Mercury

Where does it come from? How is it used in mining?
Mercury is a silvery-white, heavy metal that is liquid at ordinary room temperature and has no taste or smell. It is found in thermometers and gauges, dental amalgams, fluorescent light bulbs, lab reagents, gold and silver mining and ores of cinnabar, red sulfide and vermillion. It can be present in the form of metallic (elemental) mercury (Hg) in a dust, vapor or fume, as a non-organo alkyl compound, or as an organo alkyl compound. The organo alkyl form of mercury is present in some pesticides, antibacterial agents and explosives (mercury fulminate). The elemental form (Hg) vaporizes at any temperature down to almost 40° F below zero. In metal mining, elemental mercury is released from gold and silver ore when the metals are leached from the ore with the use of cyanide. The small amount of elemental mercury that is extracted from the ore can pose health risks to employees who work with the gold/silver-bearing solution purification and concentration circuit and in the refinery.

What are the primary health effects from exposure to Mercury?
Exposure to metallic mercury or mercury compounds, even in small quantities over a period of time, can cause severe poisoning. Mercury can enter the body by inhaling the vapors or mercury-containing dust, by swallowing (ingesting) the dusts or by absorption through the skin. Symptoms of long-term mercury poisoning are weakness, fatigue, inflammation and ulcers in the mouth, bleeding gums, loosened teeth, excessive salivation (spittle), tremors (shaking), respiratory problems, and emotional instability. Acute poisoning from high doses in a short period of time causes nausea, abdominal pain, vomiting, headaches, diarrhea and, (occasionally) cardiac weakness. Organo alkyl mercury compounds may also have teratogenic effects, which means, that developing fetuses may be harmed in exposed pregnant females.

What are the occupational exposure limits for Mercury?
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 mercury dust, mists, vapors and fume (all forms except organo alkyl mercury) is 0.050 mg/m^3 for an 8-hour time-weighted average and a short-term exposure limit of 0.15 mg/m^3 over a 15-minute period. Organo alkyl mercury compounds are limited to 0.01 mg/m3 for an 8-hour time-weighted average and a short-term exposure limit of 0.03 mg/m^3 over a 15 minute period.

While not required by the Mining Safety and Health Administration, it is highly recommended to comply with the most current recommended airborne concentration standards. The 2011 ACGIH TLV for elemental and inorganic forms of mercury is 0.025 mg/m^3 for an 8-hour time-weighted average with a "skin" notation. The "skin" notation means that mercury can be absorbed through the skin. The Immediately Dangerous to Life and Health concentration (the level that can cause immediate death) is 10 mg/m^3 for all types of mercury except organo alkyl forms and 2 mg/m^3 for organo alkyl forms of mercury.

How often should I complete exposure monitoring for Mercury?
If your mine uses mercury compounds or performs tasks to leach metals from ore, you may need to complete air sampling for mercury. 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 sampling (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 exposures to Mercury?
Mercury vapor can be measured in air using "active" air sampling pumps or "passive" badges with Hydrar or hopcalite sorbent per analytical method OSHA ID-140. OSHA ID-140 uses air sampling pumps with a flow rate of 0.2 liters per minute of air and 3 – 100 liters of air collected through a 200 milligram sampling tube. A worker can

also wear a "passive" badge that is sent to the laboratory after clipping the open badge to the collar of the worker. The analysis for "active" or "passive" air sampling is completed by cold vapor-atomic absorption spectrophotometry. Grab samples (direct-reading screening samples) can be obtained using a direct-reading Drager tube (error +/- 25%), or a direct-reading meter such as a "Jerome Mercury Vapor Analyzer". Grab samples are helpful when responding to mercury spills or when there is a need to define contaminated areas quickly.

Air, surface wipes and bulk samples for mercury particulate (dust) can also be analyzed using OSHA ID-145. The recommended media includes a 37-millimeter in diameter, 0.8 micron pore size mixed-cellulose ester filter media (for air) or Whatman #41 or #42 filter paper (for surface wipes). The flow rate for air sampling is 2.0 liters of air per minute with a recommended air volume of 10 liters of air on each air filter sample. Surface wipes using Whatman paper and bulk samples with mercury collected in 20-millilter scintillation vials are also analyzed using this method. Field blank samples should be submitted with any air and surface wipe samples and their preparation should be handled in the same fashion as the actual samples without completing actual air sampling or wiping the filter paper on a surface.

