ARTISAN HEALTH AND SAFETY MANUAL

produced by Aid to Artisans

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Aid to Artisans (ATA) creates opportunities for low income artisans around the world to build profitable businesses inspired by handmade traditions. ATA offers access to new markets, business training, eco-effective processes and design innovation through a network of partners to promote sustainable growth and community well-being.

Artisan health and safety is a primary concern both for us and for the markets artisans seek to reach. There is increasing attention to hazardous production practices, certainly for the artisans themselves but also for their families and their communities. This manual alerts artisans to needed precautions and enables them to choose alternatives in various media in order to improve the health and safety aspects of their work.

Aid to Artisans estimates the number of artisans worldwide to reach into the hundreds of millions, though the data in this sector is scarce. Their traditions span centuries and embody significant cultural attributes. Their enterprises provide needed income for artisan families and, collectively, contribute substantially to national economies.

This comprehensive guide is a vital tool to help low-income artisans incorporate health and safety issues into their production practices. Due to the wide range of materials and production processes it was not possible to include every material used by artisans. Our team created a survey which was sent to artisans and artisan groups around the world to identify frequently used materials, processes and general health and safety concerns in the artisan world. We made great efforts to address the issues of all of our respondents and are extremely grateful to them for taking the time to help us with this initiative.

The Author
Monona Rossol is a chemist, artist, and industrial hygienist with more than 30 years experience specializing in the visual and performing arts hazards. She is the founder and president of Arts, Crafts, and Theater Safety (ACTS), a not-for-profit corporation dedicated to providing health and safety services for those in the visual and performing arts. A highly regarded and internationally sought-after consultant, trainer, and lecturer, she has worked with many schools, art organizations and businesses on the cultivation of safe work environments. She is the author of seven books, including the Artist’s Complete Health & Safety Guide which won an Outstanding Academic Book Award from the Association of College and Research Libraries.

Disclaimer
This manual was written to provide the most current and accurate information about health and safety hazards in handcraft production and about applicable laws and regulations. However, the author and publisher take no responsibility for any harm or damage that might be caused by the use or misuse of any information contained herein. It is not the purpose of this manual to provide medical diagnosis, suggest health treatment, or provide legal or regulatory counsel. Readers should seek advice from physicians, safety professionals, industrial hygienists, environmental and occupational health specialists, and attorneys concerning specific problems.
Acknowledgement
Aid to Artisans would like to acknowledge the eBay Foundation for its recognition of the importance of artisan health and safety in low-income communities around the world and for providing the funding needed to complete this manual. We also recognize Monona Rossol for her tireless and passionate research. Last, but certainly not least, Aid to Artisans extends special recognition to all the artisans (too many to name here) who took the time to complete our health and safety survey which served as the foundation of this manual.
Craft workers all over the world need to know how toxic chemicals in their materials may harm them. But the large number of craft materials makes it difficult to study them. For example, there are hundreds of toxic organic chemical solvents such as mineral spirits and turpentine. There are dozens of toxic metals, including highly toxic lead and cadmium, found in traditional art and craft paints, ceramic glazes, and in metals and solders used in stained glass and jewelry. There are about 2,000 commercially available natural and synthetic dyes and pigments, each with unique hazards. And legions of “natural” materials, such as cotton, jute, palm fibers, and many types of wood contain substances which can cause allergies, irritation and even cancer in some cases.

All of these hazardous substances can be used safely if we use the right precautions and if we understand how our bodies react to toxic substances.

**Basic Concepts**

**Dose**
Chemical toxicity is dependent on the dose -- that is, the amount of the chemical which enters the body. Every chemical produces harm at a different dose. Highly toxic chemicals cause serious damage in very small amounts. Moderately toxic substances require larger doses to cause toxic effects. Even substances considered “nontoxic” can be harmful if the exposure is great enough.

Each toxic substance can produce two different types of disease depending on their dose: acute and chronic.

**Acute Effects**
Acute illnesses are caused by large doses of toxic substances delivered in a short period of time. The symptoms usually occur during or shortly after exposure and last a short time. Once you are exposed, the outcome of the disease can vary from complete recovery, through recovery with some level of disability, to--at worst--death. For example, heavy exposure to the solvents in spray paints can cause effects from lightheadedness to more severe effects such as headache, nausea, and loss of coordination. At even higher doses, unconsciousness and death could result.

**Chronic Effects**
These effects are caused by repeated small doses of the chemicals over many months or years. Chronic diseases are the most difficult to diagnose. Usually the symptoms are hardly noticeable until severe permanent damage has occurred. Symptoms appear very slowly, may vary from person to person, and may mimic other illnesses. For instance, exposure to small amounts of spray can solvents during a lifetime of craft work may produce skin damage (dermatitis) in some individuals, chronic liver or kidney effects in others, and brain damage in still other people.

**Effects Between Acute and Chronic**
There are also other effects between acute and chronic such as "sub-acute" effects produced over weeks or months at doses below those which produce acute effects. These are difficult to diagnose.
**Cumulative Toxins**

Every chemical is eliminated from the body at a different rate. Some substances, such as lead, are eliminated from the body so slowly that most of the lead which deposits in your body stays there most or all of your life.

Other chemicals leave the body so fast that medical tests can detect their presence only a few hours or days after exposure. A good example is alcohol. Even after being very drunk, the alcohol can only be detected in the body for a day or so. Most chemical solvents such as mineral spirits behave like alcohol and leave the body very quickly. But both alcohol and chemical solvents will damage the body. It is this damage that accumulates over time, not the chemical itself.

**Multiple Exposures**

We are carrying in our bodies many chemicals from pollution of our air and water. In addition, artisans often work with more than one chemical at a time. Sometimes two or more chemicals interact in the body in either an additive or synergistic way:

**Additive Exposure**

Exposure to two chemicals is considered additive when one chemical contributes to or adds to the toxic effects of the other. This can occur when both chemicals affect the body in similar ways. Working with paint solvents and drinking alcohol is an example. People who take certain medicines or recreational drugs are also likely to be more at risk from exposure to solvents on the job.

**Synergistic Exposure**

These effects occur when two chemicals produce an effect greater than the total effects of each alone. Smoking while working with asbestos is well known to increase the risk of developing lung cancer almost 100 fold. But smoking and working with any type of dust or powdered material can be more harmful to the lungs because smoking damages the lungs’ ability to handle dusts and particles.

**Cancer**

Occupational cancers are a special type of chronic illness. Chemicals which cause cancer are called “carcinogens.” Examples of carcinogens include many of the synthetic textile dyes and metals such as cadmium, lead, and chromium.

Unlike ordinary toxic substances, the effects of carcinogens do not occur right away. In fact, many substances which cause cancer cause no symptoms at all. People think they have not been harmed. Then years later – usually 10 to 20 years later -- they develop cancer. This period of time, during which there are no symptoms, is referred to as a “latency period.”

**Birth Defects**

Some chemicals should not be used by pregnant women because they can harm the fetus. Chemicals that cause birth defects are called “teratogens” and they cause damage primarily during the first trimester when the fetus is developing its organs.

But many chemicals that do not cause birth defects are still toxic to the fetus, causing brain or organ damage. These chemicals affect the fetus at all stages of pregnancy. Some chemicals that are known to cause both birth defects and toxicity to the fetus include alcohol, certain chemical solvents, and lead.
Allergies
Many chemicals cause allergic reactions such as rashes, hay fever, and asthma. Chemicals which can produce allergic reactions are called "sensitizers." People do not usually react to sensitizers the first few times they are exposed. In general, the longer you work with sensitizers, the greater the probability you will begin to react to them.

Once developed, allergies tend to last a lifetime and symptoms may become more severe over the years. A small percentage of people develop life-threatening shock reactions (anaphylaxis) to exceedingly small doses of some sensitizers. Examples of sensitizers known to cause anaphylaxis include bee sting venom or peanuts. Some industrial chemicals also have produced similar effects.

A majority of allergies are triggered by plant and animal proteins found in natural substances such as pollen, rubber, and wood dusts. Synthetic chemicals known to cause allergies include epoxy resins and batik dyes.

Some metals such as nickel, chromium and cobalt can cause allergies in metal workers. Nickel metal is such a powerful sensitizer that it causes reactions in people who merely wear jewelry made of nickel-containing alloys. For this reason, the European Union has essentially banned nickel in jewelry or any other metal item that may have prolonged contact with the skin.

How Chemicals Enter the Body
In order to cause damage, toxic materials must first enter your body. Entry occurs primarily in three ways: skin contact, breathing (inhalation) and ingestion.

Skin Contact
Our skin has a barrier of waxes, oils, and dead cells to protect us. But this barrier can be destroyed by chemicals such as acids, caustics like lye, and solvents. Once the skin is damaged, these chemicals can cause deep damage to the skin or the tissues beneath the skin. And some of these chemicals can even enter the blood and then be transported throughout the body.

Cuts, abrasions, burns, rashes, and other violations of the skin's barrier can allow chemicals to penetrate into the blood and be transported throughout the body.

There are also many chemicals that can -- without you knowing it -- enter the blood through undamaged skin. Among these are the benzene in gasoline and wood alcohol (methanol).

Inhalation
Inhaled substances are capable of damaging the respiratory system at any location -- from the nose and sinuses, to the lungs. For example, inhalation of dust of almost any type can cause sinus irritation and a runny nose, dry or itchy throat, bronchial (the tubes leading into the lungs) irritation or bronchitis, or lung effects such as asthma.

Some toxic substances are absorbed by the lungs and are transported via the blood to other organs. For example, lead in solder fumes may be carried via the blood to damage the brain and kidneys.

Other substances like asbestos or the silica dust in clay, can be inhaled deeply in the lungs and remain there for life. They damage the lungs themselves, but they do not travel through the body to
damage other organs. These dusts also usually do not cause symptoms at the time they are inhaled. Instead, they cause chronic diseases years later such as asbestosis or silicosis or cancer.

**Ingestion**
Some of the dusts we inhale are trapped by mucous in the bronchial tubes and transported up to the back of your throat where they are swallowed.

You can accidentally ingest toxic materials by eating, smoking, or drinking while working, pointing brushes with your lips, touching soiled hands to your mouth, biting your nails, and similar habits. Accidental ingestion of larger amounts occurs when people pour chemicals into paper cups or glasses and later mistake them for beverages. Some of these accidents have even killed children who were allowed into craft studios.

**Who Is At Risk?**

**Anyone who handles chemicals frequently** is more susceptible to illnesses from exposure. However, certain people are especially at risk. For example, someone who already has bronchitis or emphysema may be even more seriously harmed by dusts and inhaled substances.

The same is true for people with other chronic illnesses, pregnant women and the fetus, children, and the elderly. People taking certain medications or who use recreational drugs, alcohol, and tobacco are also at greater risk.

All craftspeople should take good care of their health, eat and sleep well, and protect themselves from contact with toxic materials.
Health-damaging chemicals can enter our body by inhalation. We can prevent inhalation of airborne chemicals with proper ventilation or respiratory protection. But to do this, it is first necessary to understand the nature of airborne contaminants such as gases, vapors, mists, fumes, and dusts that are in our air.

**Gases**

Scientists define gas as a formless fluid that expands to fill the space that contains it. We can picture this fluid as many molecules moving rapidly and randomly in space.

Air, for example, is a mixture of different gases — oxygen, nitrogen, hydrogen, and many more. Even though each of these different gas molecules has a different weight, the heavier gases will never settle out because the rapid molecular movement of all these gases will cause them to remain mixed forever. In other words, once gases are mixed, they stay mixed.

Examples of gases created during crafting include carbon dioxide and carbon monoxide from burning wood or a highly toxic gas (acrolein) created when wax is heated or burned. In these cases, the gases mix with air as they are released and do not settle. They will expand into the air around them. They can be removed from the workplace by exhausting the air with a fan or opening windows.

Gases vary greatly in toxicity ranging from highly toxic to inert and essentially “nontoxic.” However, inert gases at high concentrations lower the oxygen content of the air which you need to live. Carbon dioxide gas from dry ice or used in inert gas welding, for example, is not very toxic, but it can be deadly if released in excess in a small enclosed space.

Some gases are also flammable or explosive. Some gases have odors, some do not. Your nose cannot be relied on to detect all toxic gases.

**Vapors**

Vapors are the gaseous form of liquids. For example, water vapor is created when water evaporates—that is, releases vapor molecules into the air. Once released into the air, vapors behave like gases and expand into space. However, at high concentrations they will re-condense into liquids. This is what happens when it rains.

Some solids also convert to a vapor at room temperature. Mothballs, for example, contain a chemical solid which converts to a vapor.

Vapors vary greatly in toxicity, flammability and odor. Among the most common toxic vapors created in artwork are organic chemical vapors from chemical solvents such as those in oil paints, varnishes, lacquer and their thinners.

**Mists**

Mists are tiny liquid droplets in the air. Any liquid, water, oil, or solvent, can be sprayed to form a mist or aerosol. The finer the size of the droplet, the more deeply the mist can be inhaled. Some mists, such as paint spray mists, also contain solid material. Paint mist can float on air currents for a
time. Then the liquid portion of the droplet will vaporize—convert to a vapor—and the solid part of the paint will settle as a dust.

**Fumes**
People commonly use this term to mean any kind of emission from chemical processes. In this manual, however, only the scientific definition will be used.

Technically, fumes are very tiny particles usually created in high heat operations such as welding, soldering, or foundry work. They are formed when hot vapors cool rapidly and condense into fine particles. For example, lead fumes are created during soldering. When solder melts, some lead vaporizes, reacts with oxygen in the air and condenses into tiny invisible lead oxide fume particles.

Fume particles are so small that they tend to remain airborne for long periods of time. Eventually, however, they will settle to contaminate dust in the workplace, in the ventilation ducts, in your hair or clothing, or wherever air currents carry them.

Fume particles are too small to be seen by the naked eye. They also vary in toxicity and flammability. They also may or may not have an odor.

**Dusts**
Dusts are formed when solid materials are broken down into small particles by natural or mechanical forces. Sanding and sawing are examples of mechanical forces that produce dusts.

The finer the dust, the deeper it can be inhaled into the lung and the more toxic it will be. "Respirable" dusts—those which can be inhaled deeply into the lungs—are too small to be seen with the naked eye.

The larger dusts deposit in the upper respiratory system where they are raised by lung clearing mechanisms and ingested. These larger dust particles are often referred to as "inhalable" dusts.

**Smoke**
Smoke is created when organic matter is burned. Wood burning and hot wire-cutting of plastics are two smoke-producing activities. Smoke is usually a mixture of many gases, vapors, and fumes. For example, cigarette smoke contains over four thousand chemicals, including carbon monoxide gas, benzene vapor, and fume-sized particles of tar. The nicotine in cigarettes is not a carcinogen. Instead, it is smoke from the burning leaf and paper wrapping that causes cancer and respiratory disease. The smoke from combustion of all organic substances such as wood, coal, gasoline, and cigarettes contains cancer-causing chemicals.

**How Much Is Too Much?**
Exposure to airborne chemicals in the workplace is regulated in most countries. These governmental limits are given various names in different countries. For example, the Malaysian and United States governments call theirs “Permissible Exposure Limits.” The Canadian limits are called “Occupational Exposure Limits.” In Germany, they are called the “Maximum Workplace Concentrations” or MAKs (Maximale Arbeitsplatz-Konzentration).

Although the levels at which various chemicals are regulated differ from country to country, all of these regulations are based on a concept developed in the early 1940s by the American Conference
of Governmental Industrial Hygienists (ACGIH). The ACGIH sets air quality limits that are now called Threshold Limit Value (TLV) which are designed to protect the majority of healthy adult workers from adverse effects. They do not apply to children or the fetus, people with chronic illnesses or on certain medications, people who work longer than eight hours, or other high risk individuals.

While the ACGIH began as a US organization, membership is now open to workplace and environmental safety and health professionals in North American and globally. For this reason, many countries incorporate some or all of the TLVs into their own regulations. The other widely accepted air quality limits are the German MAKs which are adopted by most of the European Union countries.

There are TLVs and MAKs for different periods of time, such as for 15 minutes of exposure during a short job. However, the most common ones are for the eight hour day, forty hour week. These limits are Time Weighted Averages (TWAs) and they are airborne concentrations of substances averaged over eight hours. They are meant to protect people from adverse effects when they are exposed to substances at this concentration over the normal eight-hour day and a forty-hour work week for a working lifetime.

Expensive and complicated air-sampling and analysis are usually required to prove that TLVs or MAKs are exceeded. For this reason, TLVs are primarily useful to craftspeople as proof that a substance is considered toxic, and that measures should be taken to limit exposure to substances with TLVs.

Using Exposure Standards
The TLVs and MAKs can also be used to compare the toxicity of various chemicals. Table 1 lists the TLV-TWAs and MAK-TWAs of some common air contaminants. This table illustrates that while the TLV concept is rather complicated, using them is relatively simple. In general, the smaller the TLV or MAK, the less of this substance you should inhale and more stringently you need to control the substance. And in general, gases and vapors with TLVs of 200 parts per million or less are considered highly toxic. And fumes, mists and dusts with TLVs of less than 5 milligrams per cubic meter are highly toxic to inhale.

