Radon and Radon Daughters

Where does it come from? How is it present in mining?
Radon is an odorless invisible radioactive gas associated with underground mining, especially uranium mining. Radon comes from the natural radioactive decay of uranium, which is present in all rocks at varying levels. Rocks with highest percentage of uranium include: light-colored volcanic rocks, granites, dark shales, sedimentary rocks that contain phosphate, and metamorphic rocks. Radon undergoes radioactive decay into radon daughters, which can continue to undergo radioactive decay emitting alpha and beta radiation.

What are the primary health effects from exposure to Radon?
Unlike uranium (a solid), radon is a gas making it easy to inhale. Radon daughters can also be present as small particles that can also be inhaled. Exposure to radon and radon daughters has been associated with development of lung cancer in miners and is the second leading cause of lung cancer in the United States.

What are the occupational exposure limits for Radon?
Title 30 CFR §§ 57.5038 states that no person shall be exposed to more than 4 working level months (WLM) in a calendar year. Title 30 CFR §§ 57.5038 states that the maximum concentration that any person should be exposed to is 1.0 working level (WL) in active working areas.

What are the requirements for sampling frequency and recordkeeping for Radon?
Radon daughter sampling is required for all **underground** mines. At least one sample from the exhaust air must be taken. Mine operators can request that this sampling be completed by MSHA (30 CFR §§ 57.5037).

Uranium Mines
- If the concentration is less than 0.1 WL in the initial exhaust air sample, sample exhaust air at least monthly.
- If the concentration is 0.1-0.3 WL you must take worker exposure measurements randomly in all active work areas (including break rooms) randomly at least every 2 weeks.
- If the concentration is greater than 0.3 WL you must take worker exposure measurements weekly, until levels are below 0.3 WL in that area for 5 consecutive weeks.
- Required to calculate exposure in WLM for each individual working underground based upon the concentration of radon daughters and time spent in each active working area.

Non-Uranium Mines
- If the concentration is less than 0.1 WL in the initial exhaust air sample, no further monitoring.
- If the concentration is 0.1-0.3 WL you must take worker exposure measurements in all active work areas randomly at least every three months, until levels in that area are below 0.1 WL and then annually afterwards.
- If the concentration is greater than 0.3 WL you must take worker exposure measurements weekly, until levels are below 0.3 WL in that area for 5 consecutive weeks.
- Also, must calculate exposure in WLM for each individual (working underground in areas with a concentration greater than 0.3 WL) based upon the concentration of radon daughters and time spent in each active working area

Records of radon daughter exposure monitoring including sample date, location and results must be retained the mine or nearest mine office for at least 2 years and available for inspection. Also the MSHA form "Individual Record of Exposure to Radon Daughters" must be completed prior to February 15th of each calendar year, and available for inspection.

How do I measure potential exposures to radon daughters?
Sampling should be completed with equipment procedures described in the "American National Standard Radiation Protection in Uranium Mines" (ANSI N13.8-1973). MSHA inspectors use the Kusnetz method.
A sampling pump is calibrated at 2 lpm or more. A 25 mm fiberglass filter (Gelman Type AE) in a cassette is connected to the pump. Air is pumped through the filter and pump for 5 minutes. Samples must be analyzed 40-90 minutes after the pump is turned off. A special machine, called a scalar (for example Ludlum Model 2000) is used to count alpha radiation from the radon daughters. WL and WLM are calculated as:

$$WL = \frac{CPM \times EF}{Vol \times TF} \qquad WLM = \frac{WL \times T}{173}$$

where *WL* radon daughters concentration in the area in working level, *CPM* is count rate of sample in counts per minute, *EF* is efficiency factor of scalar as indicated on the machine, *Vol* is total sample volume in liters, *TF* is time factor based on time elapsed since sample was taken, WLM is miners working level months calculated for each active working area, and T is hours spent in the area per month.

Companies that can assist with measuring radon daughters:
AccuStar http://www.accustarlabs.com/Default.aspx
Ludlum Measurements, Inc. http://www.ludlums.com/
Rad Elec, Inc. http://www.radelec.com/

How do I control Radon exposures?
Ventilation is recommended for controlling radon daughters to below the exposure limits. However, NIOSH approved respirators must be used in working areas where radon daughter concentrations are over 1.0 WL. Supplied air devices or face masks containing absorbent material capable of removing both radon and its daughters should be used at concentrations over 10 WL.

References:
MSHA. 2007. Metal Nonmetal Health Inspection Procedures Handbook. PH06-IV-1(1). http://www.msha.gov/readroom/handbook/PH09-IV-1.pdf
MSHA Code of Federal Regulations (http://www.msha.gov/30cfr/0.0.htm). Regulations pertaining to Radon include: 30 CFR §§ 57.5037 through 57.5047.
USGS. The Geology of Radon. http://energy.cr.usgs.gov/radon/georadon/3.html
ANSI N13.8-1973 American National Standard Radiation Protection in Uranium Mines. http://www.ansi.org/