Once the laboratory provides you with the mass of mercury in milligrams measured on the filter/tube media, you can calculate the air concentration as $C = M / Q \times T$ where C is the concentration of mercury in mg/m^3, M is the mass of mercury measured on the filter or tube media in mg, Q is the pump flow rate in liters per minute and T is the total time of sampling in minutes. Wipe samples can be calculated as milligrams of mercury per the area the wipe was collected. Note that many laboratories will do these calculations for you if you provide the flow rate and total sample time or the sample volume (for air samples) or area wiped (for surface samples) 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, sampling tubes, wipe media and vials. Certified laboratories that can assist with measuring mercury include: Galson http://www.galsonlabs.com/ or Analytics Corporation http://www.analyticscorp.com/ .

How do I control exposures to Mercury?

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 work involved. *The table on the following page may be helpful when selecting respirators for mercury.* Mine operators must ensure that employees protect their skin and eyes (organo alkyl compounds) when using mercury compounds. Good housekeeping and routine cleaning is important to preventing ingestion of mercury-containing dusts. Lunch and change rooms must be kept clean and the verified through surface wipe sampling.

Work clothes should be vacuumed before removal. Vacuum cleaners used for this purpose must be equipped with mercury-vapor absorbing filters. Every miner should shower thoroughly (with special attention to the head and hands), and change into clean clothing before leaving the job site. Soiled clothing should be stored in vapor-proof containers and must be laundered after each use. Contaminated clothing should not be shaken or air hosed. Work and street clothing should not be stored in the same locker. Food should not be stored, dispensed or eaten in any place that might be contaminated with mercury. Smoking should be avoided completely in mercury work areas. The hands and face should be thoroughly washed with warm soapy water and rinsed before the miner eats or drinks. Mercury impervious floors and work surfaces and equipment in mercury work areas must be maintained free of cracks and crevices which might retain mercury. Mercury spillage must be cleaned up promptly either mechanically or chemically. Blowing or dry sweeping cannot be permitted.

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).
American Conference of Governmental Industrial Hygienists, Threshold Limit Values for Chemical Substances and Physical Agents, 2011.
United States Department of Labor, Mine Safety and Health Administration, "Draft - Controlling Mercury Hazards in Gold Mining: A Best Practices Toolbox", September 1997.

Type of Mercury	Concentration (mg/m^3)	APF	Respirator
Mercury vapor	Up to 0.5	10	Any chemical cartridge respirator with cartridge providing protection against the particular compound with an end-of-service-life indicator (ESLI) required.
	Up to 1.25	25	Any powered air purifying respirator with cartridge providing protection against the particular compound with an ESLI required.
	Up to 2.5	50	Any air purifying, full-face piece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the particular compound with an ESLI required; any supplied air respirator that has a tight fitting face piece and is operated in continuous-flow mode; any powered air purifying respirator with a tight-fitting face piece and cartridges providing protection against the particular compound with an ESLI required; any self-contained breathing apparatus with full face piece; any supplied-air respirator with full face piece
	Up to 10	1000	Any supplied-air respirator operated in a pressure-demand or other positive-pressure mode
Other non-organo alkyl mercury compounds	Up to 1.0	10	Any chemical cartridge respirator with cartridges providing protection against the particular compound with an ESLI required; any supplied-air respirator
	Up to 2.5	25	Any supplied-air respirator operated in a continuous-flow mode; any powered air purifying respirator with cartridges providing protection against the particular compound with an ESLI required
	Up to 5.0	50	Any chemical cartridge respirator with a full- face piece and cartridges providing protection against the particular compound with an ESLI required; any air purifying, full-face piece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against the particular compound with an ESLI required; any supplied-air respirator that has a tight-fitting face piece and is operated in a continuous-flow mode; any powered air purifying respirator with a tight-fitting face piece and a cartridge providing protection against the particular compound with an ESLI indicator required; any self-contained breathing apparatus with a full-face piece; any air-supplied respirator with a full-face piece
	Up to 10	1000	Any supplied air respirator operated in a pressure-demand or other positive-pressure mode
Organo alkyl compounds	Up to 0.1	10	Any supplied-air respirator
	Up to 0.25	25	Any supplied-air respirator operated in a continuous-flow mode
	Up to 0.5	50	Any supplied-air respirator that has a tight fitting face piece and is operated in a continuous-flow mode; any self-contained breathing apparatus with a full-face piece; any supplied-air respirator with a full-face piece
	Up to 2.0	1000	Any supplied-air respirator operated in a pressure-demand or other positive-pressure mode