The TLVs and MAKs can be very useful to help craftspeople pick out which substances they should try to avoid or be especially careful about handling. Data other than the TLV that must also be considered when selecting safer materials include how fast a substance evaporates (that is, how much gets airborne), how flammable the substance is, and other hazardous features of the chemical.

How Will TLVs and MAKs Be Used in This Book?
The TLVs, MAKs, and occasionally other respected air quality limits will be mentioned when it will help readers to assess the toxicity of the materials they use. The agency setting the limit will always be identified. And it is suggested that each reader also obtain copies of their own country’s standards for comparison which are usually found on department of labor websites.
<table>
<thead>
<tr>
<th>Substance</th>
<th>TLV-TWA ppm**</th>
<th>MAK-TWA ppm**</th>
</tr>
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<tbody>
<tr>
<td>Carbon dioxide</td>
<td>5000 (slightly toxic)</td>
<td>5000</td>
</tr>
<tr>
<td>Grain alcohol (ethanol)</td>
<td>1000</td>
<td>500</td>
</tr>
<tr>
<td>Acetone</td>
<td>500 (toxic)</td>
<td>500</td>
</tr>
<tr>
<td>Naphtha (if highly refined)</td>
<td>300</td>
<td>None</td>
</tr>
<tr>
<td>Wood alcohol (methanol)</td>
<td>200 (highly toxic)</td>
<td>200</td>
</tr>
<tr>
<td>Xylene</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>Turpentine</td>
<td>20</td>
<td>MAK-3A***</td>
</tr>
<tr>
<td>D-limonene (citrus oil)</td>
<td>None</td>
<td>20</td>
</tr>
<tr>
<td>Acrolein (from heating wax)</td>
<td>0.1</td>
<td>None</td>
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</table>

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<tr>
<th>Fumes, Mists, Dusts</th>
<th>TLV-TWA mg/m3</th>
<th>MAK-TWA mg/m3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gypsum (plaster)</td>
<td>10 (inhaletalarge particles)</td>
<td>4 (inhaletalable)</td>
</tr>
<tr>
<td>Iron oxide (rust)</td>
<td>5 (respirable-small particles)</td>
<td>1.5 (respirable)</td>
</tr>
<tr>
<td>Graphite</td>
<td>2 (respirable)</td>
<td>1.5 (respirable)</td>
</tr>
<tr>
<td>Aluminum metal</td>
<td>1 (respirable)</td>
<td>1.5 (respirable)</td>
</tr>
<tr>
<td>Lead</td>
<td>0.05</td>
<td>MAK2***</td>
</tr>
<tr>
<td>Silica (quartz, sand, etc.)</td>
<td>0.025</td>
<td>MAK1***</td>
</tr>
<tr>
<td>Cadmium (e.g. pigments)</td>
<td>0.002</td>
<td>MAK1***</td>
</tr>
<tr>
<td>Natural rubber latex</td>
<td>0.0001</td>
<td>Sen****</td>
</tr>
</tbody>
</table>

Notations

** Parts per million (ppm) is parts of airborne contaminant in 1 million parts of air. The parts can be any unit of volume, e.g. meters, liters of air, etc.
*** MAK 1, 2, and 3 are considered carcinogens for which there is no safe level. Keep exposure as low as possible.
**** Considered a sensitizer for which there is no safe level. Keep exposure as low as possible.
The air quality standards discussed in Chapter 2 demonstrate how different countries protect their workers with differing air quality standards and regulations. The differences in the regulations are important to artisans who sell to the international market. They need to know about some of these regulations. For example, some countries will not purchase goods made by companies whose workers labor in unsafe conditions.

**World Worker Protection Rules**

One worker protection rule is now part of the regulations in almost every country in the developed world. This regulation may be called by various names such as “the right to know” or “hazard communication.” These laws give workers the right to know what chemicals are in the products they use on the job, the hazards of those chemicals, and how to protect themselves.

The laws usually require employers to provide this information in the form of proper labeling and material safety data sheets (MSDSs).

**MSDSs and Labels**

The MSDSs are forms provided by the manufacturers of chemicals and products. MSDSs should provide data on a product's hazards and the precautions required for its safe use. Most countries’ laws require employers to have MSDSs readily available and to provide each worker with training to enable them to understand the terminology of the MSDSs.

Labels must provide safety warnings and advice for users, and the requirements for proper labeling also vary greatly from country to country. And since many languages may be spoken in various countries, many manufacturers are also adding symbols on the MSDSs and label that will identify the product’s hazards. One commonly used set of symbols are those of the European Union (see Figure 1).

**Compliance Today**

One problem is that many workers do not know their rights and many employers either do not know they are supposed to have MSDSs and train their workers, or they have decided not to comply with these laws.

Compliance is often weak in the craft industry, including in the United States where this author resides. Usually employers are not called to account for breaking these laws until someone is hurt or there is a complaint about conditions.

However, complying with these regulations is good for both workers and employers. A knowledgeable worker is one that will follow safety rules because he/she understands the consequences of chemical exposure. It also means, years later, workers will not develop diseases that can be traced back to the employer.
These hazard symbols for chemicals are defined in Annex II of Directive 67/548/EEC. A consolidated list with translations into other EU languages can be found in Directive 2001/59/EC (See the links section).

The 'n' in Harmful (Xn) stands for the French word nocif (harmful) and the Italian word nocivo (noxious).
MSDSs and Label Quality
Employers and workers also need to know that some manufacturers do not provide accurate MSDSs and labels. Small manufacturers in particular may lack the professional staff to write good warnings and technical information. Some other manufacturers declare their products “trade secrets” and refuse to tell users what the product contains. Many manufacturers do not disclose their ingredients for fear that buyers will seek other cheaper sources for the product. In addition, manufacturers have a built-in conflict of interest since they do not want to provide negative information about their products.

Global Harmonization
The International Labor Organization and the International Standards Organization are working with panels from countries worldwide to develop a single system of visual warning signs, terminology, MSDSs, and label requirements. Called the “Global Harmonization System” or “GHS,” it is very likely that one day many of these problems will be resolved. The purpose of GHS is not only to protect workers, but to facilitate international trade.

It will be years before the GHS system will be completely developed and adopted worldwide. But until GHS is in place, craft workers must protect themselves by learning to critically examine MSDSs and labels to identify and research their ingredients.

MSDS Ingredient Identification
Most MSDSs will identify known acute hazardous ingredients such as those that are flammable or corrosive. These are chemicals than can cause fires or explosions in the workplace or which will cause acute health effects like burning the skin, blinding if splashed in the eyes, or severe and immediate respiratory distress when inhaled.

MSDSs are also supposed to list chemicals known to cause adverse chronic health effects such as cancer, but most don’t. The problem with this requirement is that most of the estimated 100,000 chemicals used worldwide have never been tested for chronic hazards such as cancer. For example, the major testing organization, the International Agency for Research on Cancer (IARC), has assessed only about 900 chemicals for cancer effects.

Even fewer chemicals have been tested for birth defects, for damaging the reproductive organs of men and women or for long term organ damage such as brain and kidney damage. Craft workers need to keep ever in mind that the majority of the world’s chemicals are untested.

Fortunately, the European Union is addressing this problem. They have identified about 32,000 chemicals manufactured in amounts over a billion pounds a year on which there is no data. They are going to mandate that European industries begin to test these chemicals. The first data on some of these chemicals it scheduled to be released in 2012.

Identifying Untested Chemicals
It is usually easy to determine if the chemicals in your products are untested. One way is to look at the chemicals listed on the MSDS and do a little research on the internet. It is amazing the amount of information that is available. But be certain the sites you look at do not financially benefit from the sale of that chemical. Instead, look at the sites of major health and research organizations.
Another way to determine if the chemicals in your products have been tested for their ability to cause cancer is to look at the cancer ratings listed on your MSDS. Most MSDSs worldwide are required to provide the cancer category given to chemical ingredients by the International Agency for Research on Cancer. If IARC tested a chemical and found it did not cause cancer, it would be listed as IARC Category 4. On the other hand, if you see no category listed or the MSDS says that the chemical is not considered a carcinogen by IARC, this actually means the chemical has not even been evaluated for cancer effects by IARC and is probably untested.

Another way to identify an untested chemical is if there are no air quality limits for the chemicals such as TLVs, MAKs, or local workplace air quality regulations. Yet many people will see statements such as “No regulations apply” and assume this means that the chemical is safe. Instead, it means that none of these agencies have found enough data on human and/or animal exposure to set a limit for the chemical.

Use common sense and handle untested chemicals with care. They may be found to be hazardous when they are finally evaluated.

Special Problems in Crafts
Craftspeople often use unusual materials that have not been tested and are unlikely to be tested any time in the future. For example, the world has toxicity data on common woods such as pine, maple and oak—woods used by large numbers of workers in big factories so that meaningful studies can be done. But crafts workers commonly use bamboo, wicker, palm fibers (cabecinegro), tagua nuts and other woody materials. And the craft workers are usually employed in small businesses scattered throughout the world that would be hard to study.

MSDSs and Your Customers
More and more often, craftspeople are finding that their customers are also asking for MSDS or that MSDSs are required by the agency shipping the goods. Many countries now require MSDSs for all imported materials. It is good practice to have MSDSs in the workplace on all materials.

One way to obtain MSDSs is to require them as a condition of purchase. Your purchase order forms can be altered to add a written requirement that an MSDS must accompany the order. If the company you order materials from does not have MSDSs, check the label on the container for the name of the primary manufacturer and go to their website. You should be able to download an MSDS. If a primary manufacturer does not have one on their website or will not comply with a telephone or letter request for one, this company is in violation of the laws of most countries and you should try to find a better source for this product.

Worldwide Workplace Conditions
Compliance with workplace health and safety regulations also makes good business sense. More and more customers want assurances that the workers that made the crafts they are buying are working in clean, safe shops and are properly paid for their work. It’s good for business to be able to provide pictures of the shop and information about your safety programs.
Now that we understand the many types of contaminants that can be in our air (Chapter 3), we can look at ways of getting them out of the air we breathe by using respirators or ventilation.

**Selecting A Respirator**
Choosing a respirator is not simple because it must be designed to capture a specific air contaminant (gas, vapor, fume dust or mist). For example, wearing a surgical mask, which is designed as protection against biological hazards to protect you from spray paints or solvents, will actually increase your exposure to toxic solvents. Wearing a damp handkerchief will stop only very large dust particles, letting the most dangerous small ones get into your lungs.

**Health Considerations**
Before selecting a respirator, consider your general health. Drawing your breath through a mask or through respirator filters takes effort and causes physical stress. People with certain heart or lung problems should not wear them. Pregnant women may also want to talk to their doctors about the breathing stress that wearing a respirator causes. Some country’s regulations require employers to provide medical examinations for employees who will wear respirators to ensure that they do not have health defects which could be made worse by breathing stress.

**Respirator Regulations**
In many countries, such as the United States and Canada, occupational regulations require that respirators can be used only when other methods of protection, such as better ventilation are not feasible.

Most countries also have regulations requiring employers to select specific respirators for specific contaminants, to test each employee’s respirator to insure it fits properly, to train the employees on how to properly use and maintain the respirator, and to pay for respirators and any services associated with their use if they are needed for safety on the job. This means that employers must be knowledgeable about respirators and be able to hire the technical people needed to provide the required training and testing services.

If you are self-employed, work alone or in a cooperative, you will need to learn about respirators yourself in order to make some of these choices and obtain technical assistance.

**Types of Respirators**
There are three basic respirator types:

**Air-Supplying Respirators** bring fresh air to the wearer usually by means of pressurized gas cylinders or special compressors (ordinary compressors do not release clean air). These respirators are for use in highly contaminated areas or areas that do not have enough oxygen. They are complex and expensive systems.

**Powered Air-Purifying Respirators** provide wearers with air that has been pumped (usually by a small motorized unit attached to the wearer’s belt) through filters or cartridges. This filtered air is
supplied under slight pressure to a mask or shield over the wearer’s face. These also are rather expensive.

1. **Air-Purifying Respirators** use the wearer's breath to draw air through filters or chemical cartridges in order to purify it before it is inhaled. Most air-purifying respirators are priced in a range that craftspeople will find practical. These are the respirators used by most craftspeople and they also come in three types:

   a. **Disposable or Single Use Types** which look like paper dust masks and are thrown away after use.

   b. **Half-Face Types** which cover the mouth, nose, and chin, and have replaceable filters and cartridges

   c. **Full-Face Types** which look like old-fashioned gas masks and have a replaceable canister. These are only for very high concentrations of contaminants.

**Respirator Fit**

Even the very best air-purifying respirators are useless if they do not seal properly to the workers’ face. Workers cannot know whether their respirators are protecting them unless they have been tested by a person qualified to do a “fit test.” Respirator manufactures often provide the fit test equipment and will train people to do the testing. It is wise for a large craft business to send someone to the manufacturer to learn how to do these tests and provide testing for the rest of their workers.

If you do not have an employer to pay for this service, there often are trained people from larger industries or who are associated with occupational medical clinics that will do this work for a fee. There are two basic types of fit tests:

1. **Quantitative Fit Testing** in which an expensive machine measures and compares either the pressure or the contaminants inside and outside the mask or respirator. This method is usually too costly for small businesses.

2. **Qualitative Fit Testing** depends on the wearer's ability to sense an odor, taste, or irritation from one of several chemicals approved for this test which are released in a controlled way to an enclosure around the user's head. This is an inexpensive method and is the most common way to test masks and cartridge respirators.

**Fit Check or Seal Check**

Some workers mistakenly think they can test cartridge respirators themselves by doing a "fit check" or "seal check." These tests are very different from a “fit test” despite the easily confused terms.

To perform a seal check for a cartridge respirator, the wearer closes the exhalation valve with his or her hand and exhales into the face piece. Next the wearer can block air coming into the cartridges with his or her hands and inhale. The face piece should not let air leak in or out on either procedure. This check should be made each time you put on a respirator.
**Beards and Other Fit Problems**

It is especially important to remember than anything that breaks the seal between the facial skin and the respirator renders it incapable of providing proper protection. Men who cannot shave cleanly cannot be protected by air-purifying masks or respirators. These people need to use the more expensive air powered or air-supplied respirators that do not require a tight fit.

Be aware that there are some people whose faces don’t conform to the shape of the respirator or who have scars or other facial features that prevent the respirator from sealing to the face. These people also cannot get a proper fit and need to use air powered or air-supplied respirators.

**Picking the Right Cartridge**

Chemical cartridges are designed to capture specific substances such as ammonia, formaldehyde, acids, and organic solvents. Unless you know what is in the air, you cannot choose the right cartridge. Use MSDS and product literature to determine what is released when you use your materials.

In addition, there are many chemicals for which there are no cartridges. Included are ozone, nitric acid, methyl alcohol, some plastic resin chemicals (isocyanates and organic peroxides), carbon monoxide, and many more. And there never is any cartridge that will capture all the contaminants in smoke from burning of wax, wood, paper, or any organic or plant matter. This is why firefighters must wear air-supplied respirators with an air tank on their backs rather than cartridge respirators.

**Picking the Right Filter or Mask**

Cartridges or masks for particles will not capture gases and vapors at all. They will go right through. Particle filters can only capture fumes, mists, and dusts. Even then, they will only capture certain sizes of these particles.

In general, high efficiency particulate air or (often called a HEPA) filters will get really small dusts (0.3 microns in diameter at an efficiency of 99.97% or better). Other masks will let some of the very small particles through. And no mask is perfect. Some particles will always get to the wearer.

In addition, some masks and filter cartridges cannot be used around oil mist or they will function poorly. Other masks can only be worn for 8 hours before they should be thrown away. And so on. Read product literature and directions from the manufacturers very carefully.

**Cartridge Respirator Care**

At the end of a work period, remove the cartridges and clean the respirator. Store the respirator and the cartridges separately out of sunlight in sealable plastic bags. Masks also should be placed in sealable plastic bags if they are not past their service life. Respirators and masks should never be hung on hooks in the open or left on counters in the shop. Cartridges left out will continue to capture contaminants from the air.

If a respirator is shared, it should be cleaned and disinfected between users. Most respirator manufacturers provide educational materials which describe proper break-down and cleaning procedures. Inspect respirators carefully and periodically for wear and damage.
Cost of Compliance
The complexity of the rules and the cost of compliance with all the rules for either voluntary or required use are one of the strongest arguments for installing local exhaust ventilation instead. Often in the long run the ventilation is cheaper than respirators.
Basic Principles of Ventilation
There are two basic kinds of ventilation: 1) comfort ventilation to keep people healthy in offices and classrooms in which toxic substances are not used, and 2) chemical room ventilation for the industrial processes used in craft shops, such as solvent oil painting, woodworking, welding, and ceramics.

Comfort Ventilation: If you put people in a room and close all the windows and doors, they will soon become unhealthy. Simply breathing the air exhaled by other occupants is not good for people. When fresh air is not sufficiently provided, people will complain of feeling sick, tired, having respiratory problems, and the like. And sometimes mold or bacteria grows in walls and in ducts.

