Cyanide

Where does it come from? How is it used in mining?
Cyanide is a chemical that is highly reactive with water. It comes in many forms such as a colorless gas (called hydrogen cyanide - HCN) or as white solid crystals (for example, sodium or potassium cyanide – NaCN or KCN). In silver and gold mining, cyanide solutions are used in a leaching process to concentrate the metal ore. Low grade ore is finely crushed and placed into piles with a waterproof barrier beneath the piles. A weak cyanide solution is trickled through the pile dissolving the silver and gold from the ore. The cyanide-metal solution is trapped by the waterproof layer. This trapped cyanide-metal solution (called "pregnant solution") is passed through activated charcoal at a mill to be concentrated into a useful product. Cyanide can also be used in processes to coat objects with copper or bronze, in the hardening of metals, and for pest fumigation.

What are the primary health effects from exposure to Cyanide?
Cyanide is a strong and fast-acting chemical asphyxiant. A "chemical asphyxiant" is a gas prevents the blood from carrying oxygen. This causes a person to suffocate. The organs that are sensitive to cyanide, the brain and the heart, are those who depend on a large supply of oxygen from the blood. Cyanide gases cause most poisonings to workers from workers inhaling the gas. Cyanide salts are more stable than the gas, though when cyanide salts are wetted or exposed to humidity, they release this more dangerous hydrogen cyanide gas.

Exposure to cyanide can cause weakness, headaches, confusion, dizziness, fatigue, anxiety, sleepiness, nausea and vomiting. Breathing can speed up then become slow and gasping. Coma and convulsions also occur. If large amounts of cyanide have been absorbed by the body, the person usually collapses and death can occur very quickly. Long-term exposure to lower levels of cyanide can cause skin and nose irritation, itching, rashes and thyroid changes.

What are the occupational exposure limits for Cyanide?
30 CFR Part 56.5001(b) requires that mine operators control exposure to airborne contaminants below the 1973 American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs). The 1973 ACGIH TLV for cyanide is 5.0 mg/m^3 for an 8-hour time-weighted average with a "skin" notation. The "skin" notation means that there is danger of absorption of the chemical through the skin. The 1968 Pittsburg Short-Term Limit is 5.0 mg/m^3 for a period of 30-minutes.

While not required by the Mining Safety and Health Administration, it is highly recommended to comply with the most current recommended airborne concentration guidelines. The 2011 ACGIH TLV for cyanide is 5.0 mg/m^3 (cyanide salts) for a 15-minute period with the "skin" notation. The Immediately Dangerous to Life and Health concentration (the level that can cause immediate death) is 25 mg/m^3.

How often shall I complete exposure monitoring for Cyanide?
If your mine operation uses cyanide for metals leaching, hardening, or coating, air sampling is necessary. 30 CFR Part 56.5002 requires that dust, mist, and fume surveys be conducted *as frequently as necessary* to determine the adequacy of control measures. It is standard practice to sample initially (called a baseline evaluation) to determine potential exposure concentrations. Routine or periodic monitoring (usually annually) is also recommended. Sampling may need to be done more often if the tasks change, if engineering controls change, or if sampling results are above the "action limit" which, for most chemicals, is defined as 50% (or half) of the TLV.

How do I measure potential exposure to Cyanide?
To measure worker exposure to cyanide, air sampling should be completed for the entire shift to compare with the 8-hr time-weighted average limit or for either 15 or 30 minutes to compare with the TLV and MSHA short-term exposure limits, respectively. Multiple short-term samples can be collected over the work shift to calculate a time-weighted full shift exposure.

NIOSH Method 7904 is used for air sampling hydrogen cyanide gas and salts. The air sampling procedure uses a 37-millimeter diameter, 0.8 micrometer pore size poly-vinyl chloride filter with a 15 milliliter bubbler with 0.1 N KOH solution. This method requires a flow rate of 0.5 – 1.0 liters of air per minute with a collected volume of 10 – 180 liters of air. The liquid in the bubbler must be transferred into a 20-milliliter vial after sampling. The vial should be closed tightly and sealed with plastic tape. The samples must be shipped overnight to the laboratory.

Once the laboratory provides you with the mass of cyanide in milligrams measured on the filter and in the solution, you can calculate the air concentration as:

$$C = \frac{M}{Q \times T}$$

where C is the concentration of cyanide in mg/m^3, M is the mass of cyanide measured on the filter/in the solution in mg, Q is the pump flow rate in liters per minute and T is the total time of sampling in minutes. Note that many laboratories will do this calculation for you if you provide the flow rate and total sample time or the sample volume on your chain of custody. Many laboratories will also loan you the necessary equipment to obtain the samples and provide you with the appropriate filters, bubblers, and bubbler solution.

Certified laboratories that can assist with measuring cyanide:
Galson http://www.galsonlabs.com/ or Analytics Corporation http://www.analyticscorp.com/

How do I control exposures to Cyanide?
30 CFR Part 56.5005 requires the control of employee exposures to harmful airborne contaminants by prevention of contamination, removal by exhaust ventilation, or by dilution with uncontaminated air. The standard allows for respiratory protection when accepted engineering control measures have not been developed or when necessary by the nature of the work involved. The following table may be helpful when selecting the respirators for cyanide.

Type of Cyanide	Concentration (mg/m^3)	APF	Respirator
Hydrogen cyanide gas (HCN)	Up to 51.7 mg/m^3	10	Any supplied-air respirator
Potassium cyanide salts (KCN)	Up to 25 mg/m^3	10	Any supplied-air respirator
		50	Any self-contained breathing apparatus with a full face piece
Sodium cyanide salts (NaCN)	Up to 25 mg/m^3	10	Any supplied-air respirator
		50	Any self-contained breathing apparatus with a full face piece

In addition to ventilation and/or respirators, employees should use protective wear to cover exposed skin and the eyes. These can include acid resistant clothing, gloves, and face shields or splash goggles. Teflon gloves provide the longest protection (up to 8-hours) for cyanide. Teflon gloves should be thrown away every eight hours.

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).
Mine Safety and Health Administration, Pittsburg Safety and health Technical Center, "*Controlling Silver Dust and Fumes at Mine Refineries*", December 2010.
Department of Labor, Occupational Safety and Health Administration, "*Occupational Safety and Health Guideline for Hydrogen Cyanide*".
American Conference of Governmental Industrial Hygienists, Threshold Limit Values for Chemical Substances and Physical Agents, 2011.
National Institute for Occupational Safety and Health, Manual of Analytical Methods, Fourth Edition, Method 7904, *Cyanides, aerosol and gases*, August 15, 1994.