Ceramics

Ceramic art and pottery has a wide variety of hazards. The specific hazards and precautions are divided into four areas:

1. Working with clay
2. Glazing and coloring
3. Firing in a kiln
4. Potential leaching of finished ware

Clay

Clays are minerals composed of hydrated aluminum silicates, often containing large amounts of crystalline silica. Other impurities may include organic matter or sulfur compounds. Sometimes, grog (ground firebrick), sand, talc, vermiculite, perlite, and small amounts of minerals such as barium carbonate and metal oxides, are added to modify clay properties. Clays can be worked by hand or on the potter's wheel, or cast in a clay slurry into molds.

Clay is made by mixing dry clay with water in clay mixer. Clay slip is made by adding talcs which themselves can be contaminated with fibrous asbestos or asbestos-like materials.

Hazards

1. Large amounts of free silica can be produced from clay mixing. Silica has been known to cause silicosis from chronic inhalation of large amounts of free silica. Symptoms include: shortness of breath, dry cough, emphysema, and high susceptibility to lung infections. Silica dust exposure is not hazardous by skin contact or ingestion.
2. There is a danger of accidents if clay or water is added while the clay mixer is in operation.
3. Bags of clay and glaze materials can be very heavy, and lifting can cause back problems.
4. Throwing on a potter’s wheel for long periods of time can result in carpel tunnel syndrome because of the awkward position of the wrists. Back problems can occur from bending over the potter’s wheel for long periods of time.
5. Hand contact with wet clay can result in abrasion and dryness of fingertips and hands.
6. Clay scraps on the floor; bench and other surfaces can dry and pulverize, producing an inhalation hazard due to the presence of free silica. The reconditioning of clay by pulverization and sanding finished green ware can also create high concentrations of free silica.

Precautions

1. For cleanliness, clay storage and mixing should take place in a separate room. Bags of clay (and other pottery materials) should be stored off of the floor for easier clean-up.
2. All clay mixers should be equipped with local exhaust ventilation to remove fine silica dust particles from the air. Respirators are recommended when mixing clay for those individuals who mix clay often. **Contact EH&S for respirator selection and fit testing.**
3. Clay mixers should be equipped with proper machine guards so that they cannot be opened to add clay or water while the mixer blades are turning.
4. Avoid contact of clay with broken skin. Use a moisturizer.
5. To prevent back problems, always lift with knees bent. Elevate electric wheels to a height that doesn't require bending over.
6. Keep wrists in unflexed position as much as possible to prevent carpel tunnel syndrome. Take frequent breaks.
7. Recondition clay by cutting still-wet clay into small pieces, letting them air-dry, and soak in water.
8. Finish green ware while still wet or damp with a fine sponge instead of sanding when dry.
9. Wet mop floors and work surfaces daily to minimize dust levels and prevent dry scraps from becoming pulverized.

Glazes

Glazes used to color or finish clay pieces are a mixture of silica, fluxes and colorants. Common fluxes include lead, barium, lithium, calcium and sodium, and are used to lower the melting point of silica. The actual colorants, which are an assortment of metal oxides, usually account for less than 5% of the glaze by weight.

High fire porcelain and stoneware techniques eliminate the need for lead as a flux. Also, alkali earth or alkaline earth fluxes can be used for low-fire conditions instead of lead. Silica may also be removed from leadless type glazes. The substitution can be based on boric oxide as the glass-former, instead of silica. Alkali earth fluxes include sodium, potassium, and lithium oxides; alkaline earth fluxes include calcium, magnesium, barium, and strontium oxides. Minerals containing these fluxes include certain feldspars, nepheline syenite, petalite, bone and plant ashes, whiting, and dolomite.

An assortment of metal oxides or other metal compounds produce particular colors when fired. These are added in such small amounts to the glaze that they aren't usually a great hazard. Luster or metallic glazes are fired in a reduction atmosphere. These glazes can contain mercury, arsenic, highly toxic solvents such as aromatic and chlorinated hydrocarbons, and oils such as lavender oil. The common metals are often resinates of gold, platinum, silver, and copper. Some underglazes and over glazes use mineral spirits as the vehicle instead of water.

Glaze components are weighed, sorted and mixed with water. These materials are often in fine powdered form, and result in high dust exposures. Glazes can be dipped, brushed, poured, or sprayed on the ceramic piece.