For this reason, all rooms must have sufficient sources of fresh air. This air can be provided by open windows, the small cracks around old windows or doors, or a ventilation system that brings fresh air into the room. Every country has standards for the amount of fresh air that must be supplied to new buildings.

Ventilation systems for larger buildings must be designed by engineers. The air supply systems consist of fans or blowers used to circulate air from room to room throughout the building to which a small amount of outside fresh air (usually from 5 to 15%) is added. Building engineers who operate ventilation systems often are encouraged to add as little fresh air as possible to reduce heating and cooling costs.

These systems are not ones most craftspeople can design for themselves. So open windows are usually a better solution for small craft shop offices and other non-chemical using rooms.

Ventilation for Chemical Rooms: Rooms in which craft-making activities pollute the air with solvents or dusts require a special kind of ventilation called “industrial ventilation.” There are two basic types: dilution ventilation and local exhaust ventilation:

1. Dilution Ventilation does exactly what its name implies. It dilutes or mixes contaminated workplace air with large volumes of clean air to reduce the amounts of contaminants to acceptable levels. Then the diluted mixture is blown out of the work room by exhaust fans. Air for the exhaust fans must be provided by open windows or other fans that direct air into the room (see Figure 2).

This system is inexpensive to install, but it can make the workplace very hot in the summer and very cold in winter if the air that is coming in is not heated or cooled first. Heating and cooling costs can then become expensive.

Dilution ventilation should only be used to control vapors or gases of low toxicity or small amounts of moderately toxic vapors or gases. It should not be used to control dusts because it creates air currents that can stir up dust from floors and tables.
Exhaust fans should never be used to control large amounts of vapors from flammable solvents, such as from a spill or from large open containers because exhaust fans usually are not explosion-proof. At high concentrations, solvent vapors in air can explode if they pass near a hot motor or electrical charge.

2. **Local Exhaust Ventilation** is the best means by which large amounts of airborne substances, or substances of moderate to high toxicity are removed from the workplace. Table 2 lists processes which require local exhaust ventilation.

Local exhaust systems consist of 1) a hood enclosing or positioned very close to the source of contamination to draw in the air, 2) ductwork to carry away the contaminated air, 3) if needed, an air-cleaning unit to filter or purify the air before it is released outside, and 4) a fan to pull air through the system (see Figure 3).

In special cases, an exhaust fan can be positioned very close to the work station (see Figure 2, the last two drawings). In this way it is almost as effective as a local exhaust. Do not use this system with aerosol cans, spray painting, airbrush operations, or with flammable materials unless the fan is explosion proof.

Local exhaust ventilation is the best means by which materials of moderate to high toxicity--gases, vapors, dusts, fumes, etc.--are removed from the workplace. Because local exhaust ventilation captures the contaminants at their source rather than after they have escaped into the room air, exhaust ventilation systems remove smaller amounts of air than dilution systems.

The hoods for local exhaust can be fitted to the job. See Figures 4-7 for some of the basic types of hoods.

And if these systems are too expensive for the small business, some processes needing local ventilation can be taken outdoors with respiratory protection. This is provided the local environmental regulations will permit this work to be done outdoors.
A typical inexpensive dilution system used to reduce worker’s exposure to small amounts of moderately toxic gases or vapors from many point sources.

Good dilution ventilation for a single worker in a small studio must take into account the position of the worker. This system can be designed to work almost as well as local exhaust.
FIGURE 3
LOCAL EXHAUST VENTILATION

FIGURE 4
SPRAY BOOTH

FIGURE 5
FLEXIBLE DUCT EXHAUST

FIGURE 6
CANOPY HOOD OVER KILN

FIGURE 7
SIDE DRAFT SLOT HOOD
### Processes Requiring Dilution Ventilation
Painting with oil paints or solvent-containing paints
Use of small amounts of solvent-containing adhesives, inks, shellacs, and similar products

### Processes and Equipment Requiring Local Exhaust Ventilation

**Dusts:**
- Abrasive blasting
- Power sanding, grinding, and polishing wet grinding, abrading, and polishing
- Dry mixing of clays, glazes, dyes, photochemicals, etc.
- Powered carving and chipping of stone

**Heat, Fumes, and Other Emissions from:**
- Batik wax baths and ironing out stations
- Wax burn-out kilns
- Ceramic kiln firing
- Enameling, slumping, fusing, glass paint kilns
- Glassblowing furnaces
- Foundry furnaces
- Hot dye baths
- Metal soldering, melting, and casting
- Welding

**Mists:**
- Aerosol spraying
- Air-brushing
- Wet grinding, abrading, and polishing
- Power spraying (all types)

**Vapors and/or Gases:**
- Acid etching (all types including hydrofluoric)
- Acid pickling baths
- Electroplating
- Plastic resin casting
- Screen printing (all phases: printing, print drying, screen cleaning)

### Types of Hoods
A hood is the structure through which the contaminated air first enters the system. Hoods can vary from small dust collecting types built around grind wheels to walk-in-sized spray booths. Some hoods which craftspeople may find useful include the following:

**Dust-Collecting Systems**
Most grind wheels, table saws, and other dust-producing machines sold today have dust collecting hoods built into them. Some machines need only to be connected to portable dust collectors which
can be purchased off the shelf. In other cases, stationary ductwork can be used to connect machines to dust collectors. These collectors include cyclones (which settle out particles) and bag houses (which capture particles on fabric filters).

**Spray Booths**
Spray booths (see Figure 4) from small table models to walk-in-sized or larger can be purchased or designed to fit the requirements of a particular shop. Some common uses for spray booths include spraying of paints, lacquers, adhesives and other materials; plastic resin casting, and paint stripping. Since spray paints and other sprays are likely to contain flammable solvents, the spray booth, its ducts and fans, and the area surrounding the booth must be made safe from explosion and fire hazards. Usually, local environmental authorities must approve the installation of these booths.

**Movable Exhaust Systems**
Also called "elephant trunk" systems (see Figure 5), these flexible duct and hood arrangements are designed to remove fumes, gases, and vapors from processes such as welding, soldering, or any small table top processes which use solvents or solvent-containing products. Movable exhausts also can be equipped with pulley systems or mechanical arms designed to move hoods to almost any position.

**Canopy Hood Systems**
These hoods (see Figure 6) take advantage of the fact that hot gases rise. They are used over processes such as hot dye baths, wax and glue pots, stove ranges, and the like. Unfortunately, they often are installed above worktables where they are not only ineffective because the hood is too far from the table, but even dangerous because they draw contaminated air past the worker's face.

**Slot Hood Systems**
These systems (see Figure 7) draw gases and vapors across a work surface, away from the worker. Slot hood systems are good for any kind of bench work, including silk-screen printing, color photo developing, air brushing, and soldering. They are rather expensive to design and build, but they provide a shop with surfaces on which many processes can be safely carried out.

**Getting Systems Installed**
The local exhaust systems require special centrifugal fans in the ducts. Ordinary propeller fans will not work. These systems usually must be designed by ventilation engineers that specialize in industrial systems (as opposed to engineers that design ventilation for office buildings and non-chemical rooms).

If you are planning ventilation for very small shops and individual studios, a good reference called *Ventilation: A Practical Guide*, by Nancy Clark, et. al., (available on Amazon.com) provides basic ventilation principles and calculations. Mechanically inclined craftspeople may be able to use this manual to design and install simple systems.

Craftspeople should not listen to salesmen who tout products which appear to solve ventilation problems cheaply by purifying contaminated air and returning it to the workplace. Some of these devices, such as ozone generators and negative ion generators, are not only useless in most studios, but they can actually be harmful since they generate toxic ozone gas. Others, such as electrostatic precipitators, are very limited in their uses and at best can be used only as adjuncts to traditional
ventilation. For example, they can successfully remove cigarette smoke fume particles, but not the gases and vapors produced by cigarettes.

**Checking the System**

After a ventilation system has been installed, it should be checked to see that it is operating properly. To check the systems, experts use devices which measure air flow. These devices can be purchased for a few hundred dollars from engineering and industrial hygiene catalogs.

But there are simpler ways to check the system:

1. **Can you see the system pulling dust and mists into it?** If not, you might use incense smoke or soap bubbles to check the system visually. When released in the area where the hood should be collecting, the smoke or bubbles should be drawn quickly and completely into the system.

2. **Can you smell any gases or vapors?** Sometimes placing inexpensive perfume near a hood can demonstrate a system’s ability to collect vapors or it can show that exhausted air is returning to the workplace (or some other place where it should not be).

3. **Do people working with the system complain of eye, nose, or throat irritation or have other symptoms?**

4. **Is the fan so noisy and irritating that people would rather endure the pollution than turn it on?** Fans should not be loud, and engineers should be expected to work on the system until it is satisfactory.

5. **Check the maintenance schedules** for changing filters, cleaning ducts, changing fan belts and the like to see that these are being followed faithfully.
Noise, vibration, various kinds of light, and heat can damage the body. There are Threshold Limit Values (TLVs—see Chapter 2) and other guidelines that limit exposure to these physical hazards. And almost every country has regulations that apply to them as well.

**Noise**
Craftspeople perform many noise-producing tasks such as working with power tools and hammering on metal or other hard surfaces. But even playing loud music can produce ear-damaging sound. Signs of overexposure may include a temporary ringing in the ears or difficulty in hearing for a while. Except for these minor symptoms, there are no symptoms or pain to warn people that their hearing is being damaged.

In addition to loss of hearing, noise may also cause increased blood pressure and stress-related illnesses. High blood pressure is also a physical problem which has no symptoms until the pressure causes strokes or heart problems.

Noise is measured in levels of sound intensity called “decibels” (dB). These levels of sound can be measured by instruments used by safety professionals and industrial hygienists. Employers can hire industrial hygienists who will come to a workplace, measure the dB to which people are exposed, and recommend the proper ear protection such as ear plugs or ear muffs.

**Earplugs and Muffs**
If it is not economically feasible to bring in an expert, ear plugs, particularly the foam type, may provide adequate and inexpensive protection for moderate levels of noise. When selecting ear plugs or muffs, look for the attenuation or noise reduction ratings (NRR) on the labels. The larger this number, the greater the protection they provide. For example, ear plugs with a 25 dB NRR would reduce the noise level greater than those with a 10 dB NRR rating.

Make sure you follow package directions and that the ear plugs fit you. Some people’s ear canals are just not the right shape to hold the plugs. Ear muffs are a better solution for these people.

**Vibration**
Hand-held tools also transfer harmful vibration to the user. It may be noticed as a tingling of the hands and arms that usually disappears within an hour. Some people, however, risk a more permanent condition known as "white hand," "dead fingers," or Raynaud's syndrome. This disease, more correctly called Vibration Syndrome, may progress in stages from intermittent tingling, numbness, and white fingertips to pain, ulcerations, and gangrene.

To avoid this condition, use tools with low amplitudes of vibration, keep tools in good condition, take ten-minute work breaks for every hour of continuous exposure, maintain normal workplace temperatures (cold weather aggravates the condition), and grasp tools firmly, but not harder than needed for safe use. Gripping vibrating tools tightly is thought to increase the risk of developing this disease. See also *Ergonomic Injuries* below.
Light
Light occurs in many forms from very short waves of ultraviolet light, through visible light and to infrared or heat radiation (see Table 3).

**Table 3**
**Regions of the Optical Radiation Spectrum**

<table>
<thead>
<tr>
<th>Region</th>
<th>Wavelength Range nanometers (nm)</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultraviolet (UV)</td>
<td>100 to 380-400</td>
<td>Severe eye damage, cancer</td>
</tr>
<tr>
<td>Visible (light)</td>
<td>380-400 to 760-780</td>
<td>Eye strain if either too much or too little light is present during work</td>
</tr>
<tr>
<td>Infrared (IR)</td>
<td>760-780 to 1,000,000</td>
<td>Burns to the skin and cataracts in the eyes from the heat they produce in the body</td>
</tr>
</tbody>
</table>

Natural Light
Natural light from the sun contains a wide spectrum of visible, ultraviolet, and infrared rays. Artificial light contains a more limited array of light waves. It is well known that ultraviolet rays from the sun can damage the skin and eyes, and even cause skin cancer.

Artificial Light
Artificial light also contains a wide spectrum of light. Incandescent bulbs, computer monitors, and most of the small light bulb-sized fluorescent lights usually do not produce sufficient ultraviolet light to be any risk. Large fluorescent lights, halide and mercury vapor lights, however, can produce ultraviolet radiation sufficient to be harmful. Fixtures containing these types of bulbs should have glass or plastic radiation shields. Follow the manufacturer’s directions for the specific types of bulbs you use.

Eyestrain can be caused if your work area has either too much or too little light or if the lighting produces a glare on the object being crafted. This eye strain can lead to fatigue and accidents. The best workplace lighting usually is diffuse overhead lighting for general illumination combined with a smaller direct light on the task at hand.

Light from computer monitors also are associated with eye strain. Crafters who also use computers for long hours should get regular eye examinations and take frequent work breaks.

Ultraviolet (UV) Radiation
Two common ultraviolet sources are sunlight and welding. Skin cancer can occur in welders and people exposed to too much sunlight. Ultraviolet light from welding is also known to cause eye damage even blindness. Simply walking past someone who is arc welding can result in a painful “flash burn” which feels as if sand was in your eye. It may take several days for a flash burn to heal. In rare cases, permanent damage has been caused by flash burns. The precise type or shade of lens must be chosen for each type of welding.
Sunlight is another source of ultraviolet light. Good sunglasses that can block 80% or more of the sun’s UV rays should be used in strong sunlight. Sun screen creams can be used to protect the skin.

**Infrared Radiation (IR)**

Infrared radiation is also produced by the sun. And it is produced whenever metals, glass, or ceramic materials are heated until they glow red or hotter.

Infrared radiation can damage the eye by producing cataracts. The cataracts appear to be caused when the lens of the eye is heated by radiation. There usually are few if any symptoms to alert people to the fact that their eyes are being damaged. These infrared cataracts have been seen in potters, glassblowers, and enamellists who spend years looking into their kilns and furnaces.

Wear glasses that block infrared radiation. There are special goggles for glassblowers and potters that usually will provide protection. You can also use welding goggles for this (use shade numbers 2 to 4).

**Electrical Current**

Electric current can be harmful and electrocution is a hazard we all face daily. Crafts makers often face the problems of not enough voltage, not enough outlets for all their equipment, and some crafts also involve the use of water, which puts people at even greater risk.

Almost everyone who uses electrical appliances is familiar with the safety rules. Everyone knows to keep all electrical equipment and wiring in good repair and to never overload circuits. However, this is often difficult when we are working in old buildings with inadequate wiring. Whenever setting up a new shop, make it a priority to provide adequate electrical service and enough outlets and current for the equipment you need to use.

If water will be used in the work such as in dye vats, potters wheels, power washing of prints or fabrics, have an electrician specially wire the outlets to be “ground fault circuit interrupted.” These are special outlets that will shut off the current whenever a ground fault is detected which could save your life if you are standing on a damp floor.

Always buy electrical tools which have three prong plugs (are grounded) or which are double insulated. Look for a ground-wired plug or for labels or decals on equipment indicating they are grounded or double insulated before purchasing tools.

**EMF: A Special Electrical Hazard**

Electromagnetic Frequency or EMF is also emitted from all electrical appliances. This includes video display terminals, cell phones, electric motors and all sources of electric current. This kind of radiation was thought to be harmless for many years. Now there are some studies that link brain tumors to cell phone use and link increased cancer rates in children to their living near power lines. However, at this time there is no conclusive evidence that these effects are due to radiation.

To be on the safe side, pregnant women and children in particular should limit their use of cell phones or their time spent in close proximity to electrical power lines and high voltage equipment.
Stress on the Body (Ergonomic Injuries)
Craft workers often engage in activities that cause unusual bodily stresses and strains. Potters, glassblowers, and weavers, for example, engage in repetitive actions which cause wear and tear on their muscles and tendons. "Potter's thumb," for instance, is the term some potters have used to describe symptoms which are now associated with the early stages of carpal tunnel syndrome, a debilitating nerve problem.

Workers doing tasks which employ repetitive, forceful, or awkward motions are injured at rates far higher than workers doing less physical work. These are called "ergonomic" injuries. Ergonomics is the science of preventing injuries to the muscles, ligaments and/or bones called musculoskeletal disorders. Factors which increase the risk of developing this disease include:

**Repetition:** Two major examples are: repeating a motion more than twice per minute for more than two consecutive hours and using a keyboard and/or mouse for more than four hours steadily.

**Awkward Postures:** These can include working with the hands above the head or the elbows above the shoulders for more than two hours per day, kneeling or squatting for more than two hours total per day, or working the back, neck or wrist bent or twisted for more than two hours total per day. Sitting long hours can also increase the risk of developing hemorrhoids or urinary tract infections.

**Contact Stress:** Using the hand or other part of the body to hit or push something.

**Vibration:** Vibration for 1) high vibration tools such as chainsaws and jack hammers; and 2) tools with moderate vibration levels such as grinders and sanders.

