life of about 30 minutes.
Alpha radiation is released by the above processes and this consists of Helium nuclei, which travel at a very high speed but only have a range of 12cms from the source. Although alpha radiation cannot penetrate human skin, the problem comes when radon and its daughters are inhaled. Radon, being a gas, will be expelled from the lungs almost immediately and any emitted alpha radiation will be slight. The Radon daughters, however, are solid particles and these can lodge in the lung tissues. Although the human lungs can expel over 50% of any daughter particles inhaled, the remainder can cause cell mutation and cancer.

Radium is contained in the mineral pitchblende, which was once mined in Cornwall for its uranium content. Radium salts are white in colour but blacken as the Radium level decreases, emitting a blue glow due to ionisation of air by the radiation. Radon levels

in these mines are extremely high and any mine with pitchblende deposits should never be explored.

3. Units of Measurement

There are several units of measurement when dealing with radiation. The reader may wish to delve deeper into the subject and these are the ones you are most likely to come across.

a) Becquerel - 1 Becquerel (Bq) is equivalent to 1 atomic disintegration per second.

b) Millisievert - 1 Millisievert (mSv) is a concentration of 20 Bq of radiation per cubic metre of air.

c) Working Level - 1 Working Level (WL) is any combination of the short lived decay products of ^{222}Radon in a cubic metre of air that will result in the ultimate emission by them of 1.3×10^{8} MeV of alpha energy.

d) Working Level Month - 1 Working Level Month (WLM) is the amount of radiation accumulated by working in a Radon daughter concentration of 1 WL for 170 hours.

4. Safe Working Levels

Radiation occurs naturally both underground and on the surface, this background radiation averaging about 2.5 mSv per year. Measurements of radon inside houses in the UK have been found to average 1 mSv but, in a few cases, levels as high as 50 mSv occur. The International Commission on Radiological Protection (ICRP) have recommended an Action Level of 5 mSv, above which action should be taken to reduce the radon concentration.

The Ionising Radiation Regulations 1985 require employers to restrict the extent to which their employees and other persons are exposed to ionising radiations. The ICRP recommend a maximum annual dose limit of 50 mSv for people at work in an area exposed to radiation, with lower levels of 5 mSv for other persons. Areas where exposure is likely to exceed a certain level are designated as Supervised Areas and regular radon monitoring must be carried out. Areas with greater exposure levels are designated as Controlled Areas and personal radon monitoring is required.

5. Detection

Personal dosimeters with replaceable elements are generally not suitable for estimating doses caused by alpha radiation. There is a passive radon monitor, in badge form, that can be worn for single use only. This has to be sent away to a laboratory for calculating the dosage received. Details of laboratories that supply and measure passive radon monitors can be obtained from the NRPB.

The ionisation chamber works by drawing air into a cylindrical chamber, passing through a filter which removes water vapour, radon daughters and aerosols. The ionisation current of any radon gas is then measured. This, however, is not suitable for field measurement of radon daughters.

A more sophisticated method is the radiation gas monitor RGM1/1. This measures the activity of alpha and beta emitting gases in air, in the presence of a gamma radiation background.

6. Dosage

The recommended annual maximum levels of radon are cumulative and can normally be absorbed by the body with no ill effects. Unless a mine has a particularly high level of radon, a novice is unlikely to be at risk from one or two visits during the year. Leaders who regularly visit mines, however, should note that accumulated dosage may build up to a critical level and exceed the recommended annual limit of 50 mSv. They should arrange for measurements of Radon concentrations to be taken at all mines they will use and, where these are significant, to use passive radon monitors in badge form.

If a mine has good ventilation then it is likely that any exposure to Radon during a single trip will be minimal and thus represent no danger greater than that encountered from normal background radiation. It should be noted, however, that high concentrations of radon may increase exposure even with strong draughts. As a rule of thumb, choose mines with more than one entrance and try to avoid blind headings and shafts where the air is stale.

7. Guidelines for Employers

The employer has a responsibility under the Ionising Radiation Regulations 1985 to employees working in a disused mine and, if there is a possible danger of excessive exposure to radon, they should take appropriate action :-

- test all underground sites used for radon
- identify if any should be classified as Supervised or Controlled Areas
- in the case of above arrange for regular monitoring
- keep records of staff exposure.

Exposure of staff to radon can be reduced by :-

- reducing the duration of exposure
- choosing times when radon levels are lower, eg winter, high pressure
- only using sites with good through ventilation
- avoiding areas likely to have higher radon levels, eg blind shafts.

8. Example Readings

Minimum for occasional visits = 400 Bq/M^3

Mine	Reading (Bq/M^3)		Av Reading (Bq/M^3)
	Min	Max	
Bwlch-y-Plwm Mine	40	80	60
Penarth Mine	150	510*	330
Penrhyngwyn Mine	0	37	19
Talargoch Mine	30	830*	430
Wrysgan Mine	80	200	140

9. Further Information

Leaflets on radon and a list of approved laboratories supplying passive radon monitors can be obtained from :-

National Radiological Protection Board
Chilton
Didcot
Oxon OX11 0RQ
T. 0235-831600

A leaflet entitled “Radon Underground” can be obtained from the National Caving Association and this addresses the particular problems of leisure use of caves and mines.