Hazards

1. Lead compounds are highly toxic by inhalation or ingestion. Symptoms of lead poisoning include: damage to the peripheral nervous system, brain, kidney, or gastrointestinal system, as well as anemia, chromosomal damage, birth defects and miscarriages.
2. Lead-glazed food ware can leach lead if not fired properly, or if the glaze composition is not correctly adjusted. For example, the addition of copper to lead frits renders a higher solubility of lead in the final fired ware. Acidic drinks and foods such as tomato juice, citric juices, sodas, tea, or coffee, can increase this hazard.
3. A glaze label marked "lead-safe" means that the finished ware, if fired properly, will not release lead into food or drink. The actual glaze is still hazardous to handle and fire and may contain lead. Adequate control over firing conditions is very difficult in the craft studio.
4. Other fluxes such as barium and lithium are also highly toxic by inhalation, but less so than lead.
5. Certain colorant compounds of particular metals are known or probable human carcinogens, including: arsenic, beryllium, cadmium, chromium (VI), nickel, and uranium.
6. Antimony, barium, cobalt, lead, lithium, manganese, and vanadium colorant compounds are highly toxic by inhalation.
7. Antimony, arsenic, chromium, vanadium, and nickel compounds are moderately toxic by skin contact.
8. Free silica occurs in many of the clays, plant ash, flint, quartz feldspars, talcs, etc. used in glazes. See the discussion above for the hazards of silica and the disease silicosis. Weighing and mixing glazes can result in the inhalation of these toxic materials.
9. Soda ash, potassium carbonate, alkaline feldspars, and fluorspar used in glazes are skin irritants.
10. Spray application of glazes is very hazardous because of the potential inhalation of glaze mists.
11. Dipping, pouring, and brushing certain glazes may cause skin irritation and accidental ingestion due to careless personal hygiene habits.
12. Glazes containing solvents are both flammable and hazardous.

Precautions

1. Use lead-free glazes. If the glaze does not state "lead-free" or "leadless" on the label, assume it contains lead until proven otherwise.
2. Lead glazes should only be used on non-food ware items. Design lead-glazed pieces so that they won't be used for food or drink. Lead-glazed pottery should be labeled as lead-containing.
3. If possible, don't use colorants that are known human carcinogens and avoid probable human carcinogens. There is no known safe level of exposure to carcinogens.
4. Respirators are recommended when weighing and mixing powdered glazes. **Contact EH&S for selection and fit testing.** Wet glazes are not an inhalation hazard. Good housekeeping

procedures and cleanup of spills reduce the risk of inhalation or ingestion of toxic dusts. Wet mop spilled powders.

5. Gloves should be worn while handling wet or dry glazes.
6. Good dilution ventilation or local exhaust ventilation should be available when applying solvent-containing glazes.
7. Basic personal hygiene rules should be followed including restricting eating, drinking, or smoking in the studio, and wearing personal protective equipment such as gloves, and separate work clothes or coveralls. Wash hands after work. Leftover glazes and glaze scrapings can be homogenized, combined, tested, and used as a glaze.

Kilns

Electric kilns and fuel-fired kilns are used to heat the pottery to the desired firing temperature. The most common type are the electric kilns. Heating elements heat the kiln as electric current passes through the coils. The temperature rises until the kiln is shut off.

Burning gas (natural or propane), oil, wood, coke, charcoal or other materials heat fuel-fired kilns. Propane gas or natural gas is used most often. These kilns can be either located indoors or outdoors. The fuels produce carbon monoxide and other combustion gases. Fuel-fired kilns are usually vented from the top through a chimney.

Firing temperatures can vary from as low as 1382°F for raku and bisque wares, to as high as 2372 °F for stoneware, and 2642 °F for certain porcelains.

The early stages of bisque firing involves the oxidization of organic clay matter to carbon monoxide and other combustion gases. Sulfur breaks down later producing highly irritating sulfur oxides. In addition, nitrates and nitrogen containing organic matter break down to nitrogen oxides.

Galena, cornish stone, crude feldspars, low-grade fire clays, fluorspar, gypsum, lepidolite and cryolite can release toxic gases and fumes during glaze firings. Carbonates, chlorides, and fluorides are broken down to releasing carbon dioxide, chlorine, and fluorine gases.

At or above stoneware firing temperature, lead, antimony, cadmium, selenium and precious metals vaporize and the metal fumes can either escape from the kiln, or settle inside the kiln or on ceramic ware in the kiln. Nitrogen oxides and ozone can be generated from oxygen and nitrogen in air.

Hazards

1. Chlorine, fluorine, sulfur dioxide, nitrogen dioxide, and ozone are highly toxic by inhalation. Bisque firings of high sulfur clay have caused the production of great amounts of choking sulfur dioxide. Other large acute exposures to gases are not common. Inhalation of large amounts of these gases can result in severe acute or chronic lung problems. Long-term inhalation of low

levels of these gases can cause chronic bronchitis and emphysema. Fluorine gas can also cause bone and teeth problems.