**Force:** Four categories of force are lifting, pushing/pulling, pinching, and gripping. For example, lifting more than 75 pounds at any one time, more than 55 pounds more than 10 times per day; or more than 25 pounds below the knees, above the shoulders, or at arms' length more than 25 times per day are well-documented to cause ergonomic injury.

**Prevention**
To prevent these injuries, craft workers must pay careful attention to their bodies for signs of fatigue, pain, changes in endurance, weakness, and the like. In other words, listen to your body while it is still whispering rather than waiting until pain shouts for attention. Certain good work habits can help to resolve early symptoms. Some of these are:

Keep good posture.
Take frequent rest and bathroom breaks.
Alternate tasks or vary the type of work done frequently.
Warm up muscles before work; move and stretch muscles during breaks.
Ease back into heavy work schedules rather than expecting to work at full capacity immediately after holidays or periods away from work.
Modify techniques and/or equipment to avoid uncomfortable positions or movements.
Buy some of the tools, machines, and office furniture for the shop that have been redesigned to enable workers to avoid the awkward positions that cause such injuries.
If your symptoms do not respond quickly to better work habits, seek medical attention. Early medical intervention will cause the majority of ergonomic injuries to resolve without expensive treatment or surgery. Delaying treatment can leave you disabled for long periods of time or even for life.
There are a number of general precautions which should be used in all craft shops at all times.

**Housekeeping**
The most important safety rule is housekeeping: keeping the craft shop clean, neat and dry. This is not only wise, it’s the law in most counties. Providing a safe and sanitary workplace is a primary requirement for employers worldwide. It must be free of clutter and trip hazards. Clear aisles must be maintained so that people can walk about without tripping and to be able get out quickly if needed in an emergency.

**Dusts**
Use common sense when cleaning the shop. If dusts are present, do not sweep unless you can wear a respirator or other protection. Wet mopping is the preferred method to clean up toxic dusts such as metal fumes from welding or silica from clay dust.

**Water Spills & Leaks**
Do not allow spills of water or other liquids to remain on floors, making them slippery. Clean up spills around sinks, dye pots, and potters wheels. When water cannot be addressed immediately, special mats or slatted flooring should to be installed so that people will not slip.

Failure to address water in the workplace can also result in the growth of molds and bacteria, some of which cause disease. Clean and disinfect areas where mold is seen or bacterial odors are noted. If mold is a regular problem, a dehumidifier can be installed. Mold will not grow and becomes dormant when humidity is low. Even opening windows or turning on ventilation systems can reduce mold growth.

If there is severe water damage, such as from a flood or major plumbing leak, discard carpet, wall board, or other porous materials that have been soaking wet for more than 48 hours to prevent mold and bacterial growth.

**Personal Hygiene**
One of the simplest and most neglected methods of avoiding exposure to toxic substances is to practice good hygiene in the workplace. Studies show that tiny amounts of toxic substances left on the skin, or brought home on clothing can affect even the workers’ families. Some basic hygiene rules include the following:

- **Do not eat, drink or smoke** in studios, shops, or other environments where there are toxic materials. Dust settles on food, vapors can be absorbed by food, and soiled hands can transfer toxic substances to food and cigarettes. Smoking is especially hazardous because some substances inhaled through a cigarette can be converted by the heat to more hazardous forms.

- **Wear work clothes** and, if possible, change clothes and leave the work clothing in the shop. Wash work clothes frequently and separately from other clothing. If the workplace is dusty, wear some hair covering. And for safety as well as hygiene, tie back long hair, do not wear loose clothing, scarves or ties, or jewelry.
• **Wash hands carefully** after work, before eating, using the bathroom, and applying make-up.

**Storing Materials**
There must be order and safety in the storage of materials. Do not allow piles of items that teeter and can fall or shelving that is not strong enough for the materials loaded on them. And if the shelving or storage is above easy reach, a good ladder or step stool should be provided rather than having people climb up on chairs and boxes.

Make a complete list of all the chemical products in the shop and make sure every commercial product is well-labeled and has a material safety data sheet on file. Many accidents, spills, and fires can be avoided by following rules for safe storage and handling of materials.

• **Clearly mark** every bottle, box, or gas cylinder as to its contents, its hazards, and the date received and opened. Never have unlabeled containers in the shop.

• **Apply good bookkeeping rules to chemical storage.** Keep a current inventory and location information on all the materials on hand. Post locations of flammable or toxic materials and dispose of chemicals that have limited shelf-lives. Some of these can become dangerous when old.

• **Use unbreakable containers** such as plastics whenever possible.

• **Have cleaning supplies and facilities** for handling of spills at hand. Never store any material which you are not prepared to control or clean up if it spills. If respiratory protection, gloves, or other personal protective equipment will be needed for cleaning up spills, have these in the studio at all times.

• **Organize storage wisely.** For example, do not store large containers on high shelves where they are difficult to retrieve. If storage is above arm’s reach, a step stool or ladder of the correct height must be available in the room. Never store hazardous chemicals directly on the floor where they can be kicked over or above shoulder height where they can fall and spill.

• **Store reactive chemicals separately.** Check each product’s MSDS and other technical sources for advice about storage.

• **Keep all containers closed** except when using them.

• **Ventilate the storage room.** Keep it cool and keep chemicals out of direct sunlight.

• **Do not allow dispensing or mixing of chemicals in or near the storage area.**

• **If chemical corrosives or irritants are stored,** install an eye wash station and emergency shower.

• **Storage of flammable chemicals should conform to all state and provincial fire regulations.** Contact your local authorities for advice. Store large amounts of flammable solvents in metal...
non-flammable storage cabinets or specially designed storage rooms.

- **Install fire suppression systems or extinguishers** that are approved for fires caused by the types of chemicals stored. Train all workers about the fire protection used in your shop.

**Eye & Face Protection**

Impact of particles (from chipping, grinding, etc.) and chemical splash (solvents, acids, etc.) can damage the skin, face and eyes.

**Impact**

There are special glasses which are designed to protect you from flying particles. Only glasses with side shields specifically designed to resist high impact should be used. Face shields will protect the skin on your face from particles as well. But face shields are usually not strong enough to prevent penetration of really fast moving particles such as those from grind wheels or other types of power tools. Safety eye glasses should be worn underneath face shields.

Only purchase safety glasses for which the manufacturer provides written assurance that they will resist high impact. Glasses that merely look like they should work may not provide protection.

**Chemical Splashes**

If you work with corrosives or irritants such as solvents or acids protect your skin and eyes from chemical splash. Do not wear safety glasses rated for impact because they do not seal to the skin to keep chemicals away. Chemical splash protection eyewear seals tightly to the face. Some types have small ventilation holes on the sides to prevent fogging. These are acceptable for solvents and acids that are not extremely hazardous. But if concentrated acids are used, the splash goggles should have no small holes. Instead, they should have special indirect vents that air can enter or no vents at all. Follow the manufacturer’s directions for proper use and maintenance of the goggles.

Shops where corrosives are used should have water available to flush the eyes for at least fifteen minutes. There are special eye wash fountains for this purpose. If you can’t get or afford one of these, at least have a hand-held hose that can be adjusted to provide a gentle stream of water for the required 15 minutes and always work with another worker who can help you. And after flushing the chemicals, get medical advice.

**Skin & Hand Protection**

Burns and chemical splashes can also damage the skin. Wear clothing that will protect your skin. If the particles are hot (e.g. sparks) wear clothing that cannot melt or burn easily such as polyester or rayon. Wear cotton, wool or fabrics that have been treated to be fire resistant. Manufacturers’ catalogues often provide access to proper gloves for purposes such as protection from heat, radiation, and abrasion. Asbestos gloves should not be used -- substitutes for them are available.

If you work with corrosive or toxic chemicals, have water available to wash the skin. Protect your hands with chemical-resistant gloves. These can be purchased in any length up to shoulder length, and in any thickness from paper thin to very thick, and in many types of plastic and rubber to resist almost every kind of material.

Surgical or ordinary household gloves should not be expected to stand up to solvents, acids, and other strong chemicals. Avoid natural rubber gloves whenever possible (see next Chapter) to avoid
developing allergies from wearing them. There are many other types of plastics from which gloves are made.

Find a glove supplier who provides information that indicates how long each type of glove material can be in contact with a chemical before it is 1) degraded and 2) permeated. Degradation occurs when the glove deteriorates from the chemical's attack. Permeation occurs when molecules of the chemical squirm through the glove material. Permeated gloves often appear unchanged and the wearer may be unaware they are being exposed to the chemical. Common solvents like acetone and toluene can penetrate certain chemical gloves in minutes and begin damaging and/or penetrating the skin.

Do not use harsh hand soap. Never wash your hands with solvents. Rubbing baby oil (mineral oil) on the skin and then washing with soap and water will remove many paints and inks. Using a barrier cream prior to working should enable you to wash off paints with soap and water. After cleaning your skin, apply a good hand lotion to replace any lost skin oils.

The skin on the rest of the body can be protected by aprons, leggings, leather or plastic clothing, shoes, and many other special safety products.

When Accidents Happen Anyway
Be prepared for accidents. Every country has agencies which teach basic first aid. At least one person in each shop should have this training. If you work alone, it is also a good idea to take first aid training; it could save your life. Keep first aid equipment handy. At a minimum, keep the items listed in Table 4 on hand.

<table>
<thead>
<tr>
<th>Description of Products Needed</th>
<th>Quantity*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Absorbent compress</strong>, 4 x 8 inch minimum</td>
<td>At least 2</td>
</tr>
<tr>
<td><strong>Adhesive bandages</strong>, 1 x 3 inch</td>
<td>10-15</td>
</tr>
<tr>
<td><strong>Adhesive tape</strong></td>
<td>1 roll</td>
</tr>
<tr>
<td><strong>Antiseptic salve</strong>, 0.5 grams (g) each</td>
<td>0-15 (5 yards)</td>
</tr>
<tr>
<td><strong>Burn treatment</strong>, 0.5 g application</td>
<td>10-15</td>
</tr>
<tr>
<td><strong>Sterile pad</strong>, 3 x 3 inch</td>
<td>5 or more</td>
</tr>
<tr>
<td><strong>Medical exam gloves</strong></td>
<td>2 pair or more</td>
</tr>
<tr>
<td><strong>Triangular bandage</strong>, 40 x 40 x 56 inch</td>
<td>at least 1</td>
</tr>
<tr>
<td><strong>Tourniquet</strong></td>
<td>1</td>
</tr>
<tr>
<td><strong>Pain medication</strong> (aspirin, acetaminophen, etc.)</td>
<td>5 or 10 single dose packets</td>
</tr>
</tbody>
</table>

* Some countries have regulations about what must be in workplace first aid kits. Check your local regulations.
You & Your Doctor
Get regular check-ups from a physician. Medical monitoring can be a valuable tool in early recognition and prevention of occupational illnesses.

Two examples of useful medical tests are regular (in some cases yearly) lung function tests for craftspeople exposed to dusts and blood tests for lead for those artists using lead-containing materials. There are special blood or urine tests for several other toxic metals and many organic chemical exposures as well.

Choosing the right tests and interpreting the results can be done best by doctors who are in the field of Occupational Medicine or Toxicology, or who have experience with occupational health problems. If you only have access to a general physician, explain the nature of your work and bring MSDSs with you to help you explain the chemical hazards you face.
Plants Can Be Toxic
Worldwide, there seems to be a misconception that materials derived from plants and trees are always safe. But, if you think about it, the vast majority of the plants on this earth are not food and, in fact, would be harmful if we ate them. There are only a relatively small number of plants which can be ingested and it took humans millions of years to determine which ones were safe to gather from the wild or to cultivate.

Ingestion of many plants can be fatal. Examples include the deadly nightshade and rhubarb leaves which contain high concentrations of oxalic acid. Ricin, the deadliest poison known and one used in chemical warfare, is extracted from caster beans.

Inhalation of plant material is almost always harmful. For example, airborne pollens are a major cause of asthma and allergies, dust from cotton and other natural fibers can cause potentially fatal lung diseases, and wood dust causes respiratory allergies and cancer (see wood hazards below).

Extracts from plants and trees can be highly toxic. Turpentine from pine trees can cause allergies, kidney and bladder damage. And there are a host of plant extracts which are used as both legal and illegal drugs where the benefits and death are only a dose of a few milligrams apart.

All of this should not be surprising if we consider that plants and trees have survived over millions of years by learning to create vast numbers of chemicals. These chemicals are used by plants to feed, propagate, and protect themselves from insects and plant diseases. For example, two commonly used pesticides today are pyrethrin from chrysanthemums and the fly killer d-limonene, from citrus fruit rind oil.

Craftspeople need to use the same precautions when working with both natural and synthetic materials.

Plant Hazards
Plant materials such as flowers, fruit, leaves, plant roots, sea grass, seeds, and straw are used in craft items. Baskets, objects, and textile-like items can also be made from cane, abaca, cabecinegro, damagua, pita fiber, rattan or raffia. And textiles can be purchased or woven from plant fibers such as cotton, hemp, jute, flax, and sisal.

For centuries, occupational diseases such as dermatitis and weaver's cough (brown lung) have been associated with exposure to certain plant fibers including flax, hemp, sisal, and cotton. This debilitating disease, also known as byssinosis, has disabled thousands of workers worldwide. Its early symptoms include chest tightness, shortness of breath, and increased sputum flow, commonly worsening when the worker returns to work after being away a few days. The condition is reversible if exposure ceases, but after ten or twenty years of exposure, the disease can progress without further exposure and may be fatal.

Long years of exposure to hemp, sisal, jute, and flax dusts also are associated with chronic bronchitis, emphysema, and various allergic conditions. Some of these illnesses may be caused or
made worse by mildew, fungus spores, dyes, and fiber treatments (like permanent press or sizing) rather than by the fiber itself.

These health effects from cotton, hemp, sisal, flax and jute are known because large numbers of workers in industry working with these fibers have been studied. But there are no large studies of workers exposed to abaca, cabecinegro, pita fiber, rattan or majority of the other plant substances we use. We must assume that dusts from these fibers is also not good for you. Try to avoid inhaling them.

**Synthetic Fiber Hazards**

Synthetic fibers include rayon, acetate, nylon, polyester and acrylics. Their hazards also are not well-studied, but there are enough individual cases of illness to suggest that these fibers can cause respiratory problems, too. For example, nylon flocking (the velvet-like fibers glued to a substrate) has been shown in studies in Canada and Rhode Island to cause a disabling lung disease now called "flock worker's lung."

Polyethylene fibers have also been associated with illnesses. In one interesting case, a 37-year-old nonsmoker exposed for only two days to polyethylene fiber required medication, turbinate bone surgery, and mechanical washing of the lungs over an eleven-month period of time to correct the lung problems from inhaled fibers.

**Fiber Treatments**

Some fibers and textiles have been treated with chemical flame retardants, moth repellants, permanent press and stain resistant chemicals. Some of the permanent press chemicals are resins that release formaldehyde. One of the major stain resistant chemicals (perfluorooctyl sulfonate) used in the US was recently phased out because it was found to be an environmental hazard. But little is known about most of the fiber treatment chemicals and manufacturers of textiles usually do not release the identity of these chemicals to customers.

Imported textiles and basketry materials also must be treated with pesticides to prevent insects and plant diseases from being carried from one country to another. Either the pesticides are applied by the exporter, or the materials will be fumigated by the importer. But no one really checks to see if the pesticide residue on the plant materials will be a hazard to the crafters using them. Imported rattan fiber can be highly contaminated with the pesticide alpha benzene hexachloride – a pesticide which also will absorb through the skin of people handling the rattan.

Wall hangings, rugs, and other furnishings must either be made of fibers that do not readily burn (e.g., wool) or they must be treated with fire retardant chemicals and tested. Products without fire certificates can’t be used in public buildings in many countries.

**Weaving, Sewing, Basketry and Other Techniques**

Weaving, sewing, embroidering (by machine or by hand), stitching, hemming, mending, tasseling, warping cloth, spinning, knitting, macramé, and similar processes involve potential dust exposures, skin cuts and punctures from needles, and sitting and using the hands in repetitive actions for long periods of time.

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Precautions for Fiber Artists

1. **Purchase fibers and textiles from reliable suppliers** who will provide information about the origin of the materials, the dyes or pesticide treatments, fire retardants, etc.

2. **Purchase cleaned or washed fibers or textiles** when possible. If raw, uncleaned materials are used, get advice on the best methods for cleaning and disinfecting the fibers.

3. **Wash or wear gloves** when working with imported plant materials as these are almost surely treated with pesticides. If your budget permits, send samples to a lab to identify the pesticide.

4. **Do not use mildewed or musty materials.** Store fibers in clean dry places to avoid growth of micro-organisms.

5. **Avoid dust.** For example, use proper-sized needles in loom shuttles. Damp mop or sponge up dusts rather than sweeping or vacuuming. Shake out fabrics outdoors.

6. **Obtain information on moth-proofing, sizing, permanent press and other treatments** which have been applied to your materials. If the work is to be installed in a public building, be able to provide a certificate showing the materials meet fire retardant standards. If you apply treatment chemicals yourself, obtain Material Safety Data Sheets and/or ingredient information and follow precautionary instructions.

7. **Adjust the height of chairs, looms, and worktables for ergonomic comfort.** Take breaks (perhaps five minutes each half hour), stretch and exercise to relieve strain.

8. **Provide proper lighting for weaving, computer work, and other tasks.**

9. **Needles, pins, blades, or any other small sharp objects that puncture the skin should be considered blood-contaminated.** These sharps should either be discarded as medical waste or sterilized before being reused.

10. **Crafters exposed to fiber dusts should have their doctor check their lungs** periodically for early symptoms of those occupational diseases known to be caused by fiber dusts.

11. **Also follow all applicable precautions listed in Chapter 7.**

Wood Dust Hazards
Many artists consider wood dust as nothing more than a nuisance. It is far more than that. Wood dust has caused countless fires and explosions. A spark or static discharge is sufficient to detonate fine airborne sawdust.

In addition, some wood dusts cause allergic reactions of the skin (dermatitis) or lungs (e.g., asthma), some woods are toxic, and others have been treated with highly toxic pesticides, preservatives, flame retardants and other chemicals. Certain types of wood are known to cause cancer.
**Dermatitis**
There are two common types of wood-related skin diseases. One of these is irritant dermatitis which is caused most often by exposure to the sap and bark of some trees. It will affect artists if they cut trees, saw raw timber, or work with woods known to contain irritants such as cashew wood.

The other major wood-related skin disease is sensitization dermatitis. It results from an allergy to sensitizing substances present in some woods. The symptoms may start as redness and inflammation, and may proceed to severe eczema, fissuring and cracking of the skin. The condition may arise anywhere on the body that the sawdust contacted.

Some exotic woods have even caused dermatitis in persons exposed only to the solid wood, not to its dust. Rosewoods are one such type. Prolonged contact with rosewood or cocobolo musical instruments, bracelets, or knife handles has been known to cause sensitization dermatitis.

**Respiratory System Effects**
Problems such as damage to the mucous membranes, and dryness and soreness of the throat, larynx, and trachea can be caused by some woods, especially sequoia and western red cedar. These effects may proceed to nosebleeds, coughing blood, nausea, and headache. Eye irritation usually occurs as well.

Lung problems -- like asthma and alveolitis (inflammation of the lungs’ air sacs) -- affect a minority of workers exposed to irritant sawdust. However, these are serious diseases and a few woods, such as sequoia and cork oak can cause permanent lung damage. The symptoms may not appear until several hours after sawdust exposure, making diagnosis difficult. Any persistent or recurring lung problems should be reported to a physician familiar with wood dust hazards.

Some trees deposit significant amounts of silica in their heartwood and inhalation of dust from this wood can cause a lung disease called silicosis (see silica in Chapter 14).

**Cancer**
While some woods such as oak and beech have been studied well and proven to cause cancer, many experts think all wood dusts would be shown to cause cancer if significant numbers of exposed workers could be studied. The most prevalent cancer related to wood dust is cancer of the nasal cavity and nasal sinuses. Several studies and surveys have found that the majority of nasal cancers worldwide occur in woodworkers.

Early symptoms of nasal sinus cancer may include persistent nasal dripping, stuffiness, or frequent nosebleeds. The good news is that early surgical intervention can often result in a complete cure.

**Toxic Effects**
Some woods contain small amounts of toxic chemicals that may be absorbed through the respiratory tract, intestines, or occasionally through skin abrasions. These chemicals may cause symptoms such as headache, salivation, thirst, nausea, giddiness, drowsiness, colic, cramps, and irregular heart beat.

Some woods such as yew or oleander contain such high levels of toxic substances that poisoning has occurred from food containers, spoons, or spits made from these woods.
Some dark woods such as purple heart and walnut contain dyes and dyeing with wood chips is a technique still done by craft dyers. A dye chemical in walnut wood and nut hulls (juglone) may be the agent that has sickened horses and killed dogs that have chewed on the wood or hulls.

Unknown Hazards
Common woods such a pine, maple, oak, and beech have been studied for toxic composition. There also is information about toxic woods such as mahogany and teak. But crafters often work with woods we know little about such as Japanese and Indian bamboo, firewood, tagua nuts, and wicker.

But in general, the darker the wood, the more hazardous it is likely to be. The darker the color, the more chemicals are likely to be in the wood. This is because the major ingredient in wood is cellulose which is white. And cellulose is not toxic, cancer-causing or an allergen.

Rubber Trees: A Special Problem
Natural rubber is made from the sap of hevea trees. It contains a chemical called isoprene, which can be reacted to form a polymer or plastic-like material called polyisoprene -- the fancy name for natural rubber.

The natural rubber latex sap also contains many impurities including about 200 different proteins. Fifty of these proteins can cause allergies. The proteins cannot be completely removed from finished natural rubber products.

Allergies to natural rubber are serious. Symptoms include: skin rash and inflammation, hives, respiratory irritation, asthma, and systemic anaphylactic shock. In the United States between 1988 and 1992, the US Food and Drug Administration received reports of 1000 systemic shock reactions to latex. As of June 1996, twenty-eight latex-related deaths had been reported.

While these serious reactions are seen primarily among medical professionals and patients, anyone working with natural rubber latex products regularly is at risk.

Precautions for Rubber Trees & Products

1. **Switch from rubber to plastic gloves if possible.** If rubber latex gloves must be used, use reduced-protein gloves and powder-free gloves. The powder used as a lubricant can increase exposure though skin contact and inhalation.

2. **Avoid skin contact with rubber-containing adhesives, rubber plants or trees, or any other natural-rubber product.** If contact can’t be avoided, wash your hands with a mild soap immediately after removing latex gloves or working with rubber-containing products.

3. **Be alert for reactions such as itching or rashes** so you can take action promptly before the allergy gets out of hand.

4. **See your doctor if allergy symptoms start.** There is no remedy for latex allergy, but some medications can reduce symptoms. If you are diagnosed with rubber latex allergy, plan to avoid all products containing natural rubber.
5. **Learn about your latex allergies.** For instance, you should know that allergies to certain foods like avocados, potatoes, bananas, tomatoes, chestnuts, kiwi fruit, and papaya contain similar proteins and can exacerbate a latex allergy.

**Exposure Levels Applicable to Wood Dust**
The American Conference of Governmental Industrial hygienists (see Chapter 2) has set various Threshold Limit Values (TLV, eight hour time weighted averages) for wood dust. The current active standards are 1 milligram per cubic meter (mg/m$^3$) for most wood dusts. The organization’s rationale for this standard includes the following statement:

[The] principal health effects reported from exposure to wood dust are dermatitis and increased risk of upper respiratory tract disease. Epidemiologic studies of furniture workers have indicated an excess of lung, tongue, pharynx, and nasal cancer ...Certain exotic woods ... contain alkaloids that can cause headache, anorexia, nausea, bradycardia, and dyspnea on inhalation.²

One wood, Western red cedar, has an even lower TLV of 0.5 mg/m$^3$ due to its ability to cause severe respiratory allergies.

**Treated Wood**
Almost every imported wood and most domestic woods have been treated with some kind of additive. These can include fire retardants, pesticides, and preservatives. These chemicals range in toxicity from relatively safe to highly toxic. The most hazardous of the additives are pesticides applied to wood intended for use in contact with the outdoor elements.

It is usually difficult to find out exactly what chemicals have been used on wood. Three common wood preservatives are pentachlorophenol (PCP), arsenic-containing compounds, and creosote. These three types of preservatives are associated with cancer, birth defects, and many other hazards. Wood preserved with these chemicals is banned in most countries except for certain outdoor uses, so craft workers should avoid them. There are many other more suitable preservatives on the market. Two types are metal naphthanates and various boron compounds.

**Plywood & Composition Boards**
Many health effects also can be caused by wood glues and adhesives. Plywood, fiberboards, medium density fiberboard (MDF) and many other wood products contain urea-formaldehyde or phenol-formaldehyde resins. These glues release formaldehyde gas which is a strong eye and respiratory irritant and allergen. Formaldehyde is also a suspect carcinogen known to cause nasal sinus cancer in animals.

Some manufacturers are using adhesives that do not release formaldehyde such as urethane plastics. These boards are usually more expensive.

**Wood Burning**
Burning wood or any other plant material will produce toxic smoke and substances that cause cancer. See “smoke” in Chapter 2.

Paper
Paper is usually made from either fiber (rags) or wood. Paper dusts may have similar hazards and also need to be controlled.

Precautions for Wood Use

1. **Avoid inhalation of dust from all woods.** Especially avoid inhaling dust from known toxic or allergy-provoking woods and woods treated with PCP, arsenic or creosote.

2. **For occupational health problems, consult a doctor** and pay special attention to your sinuses and upper respiratory tract. Suspect that a health problem may be related to your work if it is alleviated on weekends or during vacations.

3. **Use shaping methods that do not create much dust,** such as chiseling or sharpening, or use ventilation to control dusts from sawing and sanding. Ventilation is also needed if wood materials are burned.

4. **Wear ear plugs** to protect your hearing if noisy power saws and machines are used.

5. **Be prepared for accidents** such as cuts by having a first aid kit and some training. Never work alone with machinery, cutting or shaping tools.

6. **Be aware that wood dusts are highly combustible.** Clean up the studio including getting accumulated dust off of all surfaces, pipes, fixtures and walls.

7. **Follow all additional general precautions listed in Chapter 7.**
CHAPTER 9
ANIMAL PRODUCTS: WOOL, SILK, LEATHER, HORN, BONE & SHELL

For centuries, occupational diseases such as dermatitis, skin and lung diseases have been associated with exposure to textiles made from wool, silk, and other animal fibers, and to working with leather, bone, horn and shell.

Animal Fiber Hazards
Fibers used by artists may include wool, silk, hair from goats, alpaca, horses, rabbit, dogs, and other animals. Allergies to such fibers or animal dander are common and can affect fiber artists.

Many allergic reactions to animal fibers are not from the fibers themselves, but from mold, mildew, bacteria, and other organisms which can contaminate fibers. Contaminants from fiber processing can also cause reactions. For example, greasy wool can contain toxic sheep dip chemicals. Uncarded or dirty wool or hair can contain little twigs and grass seeds which can cut or puncture the fingers of weavers and spinners.

Diseases Transmitted from Animals to Humans
Animal diseases that can be transmitted to people from live animals often can be transmitted to users of animal fibers, leather, bone or other animal products. The most well-known of these diseases is anthrax.

Anthrax
Inhalation of invisible anthrax spores while working with wool, hair, leather, horn or bone harvested from diseased animals can cause a virulent, often fatal lung infectious disease. Anthrax can also infect the skin, and this disease, if treated promptly, is rarely fatal.

Anthrax is caused by bacteria that live in the soil worldwide. Outbreaks of the disease begin when grazing animals, either domestic or wild, become weak and stressed by hunger and begin ingesting more soil as they crop the grass shorter. Once established in one group of animals, the disease can be passed from prey to predator and from one species to another.

Once animals are infected, all of their products – meat, hide, fur, bone and horn – can be infected. There has even been a case of fatal anthrax in a craftsman making piano keys from elephant ivory reported in the International Labor Organization Encyclopedia in 1983.

Craftspeople can be at risk of purchasing anthrax-contaminated materials when governmental agricultural and import surveillance programs are inefficient. Anthrax also can be brought into countries by individual craftspeople who bring in animal materials from other countries in their personal luggage.

In 1976, an artist-weaver in the United States died from contact with anthrax-contaminated Pakistani wool that was not detected by import inspectors. In 2006, another death occurred in Scotland when a drum maker was working with animal hides from Africa. In the US there were two drum makers who contracted anthrax from African hides in 2006 and 2007 and one of these almost died. (This list does not include a number of anthrax deaths related to domestic terrorism in the US.)
Other Diseases
Other diseases which affect those working with animal products include Q fever, mange, lice, and more. Even working with dog hair can be hazardous since dog tapeworm larva can cause hyatids (cysts) to form in the liver, skin, and other areas of the body. Foot and mouth disease, a group of fatal brain (spongeform encephalitis) diseases such as mad cow, scrapie, (affecting sheep primarily), hantavirus, avian flu, and even rabies could be transmitted by working with animal materials.

Craftspeople who harvest animal products are most at risk. These people might want to consider getting vaccinated against anthrax, tetanus, and other common diseases. Otherwise, craft workers should work only with sources from apparently healthy animals and follow all good hygiene work practices.

Leather Tanning Chemicals
Statistical studies of leather workers have shown high rates of bladder and nasal sinus cancer. These effects may be related to the tanning chemicals used to preserve hides.

Leather can be preserved with extracts from certain plants which are natural sources of tannic acid are still used for "vegetable tanning" of sole and heavy duty leathers. Many other leathers are tanned with minerals such as the sulfates of chromium, aluminum, or zirconium. Other tanning chemicals include sulfonated phenol or naphthols that have been condensed with formaldehyde. A few special leathers and skins for taxidermy and natural history specimens also may be treated with arsenic and powerful pesticides.

Tannin is a suspect carcinogen. Chrome sulfates and some other chrome compounds are sensitizers and suspect carcinogens. Synthetic tanning chemicals such as sulfonated phenols are very toxic. Craftspeople who apply the tanning chemicals are most at risk, but all users of tanned leather will have some exposure to them.

Tanners should also remember that human skin also can be tanned. Tanning chemicals should be kept off the skin.

Fiber Treatments
Many fabrics are treated with chemicals such as formaldehyde-emitting permanent press treatments, sizing, fire retardants, stain-guarding chemicals, moth proofing, and the like. Some of these have been shown to cause allergies and other effects while many others have not been well-studied. For example, a complex organic chemical fire retardant called “tris” was used for many years, even in children’s sleepwear, until it was found to be a carcinogen.

Artists who have unusual reactions to working with particular materials should also consider fiber and fabric treatment as a possible source of the difficulty. When applying fiber treatments themselves, artists should obtain as much information about the chemicals as possible.

Dyeing
Dyes can be used on all animal fibers, leather, and other animal products (see dye hazards in Chapter 10).
Adhesives
There are a number of leather and fabric glues on the market. Many contain highly toxic solvents and are highly flammable. (See Chapter 11 for information on how to handle these products.)

Cleaning & Finishing Leather
Cleaning can be done with oxalic acid or saddle soaps. Saddle soap has no significant hazards unless it is preserved with strong pesticides. Oxalic acid is corrosive to skin, eyes, digestive, and respiratory tracts. Once absorbed, oxalic acid is damaging to the kidneys.

Finishes for leather may consist of oils such as neatsfoot oil and waxes, most of which have no significant hazards. Other types of leather finish are lacquers and resins dissolved in solvents. Skin contact and inhalation of these can be hazardous.

Cleaning Textiles
Most of the soaps and detergents used to wash fabrics are not very toxic. Some, however, such as the phosphate detergents, can cause environmental damage. Dry cleaning solvents can be hazardous (see Chapter 11).

Accidents & Ergonomic Injuries
Tools such as knives, awls, punches, and a host of specialized tools are used in leather work. Needles, sewing machines, scissors and many other sharp tools are used in textile work. Care should be taken to keep these tools in good repair and to use them safely.

Sanding of leather, horn, and bone can be done by hand or with electric sanders. This sanding dust contains not only the animal material, but any tanning chemicals, dyes, or glues present on the substance. Dust exposure should be prevented and eyes should be protected from flying particles.

Some of these processes involve repetitive actions such as during pounding of silk and other textiles, cutting with scissors, using leather awls and punches and the like. (See chapter 6 for more information on preventing these injuries.)

Bone, Antler, Ivory and Horn
There are some special hazards associated with harvesting these animal materials because toxic solvents often are used to dissolve fats and oils from these materials to clean them. In addition, some crafts involve decorating these materials by burning designs into their surfaces. This creates a toxic smoke that must be removed by ventilation. No mask or respirator is effective against the smoke.

Shells
Shells, including mother-of-pearl, abalone, and coral are also technically animal substances. They can be ground and sanded in the process of making jewelry or craft objects. Dust from these processes causes respiratory allergies, especially if the shell is not properly washed and contains organic matter.

Inhalation of mother-of-pearl dust can cause fevers, respiratory infections, and asthmatic reactions. Years ago, repeated inhalation of mother-of-pearl dust by adolescents working in the pearl button
industry caused defects and lesions of the long bones of their arms and legs. With young workers again being employed long hours, we may see a return of this unusual disease.

**Feathers**

Feathers for crafts and for pillow stuffing can cause "feather-pickers disease" which is characterized by chills, fever, coughing, nausea, and headaches. These symptoms usually abate when the individual develops a tolerance for feathers. Tolerance may take weeks or even years to develop. But some people become permanently and seriously allergic to feathers.

Moth repellents such as paradichlorobenzene or naphthalene are commonly applied to feathers. These are toxic substances and both are listed by many agencies as possible cancer agents.

**Precautions for Working with Animal Products**

1. **Obtain material safety data sheets** on all chemical products such as glues, adhesives, tanning chemicals, soaps and cleaners, and more. Choose the safest products when possible.