2. Many metal fumes generated at high temperatures are highly toxic by inhalation. Since lead vaporizes at a relatively low temperature, it is especially hazardous.
3. Carbon monoxide from fuel-fired kilns or the combustion of organic matter in clays is highly toxic by inhalation and can cause oxygen starvation. One symptom of carbon monoxide poisoning is an intense frontal headache, unrelieved by analgesics.
4. Hot kilns produce infrared radiation, which is hazardous to the eyes. There have been reports of cataracts, from years of looking inside the hot kilns.
5. Heat generated by the kiln can cause thermal burns. The Edward Orton Jr. Ceramic Foundation reported that when a kiln was operated at 2370 °F, the surface temperature was at and above 595 °F, and the temperature one foot away from the peephole was 156 °F.
6. Heat produced by even small electric kilns can cause fires in the presence of combustible materials or flammable liquids.
7. If an electric kiln fails to shut off, the heating elements melt which can cause fires. Gas kilns also generate a lot of heat, and room temperatures often exceed 100 °F.

Precautions

1. Infrared goggles approved by the American National Standards Institute (ANSI) or hand-held welding shields should be worn when looking into the operating kiln. Shade number from 1.7 to 3.0 is recommended, but a darker shade may be required if spots appear in front of one's eyes after looking away from the kiln.
2. Do not use lead compounds at stoneware temperatures since the lead will vaporize.
3. Lumber, paper, solvents, or other combustible and flammable materials should not be stored in kiln areas.
4. Always check that the kiln has shut off.
5. If gas leaks are suspected, (e.g. gas odor): shut off gas at the source; shut off power to the kiln room at the circuit breaker; and call the campus police. Test for leaks with nonfat, soapy water or use approved leak-detection solutions.

SPECIAL PROCESSES

While most glaze firings refer to firing a glaze-coated pot in the kiln, special processes sometimes are used. *Salt glazing* and *raku firing* are two examples.

Salt Glazing

This process involves throwing wet salt (sodium chloride) into the heated kiln while the bisque ware is being fired. Wet salt at high temperatures decomposed to sodium and chlorine. The sodium reacts with the bisque ware to form a glaze. Large amounts of hydrogen chloride gas and possibly chlorine are also formed.

Sodium carbonate (washing soda) can also be used. Carbon dioxide is generated instead of hydrogen chloride.

Hazards

1. Hydrogen chloride gas is highly toxic by inhalation. Health effects are both similar and more irritating compared with most other kiln gases.
2. Hydrogen chloride and water vapor form hydrochloric acid, which will corrode metal fittings in the area.

Precautions

1. Substitute safer sodium carbonate for sodium chloride.
2. Sodium chloride salt glazing should only be done outdoors. Kilns should be equipped with chimneystack that are tall enough to disperse the hydrogen chloride safely.
3. All gas piping and metal fixtures should be routinely checked for corrosion.

Raku Firing

Raku involves first firing ware at a low temperature in a regular gas kiln, and then removing the still hot pieces and placing in them in sawdust, leaves or other organic materials for a reduction phase.

Hazards

1. See above for the hazards and safety precautions used with gas kilns.
2. The reduction step produces large amounts of smoke and carbon monoxide.
3. Treated wood or other materials can yield an exposure to highly toxic preservatives or pesticides, such as arsenic and chromium compounds.

Precautions

1. Raku should only be performed outdoors due to smoke production.   Ensure raku is not performed near air intakes or open windows of buildings.
2. Do not use materials that have been treated with preservatives or pesticides for the reduction phase.

LEACHING OF FINISHED CERAMIC WARE

Lead Leaching

There is a real concern about lead leaching into food and drink from pottery fired with lead glazes. Both the U.S. Food and Drug Administration (FDA) and the Canadian Consumer and Corporate Affairs regulate how much lead can leach from food ware into food and drink. Acidic liquids are of particular concern. Similarly, continual microwave reheating, (e.g. a coffee mug at work) can yield greater leaching of lead glazes. Many cases of lead poisoning, and even some fatalities, have occurred from the leaching of lead from lead-glazed pottery.

While commercial ceramics companies routinely test their ware for lead leaching, craft potters do not have the same quality control as does the ceramics industry, and lead leaching is more of a problem.

According to United States regulation, ceramic ware that does not pass the lead leaching tests must have a permanent fired decal stating:

"NOT FOR FOOD USE - MAY POISON FOOD.

FOR DECORATIVE PURPOSES ONLY."

As mentioned earlier, you can also drill a hole in the pottery so it cannot be used for liquids or food.

Preferably, **do not use lead glazes**, especially for food and drink vessels. Any food ware finished with lead glazes should be tested regularly by certified laboratories.

Other Leachable Metals

Other metals can leach into food and drink. Cadmium is the single metal besides lead presently regulated in the United States and Canada. However, other possible toxic metals in glazes can leach. Barium has been seen in some tests to leach in hazardous amounts from certain glaze formulations. If a barium glaze, or other glaze, changes color from contact with food, do not use the vessel for food. Try to use only glazes with calcium, magnesium, potassium, and sodium fluxes and minimize the amounts of toxic metal colorants. Routine testing for other metal leaching should be done. More research needs to be done in this area.