2. **Work on easy to clean surfaces and wipe up spills and dust immediately.** Follow Material Safety Data Sheet advice and have handy proper materials for controlling spills and for chemical disposal. Wet-mop and sponge floors and surfaces. Do not sweep.

3. **Practice scrupulous personal hygiene.** Do not eat, smoke, or drink in the workplace. Wash hands and change out of work clothing before leaving the studio. Wash work clothes frequently and separately from other clothes.

4. **Avoid skin contact or inhalation of tanning chemicals** by using exhaust ventilation and/or respiratory protection and gloves.

5. **Use chemical splash goggles** when using corrosive chemicals such as oxalic acid or solvents.

6. **Try to purchase animal products that are ready to use** such as pre-tanned leather, cleaned and carded wool, etc. rather than harvesting animal skins, fur and wool, bone and horn.

7. **Clean leather with saddle soaps** or other detergent and soap cleaners when possible. Avoid oxalic acid cleaners.

8. **Clean shell, bone, horn, antler and other animal products** well before working with them.

9. **Control sanding dusts of all animal products** such as leather, horns and shells with local exhaust ventilation and/or respiratory protection. Wear eyewear rated for impact to protect against flying particles.

10. **If dyes are used, follow all precautions for dyers** (see Chapter 10). Choose acrylic water-based leather dyes or dyes dissolved in ethyl alcohol when possible.

11. **Follow all rules for solvent use** when working with solvent-containing dyes, glues, and finishes (see Chapter 9, Solvents).
12. **Keep tools sharp and all machines in good repair.** Prepare for accidents by having first aid materials for trauma and post emergency procedures. Keep tetanus and other immunization shots up-to-date.

13. **Always remove smoke** with good ventilation when burning animal materials such as horn.

14. **Allow mothball odors to air out and dissipate** before working with feathers or textiles that have been kept in mothballs.

15. **When work involves noise or repetitive motions follow precautions in Chapter 6.**

16. **Be prepared to provide your doctor with precise information** about the materials you use and your work practices.

17. **Follow all applicable general precautions in Chapter 7.**
This chapter will cover dyes for all types of materials: plant fibers, animal fibers, leather and the like. Pigments will be covered because some are very similar to dyes and they can be used in fabric paints. Wax will also be covered because it is used in batik dyeing.

**What Are Dyes and Pigments?**
The origins of pigments and dyes are lost in antiquity, although we know that both sprang from common natural products such as berries, roots, minerals, and insects. When mauve, the first synthetic dye, was discovered in 1856, it catalyzed the development of the organic chemical industry. Since then over 2000 commercially available synthetic chemical dyes and pigments have been created.

The distinction between pigments and dyes is based on usage and physical properties rather than on chemical constitution. The principle characteristic of a pigment is that it is substantially insoluble in the medium in which it is used. Dyes, on the other hand, dissolve in the liquid in which they are applied so that they can stain or react with the fiber.

But this is an arbitrary distinction. In fact, there are numerous colorants that serve as both dyes and pigments. For example, a water-soluble colorant that is insoluble in oil can serve as both a dye in water and a pigment in oil paint.

**Organic Pigments and Dyes**
The term “organic” is applied to chemicals based on carbon. Most of the plant and animal materials we have discussed in previous chapters have been organic chemicals. So organic pigments and dyes are those based on carbon chemicals that are either derived from natural sources such as indigo or alizarin crimson from madder root, or they are synthesized by the dye industry in huge vats. Examples of synthetic dyes are the batik fiber reactive dyes, and the fluorescent dye colors. An example of synthetic organic pigments is phthalocyanine blues and greens.

**Inorganic Pigments**
Inorganic pigments come from the earth (ochres, for example), or they are manufactured from metals or minerals (like lead white or cerulean blue). These pigments have been used for many years and their toxic effects are fairly well known. The lead-containing colors are especially toxic and have a long history of causing poisoning. For this reason, most countries ban them for use in consumer wall paints. But artists' paints and inks, boat paints, automobile paints, and metal priming paints usually still employ them.

Other inorganic pigments may include compounds of cadmium, chromium, cobalt, copper, manganese, barium, nickel, and occasionally mercury. Some of the safer pigments are those based on iron oxides such as yellow ochre and Indian red.

**Hazards of Organic Dyes & Pigments**
There are hundreds of organic pigments used in art materials and probably almost 1000 organic dyes used in the textile industry. Only a small percentage of the natural and synthetic dyes and pigments...
have been studied for toxicity or long-term hazards. Those which have been studied are often found to be toxic and some cause cancer in animals. This is probably because many organic dyes are based on highly toxic or cancer-causing classes of chemicals. Included are aniline, benzidine, and anthraquinone.

**Cancer Causing Dyes and Pigments**

Benzidine is one of the chemical classes of organic dyes and pigments. In the 1970s hundreds of bladder cancer cases among Japanese Kimono painters were traced to these dyes. More recent epidemiological studies of artists, painters and printmakers also found elevated incidence of diseases, especially bladder cancer.

Only three of the hundreds of benzidine dyes have actually been tested in animals and proven to cause cancer. But these studies show that all the benzidine dyes can break down in the body to release benzidine or related chemicals which are known cancer causing substances.

In Germany and other European countries, a law called the Dye Directive had addressed this problem with common sense. The law says that if a dye breaks down to release a carcinogen, the dye itself is a carcinogen. The Dye Directive does not allow dyes that release any of 22 proven carcinogens such as benzidine to be used on items that contact with the skin such as clothing, bed linens, or glasses frames. As a result, hundreds of dyes currently available on the market cannot be used on products destined for Europe. However, there are no laws against using these same cancer-causing dyes in many other countries including the United States and Canada.

**Impurities**

Some synthetic dyes and pigments also are hazardous because they contain highly toxic impurities such as cancer-causing PCBs. These impurities, polychlorinated biphenyls, are unwanted side-products created during manufacture. This is just one more reason to treat dyes and pigments as toxic substances.

**Pigment and Dye Identification**

Some manufacturers deliberately withhold the exact composition of their dyes and pigments by identifying them by traditional names (Prussian blue, Mars brown, etc.), simple colors (white, red, etc.), fanciful names designed to attract customers (peacock blue), or their own internal product numbers. Instead, they should provide chemical identification for each colorant. There are several ways to do this:

**The Color Index**

The proper internationally accepted system of dye and pigment identification is found in the Color Index (C.I.).¹ This is a set of volumes (or disk) that classifies and provides technical information on all classes of dyes and pigments. Dyers should ask their suppliers to provide Color Index identification which consists of two items: 1) a C.I. name and 2) a C.I. constitution number. Examples of proper names/constitution numbers are:

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¹ *Color Index International*, Society of Dyers and Colorists (P.O. Box 244 Perkin House, 82 Grattan Road, Bradford West Yorkshire BD1 2JB England), and the American Association of Textile Chemists and Colorists (One Davis Drive, P.O. Box 12215 Research Triangle Park, NC 27709-2215, U.S.A.).
Pigment Name: C.I. Pigment Violet 23; Constitution # C.I. 51319 or
Dye Name: C.I. Acid Red 173; Constitution # C.I. 32390

**Chemical Abstract Service**

Another organization that identifies chemicals including dyes is the Chemical Abstracts Service (CAS). This service indexes articles and studies that are listed in *Chemical Abstracts*, a publication of the American Chemical Society. The index number for each chemical is called the CAS registration number (CAS RN). These numbers are assigned sequentially so they have no chemical significance. For example the CAS RN for the highly toxic dye chemical, benzidine, is 92-87-5. Using this number as a reference, more information can be found on the internet.

**Chemical Names**

Each dye has dozens of legitimate chemical names. These names can be very long and confusing, even to many chemists. An example of a single chemical dye name is:

disodium salt of ethyl[4-[p-[ethyl(m-sulfobenzyl)amino-α-(o -lfophenyl)benzylidene]-2,5 -
cyclohexadien-1-ylidene](m-sulfobenzyl)ammonium hydroxide.

This dye is also called: C.I. Food Blue 2, C.I. 42090, CAS RN 38444-45-9, or FD&C Blue No. 1.

**New Classifications**

All of these methods of identification above will soon be eclipsed by the new European and international identification numbering system. This is called the Global Harmonization System or GHS. And soon there will be a single numbering system that will be used worldwide to identify chemicals.

**Indigo**

Many craft dyers use natural indigos or synthetic indigotin. Indigo provides a good example of the general problem of identification of both natural and synthetic organic dyes. Some natural sources for indigo include:

* Natural Indigo is obtained by fermenting the leaves of *Indigofera sumatrana* (Bengal Indigo).

* Gara Indigo, the powdered dry leaves of *Lonchocarpus cyanescens* contains ~ 0.6% indigotin and is extensively used in W. Africa and the W. Sudan.

* Kalkudai or Pala Indigo obtained from *Wrightia tinctoria* and used in S. India.

* Wild Indigo Root from *Baptista tinctoria* can be used as an inferior substitute for indigo.

The most common source of natural indigo is obtained from *Indigofera sumatrana*. This dye mixture contains four chemicals, but the main active dye ingredient is Indigotin:

* When derived from the plant, Indigotin is called C.I. Natural Blue 1, C.I. 75780.

* When this same chemical is made synthetically it is called: C.I. Vat Blue 1, C.I. 73000.

* When this same chemical is used as a pigment rather than a dye it is C.I. Pigment Blue 66.
Indigotin was tested with bacteria (Ames test) and shown to cause DNA damage – that is, it causes the bacteria to mutate. Compounds that can do this often are capable of doing the same to human DNA or cause cancer or birth defects. Additional testing is advisable but has not been done.

**Indigosol**
Dyers should not confuse indigo with Indigosol, which is a common brand of vat dyes of many colors. A major distributor’s website says that their Indigosol dyes are derivatives of anthraquinone. Five anthraquinone chemicals have been tested in animals and they can cause cancer. Many experts expect that all of the anthraquinone chemicals will also cause cancer in animals, but most have not been tested and are often sold as nontoxic.

**Other Chemicals Used When Dyeing**
Many dyes also must be used with hazardous dye-assisting or mordanting chemicals. These chemicals are added to dye baths to help dyes react with fabrics properly. A list of common dye assisting chemicals and their hazards can be found in Table 5, Hazards of Mordant and Dye Assisting Chemicals.

Leather dyes, like textile dyes, tend to be hazardous chemicals. In addition many are dissolved in toxic solvents rather than water. Some of the typical leather dye solvents are the chlorinated hydrocarbons, glycol ethers, and aromatic hydrocarbons (see Table 6, Chapter 11). Some leather dyes are dissolved in ethyl alcohol and these are safer to use. Safer still are the new water-based acrylic leather dyes.

**Exposure to Dye Products**
Dyes are most hazardous in the powdered state. Skin contact and inhalation of even very small amounts of dyes in this concentrated form should be avoided. Dyes sold in liquid form are safer to handle. Liquid dyes also may have some strong preservatives and inhibitors in them to keep the dye from degrading. Some also contain solvents.

Dyes applied in hot baths release steam which may contain small amounts of toxic chemicals from dye impurities and decomposition products and ventilation should be provided.

**Dye Techniques**
Dyes are used by artists in batik, tie-dyeing, discharge dyeing and a number of other techniques.

**Batik**
Batik dyeing traditionally employs fiber reactive dyes on silk. However, batik techniques are now used with a number of different dye classes on many fabrics, on paper, and other materials. The batik process uses wax (beeswax, paraffin, etc.) as a dye resist. The wax is heated to melting and applied to the fabric. After the resisted fabric is dyed, the wax is removed by ironing the fabric between sheets of newsprint, or by applying solvents such as dry cleaning fluids, mineral spirits, etc.

Heated wax is a fire hazard. Hot wax or the vapors rising from wax pots can explode into flame easily, so open flames, gas burners, and the like should not be used to heat wax. Instead, equipment such as electric stoves, crock pots, and electric frying pans may be used if their controls can be set accurately at the lowest temperature at which the wax remains liquid.
Heated wax also emits toxic chemicals, including acrolein and aldehydes such as formaldehyde. Wax emissions require exhaust ventilation because there are no suitable air-purifying respirators for acrolein. Some artists avoid using heated wax by applying cold wax emulsions which are suitable for some purposes.

Irons for pressing wax out of fabrics also should be set at the lowest temperature required for wax removal. Exhaust ventilation such as table-level window exhaust fans should be provided. If solvents are used for wax removal, all the rules for solvent use should be followed (see Chapter 11). Some artists boil or steam fabrics to remove most of the wax and then send them to professional dry-cleaners for complete removal.

For some purposes, much safer vegetable matter batik resists which can be washed out with strong soap and water now are being developed and sold.

**Tie Dying**
Tie dyeing is done by applying dyes to fabrics which have been tied tightly. Concentrated dye solutions are usually used making exposure to these solutions more hazardous by skin or eye contact.

**Discharge Dyeing, Stripping and Bleaching**
Discharge dyeing, stripping, and bleaching involves applying chlorine bleaches or other harsh chemicals to dyed fabrics. These chemicals remove dyes by destroying their chemical bonds. In the process, dyes may be broken down into even more hazardous chemicals. For example, benzidine dyes may be broken down to free benzidine; aniline (azine) dyes may release highly toxic aniline.

Using bleach to remove dye stains from your skin would have the same effect. Bleach also irritates and damages the skin. Skin contact with dyes should be avoided, but in case of accidental contact, it is best to let stains wear off. Gloves and ventilation should be provided when dye stripping or discharge dyeing.

**Precautions for Dyers**

1. **Plan the dye room or area with health and safety in mind.** Floors and surfaces should be made of materials which are easily sponged clean and which will not stain. General ventilation rates should not be so high that dusts are stirred up.

2. **Install ventilation systems appropriate for the work done.** For example, provide exhaust and work right in front of a window exhaust fan when heating dye pots, reverse dyeing, or wax heating and removal. If clothes dryers are used, they should be connected to flexible hose exhaust systems to control emissions and lint.

3. **Obtain material safety data sheets (MSDSs) on all dyes and textile paints.** If dyes and pigments are not identified (e.g. by Color Index names, Chemical Abstracts Service numbers, or GHS identification) ask your supplier for this information.

4. **Use material safety data sheets and product labels to identify the hazards** of any toxic solvents, acids, or other chemicals in dyes, paints, inks, mordants, or other materials. If solvents are used in
dyes or for removal of wax, follow all precautions for solvents (see Chapter 9), and pay special attention to fire safety.

5. Choose water-based products over solvent-containing ones.

6. Buy premixed liquid dyes if possible. Dyes and pigments are most hazardous and likely to be inhaled in a dry powdered state.

7. Weigh or mix dye powders or other toxic powders where local exhaust ventilation is available or use a glove box.

8. Keep containers of powdered dyes and pigments, solvents, etc. closed.

9. Avoid procedures which raise dusts or mists. Sprinkling dry dyes or pigments on wet cloth, airbrushing, and other techniques which raise dusts or mists should be discontinued or performed in a local exhaust environment such as a spray booth.

10. Avoid skin contact with dyes by wearing gloves. If skin staining does occur, wash skin with mild cleaners and allow remainder to wear off. Never use solvents or bleaches to remove dye splashes from your skin.

11. Melt and remove wax at the lowest possible temperature. Do not heat wax with open flames such as those that burn on gas stoves. Use devices like double boilers, electric stoves or fry pans with good heat control mechanisms. Use wax emulsion products when possible. Irons used to remove wax should be set as low as possible. Sending fabrics to professional dry-cleaners is a viable, but expensive alternative. Investigate non-wax resists as substitutes.

12. Wear protective clothing, including a full-length smock or coveralls. Leave these garments in your studio to avoid bringing dusts home. Wash clothing frequently and separately from other clothes.

13. Protect eyes by wearing chemical splash goggles if you use caustic dyes or corrosive chemicals. Install an eye wash fountain (and emergency shower if large amounts are used).

14. Clean up spills immediately. Follow Material Safety Data Sheet advice and have handy proper materials to handle spills and disposal. Wet-mop and sponge floors and surfaces. Do not sweep.

15. Avoid ingestion of materials by eating, smoking, or drinking outside your workplace. Never point brushes with your lips or hold brush handles in your teeth. Never use cooking utensils for dyeing. A pot which seems clean can be porous enough to hold hazardous amounts of residual dye. Wash your hands before eating, smoking, applying make-up, or other personal hygiene procedures.

16. Dispose of dyes, mordants, and other chemicals in accordance with health, safety, and environmental protection laws.
17. **Be prepared to provide your doctor with precise information** about the chemicals you use and your work habits. Arrange for regular blood tests for lead if you use lead-containing textile paints or pigments.

18. **Follow all applicable general precautions in Chapter 7.**
Table 5
Hazards of Mordents, Dye Assisting, and Discharge Chemicals

Many dyes need other chemicals to set the dye, change the acidity of the dye bath, or assist the dye process. The hazards of these chemicals by inhalation or skin contact are listed below. The entries with asterisks (*) can be poisonous if ingested and should be kept out of reach of children.

**Alum (potassium aluminum sulfate)**
Some people may be allergic to it, but no special precautions are needed when using it.

**Ammonia (ammonium hydroxide)** *
Avoid concentrated solutions. Household strength ammonia is diluted and less hazardous. Inhalation of its vapors can cause respiratory and eye irritation. Wear gloves and avoid inhalation.

**Ammonium Alum (ammonium aluminum sulfate)**
Hazards are like those of alum (see above).

**Caustic Soda (lye, sodium hydroxide)** *
Very corrosive to the skin, eyes, and respiratory tract. Wear gloves and goggles.

**Clorine Bleach (household bleach, 5 percent sodium hypochlorite)** *
Corrosive to the skin, eyes, throat, and mucous membranes. Wear gloves and goggles. Mixing with ammonia or urea results in the release of highly poisonous gases (nitrogen trichloride, nitrogen oxides, chlorine, etc.). Mixing with acids releases highly irritating chlorine gas.

**Citric Acid**
No significant hazards.

**Clorox (see chlorine bleach)** *

**Copper Sulfate (blue vitriol)** *
May cause allergies and irritation of the skin, eyes, and upper respiratory tract. Chronic exposure to copper sulfate dust can cause ulceration of the nasal septum.

**Cream of Tartar (potassium acid tartrate)**
No significant hazards.

**Discharge Pastes and Liquids**
These are various forms of dry and liquid bleaches and oxidizers which destroy the dye molecules breaking them down often to more toxic precursors. (see chlorine bleach).

**Fabric Softeners**
These fluff up fabrics and coat the fibers with substances which increase their flammability. Do not use with fabric which should be fire retarded like children's clothing and bedding. Dryer sheets are recommended instead.
Ferrous Sulfate (copperas)*
Slightly irritating to skin, eyes, nose, and throat. No special precautions necessary.

Formic Acid (methanoic acid)*
Highly corrosive to eyes and mucous membranes. May cause mouth, throat, and nasal ulcerations. Wear gloves and goggles.

Formusol (formaldehyde hydrosulfite or sodium formaldehyde sulfoxylate)
Heat will release sulfur dioxide and sodium oxide which are irritating to the respiratory system. Sulfites also release sulfur dioxide when mixed with water.

Glauber's Salt (sodium sulfate)*
Slightly irritating to skin, eyes, nose, and throat.

Ludigol (monosodium salt of nitrobenzene sulfonic acid)*
A severe skin and eye irritant.

Nitrobenzene Sulfonic Acid*
A severe skin and eye irritant. Decomposes violently at ~390°F. When possible use instead the sodium salt of this compound. See Ludigol or Sitol.

Oxalic Acid*
Skin and eye contact may cause severe corrosion and ulceration. Inhalation can cause severe respiratory irritation and damage. Wear gloves and goggles.

Potassium Carnonate (potash, pearl ash)*
Moderately irritating to skin and eyes.

Potassium Dichromate (potassium bichromate, chrome)*
Skin contact may cause allergies, irritation, and ulceration. Chronic exposure can cause respiratory allergies. A suspect carcinogen. Wear gloves and goggles.

Salt (sodium chloride)*
Some all-purpose dyes contain enough to be toxic to children by ingestion. No other significant hazards.

Sitol (see Ludigol)*

Sodium Acetate*
A skin and eye irritant. Reacts violently with potassium nitrate and several other chemicals.

Sodium Alginate
No significant hazards.

Sodium Bisulfate (sodium acid sulfate)*
Corrosive to skin, eyes, and mucous membranes. Mutation data reported, reacts with moisture to form sulfuric acid. Incompatible with bleach and many other common chemicals.
Sodium Carbonate *
Corrosive to the skin, eyes, and respiratory tract.

Sodium Chloride (salt)* (see salt above)

Sodium Hexametaphosphate*
No significant hazards. Like all phosphates, it promotes algae and bacterial growth in septic systems or bodies of water.

Sodium Hydrosulfite (sodium dithionite)*
Irritating to the skin and respiratory tract. Stored solutions decompose to give irritating and sensitizing sulfur dioxide gas. Mixtures with acids will release large amounts of sulfur dioxide gas.

Sulfuric Acid (oleum)*
Highly corrosive to the skin and eyes. Vapors can damage respiratory system. Heating generates irritating and sensitizing sulfur dioxide gas. Wear gloves and goggles.

Synthrapol (isopropyl alcohol +detergent)*
Corrosive to the skin and eyes. Vapors can irritate respiratory system, cause narcosis. Wear gloves and goggles.

Tannin (tannic acid)*
Slight skin irritant. Causes cancer in animals. Handle with care.

Thiourea (thiocarbamate, thiocarbamide, isothiourea)*
Poison, carcinogen, reproductive hazard, skin irritant, allergen.

Thiourea Dioxide (Thiox®)
This is an outdated name for formamidinesulfonic acid. There is very little data on this chemical except that it is an irritant and one MSDS says that animal studies showed depressed thyroid activity. Like all amides, it is probably a sensitizer. Wear gloves and goggles.

Tin Chloride (tin, stannous chloride)*
Irritating to the skin, eyes, and respiratory tract.

Urea*
Adverse reproductive and fertility effects when in amounts higher than normal in the body. Reacts with hypochlorites (bleaches) to form toxic and explosive gas (nitrogen trichloride).

Vinegar (dilute acetic acid)
Glacial (pure) acetic acid is highly corrosive and the vapors are irritating. Vinegar (about 5 percent acetic acid) is safer. Mildly irritating to the skin and eyes.
Solvents are used in most paints (including many so-called water-based paints), varnishes, inks, and their thinners, in aerosol spray products, leather and textile dyes, permanent marking pens, adhesives, and much more.

**What are Solvents?**
The term “solvents” refers to those liquid organic chemicals that are used to dissolve solid materials. Solvents can be made from natural sources such as turpentine and citrus rind, but most are synthetic or derived from petroleum. Solvents are used widely because they evaporate quickly and cleanly.

**Solvent Toxicity**
There are no “safe” solvents. All solvents, natural or synthetic, are toxic. Contact either with liquid solvents or inhalation of the vapors they emit into the air are hazardous.

In general, solvents can irritate and damage the skin, eyes, and respiratory tract, cause a narcotic effect on the nervous system, and damage internal organs such as the liver and kidneys. This kind of damage can be acute (from single heavy exposures) or chronic (from repeated low dose exposures over months or years). In addition, some solvents are especially hazardous to specific organs or can cause specific diseases such as cancer.

**Skin Contact**
All solvents can dissolve the skin's protective barrier of oils, drying and chapping the skin and causing a kind of dermatitis. In addition, some solvents burn and irritate the skin. Natural solvents such as turpentine and citrus oil are particularly toxic and known to cause skin allergies. Some solvents penetrate the skin, enter the bloodstream, travel through the body and damage other organs.

**The Eyes and Respiratory Tract**
All solvent vapors can irritate and damage the sensitive membranes of the eyes, nose, and throat. Inhaled deeply, solvent vapors also can damage lungs. The airborne concentration at which irritation occurs varies from solvent to solvent. Often workers are unaware of solvents’ effects at low concentrations. Their only symptoms may be increased frequency of colds and respiratory infections. Years of such exposure could lead to chronic lung diseases such as chronic bronchitis.

At higher concentrations symptoms are more severe and may include nose bleeds, running eyes, and sore throat. Inhalng very high concentrations or aspirating liquid solvents may lead to severe disorders including chemical pneumonia and death. Liquid solvents splashed in the eyes can cause eye damage.

**The Nervous System**
All solvents can affect the brain or central nervous system (CNS) causing “narcosis.” Immediate symptoms of CNS effects may include dizziness, irritability, headaches, fatigue, and nausea. At progressively higher doses, the symptoms may proceed from drunkenness to unconsciousness and death. Years of chronic exposure to solvents can cause permanent CNS damage resulting in memory
loss, apathy, depression, insomnia, and other psychological problems which are hard to distinguish from problems caused by everyday living.

Solvents also may damage the peripheral nervous system (PNS) which is the system of nerves leading from the spinal cord to the arms and legs. The symptoms caused by this PNS damage are numbness and tingling in the extremities, weakness, and paralysis. Some solvents such as n-hexane (found in some rubber cements and many spray products) can cause a combination of CNS and PNS effects resulting in a disease with symptoms similar to multiple sclerosis.

**Damage to Internal Organs**
There is considerable variation in the kinds and degrees of damage different solvents can do to internal organs. Many solvents can damage the liver and kidney as these organs attempt to detoxify and eliminate the solvents from the body. Many solvents also can alter heart rhythm, even causing heart attacks or sudden cardiac arrest at high doses. This may be the mechanism which has killed many “glue sniffer.”

Some solvents also are known to cause cancer in humans or animals. For example, benzene -- a contaminant in petrol (gasoline) -- can cause leukemia.

**Reproductive Hazards and Birth Defects**
Studies of one of the least toxic solvents -- grain alcohol -- show that babies born to drinking mothers may be of low birth weight and have varying degrees of mental retardation including Fetal Alcohol Syndrome. This syndrome also has been seen in babies born to “glue sniffing” mothers who inhaled solvents other than alcohol.

A study showing a connection between solvents and birth defects in humans was published in the *Journal of the American Medical Association* in March 1999. The researchers studied Canadian women exposed to organic solvents in many types of jobs including artists or graphic designers and painters. The study indicates that "...women exposed occupationally to organic solvents had a 13-fold risk of major malformations as well as increased risk for miscarriages in previous pregnancies."

A second follow-up study published in the *Archives of Pediatrics and Adolescent Medicine* (October 2004) evaluated the “normal” children of 32 of the women who used solvents in on the job from the first study. The solvent exposures were not excessive and lasted between 1 and 40 hours per week for between 8 and 40 weeks during their pregnancies. The children of these women were compared with children of women who did not work with solvents who were of the same ages, IQs, incomes, and lifestyles. All the children were tested between 3 and 9 years of age and those of the solvent-exposed mothers were found to have poorer language, memory and attention skills, more hyperactivity and impulsivity.

**Explosion and Fire Hazards**
Two properties which affect a solvent's capacity to cause fires and explosions are evaporation rate and flashpoint. In general, the higher a solvent's evaporation rate (see definition in Table 6) the faster it evaporates and the more readily it can create explosive or flammable air/vapor mixtures. Flash points are the lowest temperature at which vapors are created above a solvent’s surface in sufficient amounts to ignite in the presence of a spark or flame. The lower the solvent's flashpoint, the more flammable it is. Materials whose flashpoints are at room temperature or lower are particularly dangerous.
The chlorinated hydrocarbons (see Chemical Classes, below) are usually not flammable and have no flash points. However, heating or burning them creates highly toxic decomposition products including phosgene gas (warfare gas). Hazardous amounts of toxic gases can be created even by working with chlorinated solvents in a room where a pilot light is burning. All solvents, flammable or not, should be isolated from sources of heat, sparks, flame, and static electricity.

Chemical Classes of Solvents
All solvents fall into various classes of chemicals. A class is a group of chemicals with similar molecular structures and chemical properties. Important classes of solvents are aliphatic, aromatic, and chlorinated hydrocarbons, alcohols, esters, and ketones. Table 6 shows various solvents and their properties by class.

Rules for Choosing Solvents

1. **Compare threshold limit values.** Choose solvents with high threshold limit values whenever possible. (See definition in Chapter 2).

2. **Compare evaporation rates.** Choose solvents with low evaporation rates whenever possible. In fact, some very toxic solvents which evaporate very slowly may not be as hazardous to use as less toxic ones that evaporates very quickly.

3. **Compare flash points.** Choose solvents with high flashpoints whenever possible. Chlorinated solvents with no flash points, however, should not be considered safe. (See Explosion and Fire Hazards section above.)

4. **Compare toxic effects.** Although all solvents are toxic, some may be especially dangerous to you. For example, if you have heart problems, it makes sense to avoid solvents known for their toxic effects on the heart.

5. **Compare within classes.** Often solvents in the same chemical class can be substituted for each other and chemicals in the same class usually dissolve the same materials and work similarly.

Safety Rules for Solvent Use

1. **Try to find replacements for solvent-containing products.** New and improved water-based products are being developed every day. Keep abreast of developments.

2. **Use the least toxic solvent possible.** Consult material safety data sheets and use Table 6 to select the safest solvents.

3. **Avoid breathing vapors.** Use solvents in areas where local exhaust ventilation is available. Dilution ventilation can be used for small amounts of solvents or solvent-containing products (see Chapter 5). Use self-closing waste cans for solvent-soaked rags, keep containers closed when not in use, and design work practices to reduce solvent evaporation.
4. **Avoid skin contact.** Wash splashes off your skin immediately with water and mild soap. Wear gloves for heavy solvent exposure (see Chapter 7 for glove selection advice). Never clean hands with solvents or solvent-containing hand-cleaners. If accidents can be foreseen in which large areas of the skin would be splashed, install an emergency shower.

5. **Protect eyes from solvents.** Wear chemical splash goggles whenever there is a chance a splash may occur. Install an eye wash fountain or other approved source of clean water which provides at least fifteen minutes flow. Prominently post emergency procedures (usually near telephone) for obtaining emergency medical advice and treatment if necessary.

6. **Protect against fire and explosion** by following all regulations and codes for use, handling, ventilation, and storage. Never smoke or permit heat, flames, or sparks near solvents. Install sprinkler system if possible. Fire extinguishers approved for solvent fires should be present and workers trained to use them. Store solvent in approved flammable storage cabinets. Ground wire containers from which solvents are dispensed. Local exhaust ventilation fans for solvent vapors must be explosion-proof.

7. **Be prepared for spills.** If spills of large amounts are likely, use chemical solvent absorbers sold by most major chemical supply houses.

8. **Use and dispose of solvents in accordance with environmental regulations.**

9. **Follow all applicable precautions in Chapter 7.**

---

**TABLE 6 COMMON SOLVENTS AND THEIR HAZARDS**

<table>
<thead>
<tr>
<th>Column 1</th>
<th>Solvent class</th>
<th>designates the chemical group into which solvents fall. Under each class heading are listed individual solvents and their common synonyms.</th>
</tr>
</thead>
</table>

**Column 2**  **Threshold Limit Value-Time Weighted Averages** are the 2006 ACGIH (American Conference of Governmental Industrial Hygienists) eight-hour, time-weighted **Threshold Limit Values (TLV-TWA)**. They will be in parts per million (ppm) unless otherwise noted.

**Column 3**  **German Maximum Concentration Workplace levels** (MAKs) in parts per million (ppm).

**Column 4**  **Flash Point** (FP) in degrees Centigrade (°C). The FP is the lowest temperature at which a solvent gives off sufficient vapor to form an ignitable mixture with air near its surface. The lower the FP, the more flammable the solvent and the greater the fire hazard.

**Column 5**  **Comments** on particular effects of the solvent. All solvents can cause narcosis at high levels. The symptoms listed here are those for which the TLVs were set or other special hazards. Abbreviations include central nervous system (CNS) damage, peripheral nervous system (PNS) damage, upper respiratory tract (URT) damage, skin damage, narcosis, etc.
<table>
<thead>
<tr>
<th>Solvent Class name:</th>
<th>TLV-TWA ppm</th>
<th>MAK-TWA ppm</th>
<th>FP C°</th>
<th>Comments / Major Hazards</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alcohols</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ethyl alcohol: ethanol, grain alcohol, denatured alcohol</td>
<td>1000</td>
<td>500</td>
<td>13</td>
<td>Least toxic. Denatured means contains small amounts of various unpalatable/toxic additives.</td>
</tr>
<tr>
<td>isopropyl alcohol: 2-propanol, rubbing alcohol</td>
<td>200</td>
<td>200</td>
<td>12</td>
<td>Eye, URT, CNS effects. Cancer effects unknown.</td>
</tr>
<tr>
<td>methyl alcohol: methanol, wood alcohol</td>
<td>200</td>
<td>200</td>
<td>11</td>
<td>Headaches, eye damage. Skin absorbs. High doses can cause blindness.</td>
</tr>
<tr>
<td>isoamyl alcohol: 3-methyl-1-butanol, fusel oil</td>
<td>100</td>
<td>200</td>
<td>40</td>
<td>Eye, URT irritation.</td>
</tr>
<tr>
<td>n-butyl alcohol: n-butanol</td>
<td>20</td>
<td>100</td>
<td>35</td>
<td>Eye, URT irritation. Lacrimator.</td>
</tr>
<tr>
<td><strong>Aliphatic Hydrocarbons</strong></td>
<td></td>
<td></td>
<td></td>
<td>Many of these are mixtures of chemicals derived from petroleum.</td>
</tr>
<tr>
<td>heptane: n– &amp; iso-heptanes</td>
<td>400</td>
<td>500</td>
<td>-4</td>
<td>One of least toxic- substitute for n-hexane. CNS impairment, URT irritation.</td>
</tr>
<tr>
<td>vm &amp; p naphtha: benzine, paint thinner</td>
<td>300</td>
<td>None</td>
<td>0 to -7</td>
<td>One of the least toxic in class. Good turpentine substitute. &quot;Odorless&quot; = aromatic hydrocarbons removed. URT &amp; eye irritation, CNS damage.</td>
</tr>
<tr>
<td>gasoline</td>
<td>300</td>
<td>None</td>
<td>-43</td>
<td>Do not use. Extremely flammable. May contain skin-absorbing benzene, organic lead compounds or new toxic anti-pollution additives.</td>
</tr>
<tr>
<td><strong>Aromatic Hydrocarbons</strong></td>
<td></td>
<td></td>
<td></td>
<td>A hazard class. Avoid if possible.</td>
</tr>
<tr>
<td>xlyenes: xylol, dimethyl benzenes</td>
<td>100</td>
<td>100</td>
<td>-6.5</td>
<td>URT &amp; eye irritation, CNS impairment. Stomach pain reported with m-xylene.</td>
</tr>
<tr>
<td>toluene: methyl benzene, phenyl ethane</td>
<td>20</td>
<td>50</td>
<td>40</td>
<td>CNS impairment. Visual impairment; female reproductive system damage, pregnancy loss. Try to avoid.</td>
</tr>
</tbody>
</table>
### Solvents

<table>
<thead>
<tr>
<th>Solvent/Class</th>
<th>MAK</th>
<th>MAK</th>
<th>68</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>styrene: vinyl benzene, phenyl</td>
<td>20</td>
<td>20</td>
<td></td>
<td>CNS impairment, URT irritation, peripheral neuropathy. Try to avoid.</td>
</tr>
<tr>
<td>ethylene</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>benzene: benzol</td>
<td>0.5</td>
<td>MAK</td>
<td>11</td>
<td>Do not use. Causes leukemia. Skin absorbs.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1*</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Chlorinated Hydrocarbons</strong></td>
<td></td>
<td></td>
<td></td>
<td>Many in this class cause cancer. Avoid.</td>
</tr>
<tr>
<td>methylene chloride:</td>
<td>50</td>
<td>MAK-</td>
<td>**</td>
<td>Avoid. Suspect cancer agent. Forms carbon monoxide in the blood. CNS &amp;</td>
</tr>
<tr>
<td>dichloromethane</td>
<td></td>
<td>3A*</td>
<td></td>
<td>heart damage.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perchloroethylene: perc</td>
<td>25</td>
<td>MAK-</td>
<td>**</td>
<td>Suspect cancer agent. Irregular heart beat, CNS damage, skin reddens after</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3B*</td>
<td></td>
<td>alcohol ingestion. Deadly if combined with heavy drinking.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>These solvents do not have</strong></td>
<td></td>
<td></td>
<td></td>
<td>These solvents do not have typical flash points. They Dissociate with heat</td>
</tr>
<tr>
<td><strong>flash points. They</strong></td>
<td></td>
<td></td>
<td></td>
<td>or ultraviolet radiation to form toxic gases such as phosgene.</td>
</tr>
<tr>
<td><strong>Dissociate</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>with heat or ultraviolet</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>radiation to form toxic</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>gases such as phosgene.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Esters/Acetates

<table>
<thead>
<tr>
<th>Ester/Acetate</th>
<th>MAK</th>
<th>MAK</th>
<th>24</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ethyl acetate</td>
<td>400</td>
<td>400</td>
<td></td>
<td>Least toxic in class. URT &amp; eye irritant.</td>
</tr>
<tr>
<td>methyl acetate</td>
<td>200</td>
<td>100</td>
<td>14</td>
<td>Headache. URT irritant. Ocular nerve damage.</td>
</tr>
<tr>
<td>isoamyl acetate: banana oil,</td>
<td>50</td>
<td>50</td>
<td>64</td>
<td>Eye &amp; URT irritant. Used for fit-testing.</td>
</tr>
<tr>
<td>Isopentyl acetate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Glycol Ethers (cellosolves)

<table>
<thead>
<tr>
<th>Glycol Ether</th>
<th>MAK</th>
<th>MAK</th>
<th>43</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-ethoxyethanol: cellosolve, ethyl cellosolve, ethylene glycol monoethyl ether</td>
<td>5</td>
<td>2</td>
<td>43</td>
<td>Reproductive hazard for men and women. Skin absorbs. Do not use.</td>
</tr>
</tbody>
</table>

### Ketones

<table>
<thead>
<tr>
<th>Ketone</th>
<th>MAK</th>
<th>MAK</th>
<th>27</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>methyl ethyl ketone: MEK, 2-butanone</td>
<td>200</td>
<td>200</td>
<td></td>
<td>URT irritation. CNS &amp; PNS damage. Severe nerve damage when combined with n-hexane.</td>
</tr>
<tr>
<td>methyl isobutyl ketone: MIBK</td>
<td>50</td>
<td>20</td>
<td>53</td>
<td>URT &amp; eye irritant. Kidney damage. May be more toxic in combination with n-hexane.</td>
</tr>
</tbody>
</table>
**methyl butyl ketone: MBK**

<table>
<thead>
<tr>
<th>MAK</th>
<th>71</th>
<th>61</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>5</td>
<td>Do not use. PNS &amp; testicular damage, skin absorbs.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Natural</th>
</tr>
</thead>
</table>
| turpentine: monoterpenes

<table>
<thead>
<tr>
<th>MAK</th>
<th>71</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>Causes allergies (dermatitis, asthma), URT &amp; other skin irritation. CNS impairment, lung damage. Use odorless paint thinner instead.</td>
</tr>
</tbody>
</table>

| limonene: citrus oil, citrus turps, menthadiene, dipentene

<table>
<thead>
<tr>
<th>MAK</th>
<th>71</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>20</td>
</tr>
</tbody>
</table>

* Considered a carcinogen for which there is no safe level. Keep exposure should be as low as possible.
What Are Paints, Varnishes and Stains?

Today craftspeople use a vast array of surface coatings. These products have many properties in common because almost all of them contain pigments suspended in a substance that is called a “vehicle” or “base.” These bases can be liquids such as an oils, waxes, solvents, a natural such as lac (in lacquer and shellac) or a plastic suspended in a water emulsion such as acrylic, or just plain water (for some water colors). Often we refer to paints, varnishes and stains as oil-based or water-based to indicate which are suspended in water and which in oils or solvents.

Paints, varnishes and stains must also be cleaned up or thinned and some of these chemicals are also hazardous. For example, turpentine or petroleum solvents will thin and clean up oil paints.

For the hazards of the pigments, see Chapter 10. If the paint contains solvents (see Chapter 11).

What Are Adhesives?

Most glues and adhesives are similar to paints because they are either synthetic or natural polymers. The synthetic polymers are plastics like cyanoacrylate in super glue and latex emulsion glues like white carpenters glue. The natural polymers include rubber cement from the sap of rubber trees or wheat pastes.

Most adhesives are less hazardous to use than paints because they are used in smaller amounts. But it is still necessary to know their hazards since crafts people may use them for hours a day in applications that bring them in intimate contact with the adhesives.

Latex Bases

Many water-based latex bases or vehicles for surface coatings and adhesives are not toxic themselves, but may contain toxic additive preservatives to keep mold and bacteria from degrading them, such as stabilizers to keep ingredients in suspension, plasticizers to keep the paint film flexible (in latex paints and white glues), antioxidants to keep ingredients from combining with oxygen, retarders to slow the setting time, fillers, wetting agents, and more.

These additives affect characteristics such as drying time and workability. The hazards of many of these additives have not been well researched, and manufacturers are often reluctant to divulge the identity of these additives and they are unlikely to be listed on labels.

Preservatives

Base preservatives can be especially hazardous since their purpose is to kill microorganisms. Common paint, varnish and stain preservatives include formaldehyde (sometimes in the form of paraformaldehyde or formalin), phenol, mercury compounds, bleach, and a host of commercial fungicides and pesticides.

Even though these additives are present in small amounts, they have caused illness in artists. For example, a mural artist developed mercury poisoning some years ago from soluble mercury preservatives used in her paints. In the US, mercury preservatives were not outlawed in consumer wall paints until 1991, and the ban still does not extend to art and craft paints. Mercury preservatives may still be used in some countries in consumer paints.
Exposure to Base Ingredients
Base ingredients for paints and adhesives can be divided into volatile (will evaporate into the air) and nonvolatile components. Since nonvolatile ingredients do not become airborne, they usually present no significant hazard to crafters unless they are used in techniques that make them available to be inhaled, such as spray painting, or if excessive skin contact occurs. Volatile base ingredients, on the other hand, can be inhaled by crafters while they work or while surfaces are drying. Acrylic art paints, for example, usually contain ingredients which release ammonia and formaldehyde gases while they dry.

VOCs
Some of these volatile ingredients may also be bad for the environment and can cause smog or damage the biospheric ozone layer. These ingredients are called volatile organic chemicals (VOCs) and are regulated in many countries. Paint and varnish makers today are reformulated to include smaller amounts of VOCs in their products.

Consumer Latex Paints, Varnishes and Stains
These consumer wall paints, often called “latex” paints, can be made of almost any plastic. Most are acrylic, but vinyl, urethane, and other water-based latex paints are available. These water-based paints usually have two biocides (pesticides) in them plus many, many additives:

1. Biocides to protect wet paint in the can from bacteria and mold and which usually evaporate into the air as the paint dries;

2. Biocides which remain as solids in the paints to protect the dry film; and

3. Additives of many types. There can be up to 30 different chemicals present in small amounts, including antioxidants, freeze-thaw stabilizers, anti-skinning agents, acidity control agents, rust inhibitors, and much more. Most of these are complex chemicals with long names. Most have never been tested for their effects on people. Some are expected to be toxic based on their chemical class, and some will be considered VOCs while other volatile solvents are not regulated because they do not damage the environment.

Consumer Oil Paints, Stains and Varnishes
These are only manufactured now for specialty paints in most countries because they contain large amounts of environment-damaging volatile solvents. If you use these, follow the precautions for solvents in Chapter 11.

Artist’s Oil Paints
Oil paints are made by mixing pigments into oils such as linseed oil. Oil paints are commonly thinned and cleaned up with solvents such as turpentine. Dilution ventilation sufficient to keep solvent exposure low should be provided. Some people use oil paints without solvents and clean brushes and skin with baby oil followed by soap and water. This is a very safe way to work and requires no special ventilation.

Oil paints are commonly mixed with additional oil to make them more liquid and to cause the paint to “set” or “dry” to a hard film that can no longer be dissolved by solvents. Linseed oil is the most common oil, but poppy seed, walnut, sunflower, and some synthetic oils also are used. These oils
contain chemical driers based on toxic metals such as lead, cobalt, or manganese. Rags and paper
towels damp with these oils can spontaneously ignite as the oil sets. Many studios and shops have
been lost to fire from setting oils catching waste on fire long after everyone has left work.

Water washable oil paints that eliminate solvent exposure because they can be thinned and cleaned
up with water are now available. These relatively new materials are now manufactured by most of
the major art materials companies. The same pigments are used in these paints, but they need no
special ventilation to use safely. They are as permanent as traditional oils. They may still be able to
cause spontaneous combustion and the rags should still be treated as potential fire hazards.

**Acrylic Art Paints (Water-Based Emulsions)**
Acrylic art paints are composed of synthetic acrylic resins and pigments with many additives, usually
including an ammonia-containing stabilizer and often formaldehyde or some other preservative.
Without a preservative, the paint will support bacterial and mold growth. The small amounts of
ammonia and preservative released during drying can cause respiratory irritation and allergies, but so
will emanations from mold and bacteria, which will grow without the preservatives. Very little
ventilation is needed (e.g. an open window.)

**Acrylic Paints (Solvent-Based)**
Acrylic paints are synthetic acrylic resins and pigments dissolved in solvents. The solvents should be
identified and the ventilation should be sufficient to keep the solvent's concentration at a safe level.

**Alkyd Paints**
Alkyd paints are alkyd resins and pigments dissolved in solvents. Provide dilution ventilation at a
rate sufficient to keep solvent concentrations at safe levels.

**Casein Paints**
Casein paints are made from dried milk, pigments, and preservatives. Some contain ammonium
hydroxide which can be irritating to the skin and eyes and dust from the powdered paint should not
be inhaled. There are usually very strong preservatives added because the casein is a good source of
food for microorganisms. Usually, no special ventilation is needed.

**Stains**
Stains are primarily pigment or dyes (Chapter 10) suspended in either water or a chemical solvent
(see Chapter 11).

**Tempera Paints**
Tempera paints are pigments suspended in emulsions of substances like oils, egg, gum casein, and
wax. Preservatives are added to kill microorganisms. If no solvents are used in these paints, no
special ventilation should be needed.

**Varnishes**
Varnishes are natural or synthetic resins or waxes which are usually dissolved in organic chemical
solvents. Those dissolved in alcohol are less toxic than those containing turpentine or aromatic
hydrocarbons. Varnishes should be used following all precautions for solvent use in Chapter 11.
**Watercolors (Dry Cakes)**
Water colors are composed of pigments, preservatives (often paraformaldehyde) and binders such as gum Arabic. Liquid watercolors may also contain water, glycerine, glucose, and other materials. Both liquid and dry watercolors may give off small amounts of formaldehyde, but no special ventilation should be needed.

**Rules for Safe Use of Paints Varnishes and Stains**

1. **Obtain material safety data sheets (MSDSs)** on all paints, thinners, varnishes, stains, lacquers, etc. If the pigments are not identified on the label by Color Index (C.I.) names or numbers, ask your supplier for this information (see Chapter 10).

2. **Avoid applications that get the material AIRBORNE** such as air-brushing or spraying. These processes always require local exhaust ventilation (see Chapter 5) or suitable respiratory protection (see Chapter 4). When surface coating materials are applied by other methods such as brushing, rollering or dipping, the only hazards are from the volatile ingredients in the products.

3. **Follow the precautions in Chapter 11** if the products contain volatile solvents. Be aware that there may be volatile ingredients in latex paints that are not revealed on MSDSs or labels.

4. **Use water-based products over solvent-containing products.** However, do not assume that water-based products contain no solvents. Check the MSDS.

5. **Use tlv's and other toxicity data to choose the safest solvents** and provide gloves, eye protection (when pouring solvents), and ventilation (see Chapter 11).

6. **Do not clean oily brushes with solvents or leave brushes standing in solvent overnight.** There are many safer cleaning methods including using baby oil followed by soap and water, or using some of the brush cleaning soaps developed by manufacturers specifically for brush cleaning.

7. **Buy premixed paints and avoid powdered pigments.** Pigments and paints are most hazardous when they are inhaled in a dry powdered state (see Chapter 10).

8. **Choose studio locations with safety in mind.** Floors, tables, and shelving should be made of materials which can be easily cleaned. A sink should be at hand. Isolate the studio from living spaces. Never use or clean up brushes and applicators in kitchen areas.

9. **Plan studio ventilation appropriate for your materials.** For example, if solvents are used, provide sufficient dilution ventilation to remove vapors from the studio. If powdered paints or pigments are used, plan local exhaust ventilation such as a chemical fume hood or spray booth.

10. **Avoid dusty procedures.** Sanding dry painted, stained or varnished surfaces, sprinkling dry pigments or dyes on wet paint or glue, and other techniques which raise dust should be avoided or performed in a local exhaust environment or outdoors.

11. **Follow all solvent safety rules** if you use solvent-containing products, and give extra attention to fire safety. Rags damp with setting oils like linseed and poppy oil will spontaneously ignite. Place them in an air tight metal container or in water.
12. **Avoid skin contact** by using techniques that keep the materials from getting on your skin, or by wearing gloves (see Chapter 7). Wash off splashes on the skin with safe methods such as rubbing baby oil on the skin followed by soap and water. Never use solvents or bleaches to remove splashes from your skin.

13. **Wear protective clothing**, including a full-length smock or coveralls if splashes are likely. Leave these garments in the shop and wash frequently and separately from other clothing.

14. **Avoid ingestion of materials**. Eat, smoke, or drink outside your studio. Never point brushes with your lips or hold brush handles in your teeth. Wash your hands before eating, smoking, applying make-up and other personal hygiene procedures.

15. **Work on easy-to-clean surfaces**. Wipe up spills promptly. Wet mop and sponge floors and surfaces. Do not sweep. Never use flammable liquids in studios with wooden floors or floors with cracks and openings between the flooring elements.

16. **Dispose of waste solvents, paints, and other materials in accordance with health, safety, and environmental protection regulations**.

17. **Follow all applicable precautions in Chapter 7**.

**Adhesives**

Glues and adhesives are covered in this chapter because they, too, are made of natural substances like rubber or from the same plastics as latex paints and varnishes.

**Monomers and Polymers**

Plastics are created when a chemical called a "monomer" reacts with itself to form large molecules called a “polymer.” Polymers are often long chains of monomer molecules. This reaction is called “polymerization.” For example, when a monomer called methyl methacrylate is polymerized, it becomes polymethyl methacrylate, better known as Lucite®.

Most monomers are very toxic, but once polymerized, the polymer or resin is not usually hazardous. For example, methyl methacrylate is very toxic, but Lucite® solid plastic is essentially nontoxic. And this type of plastic can be bent and melted.

Some polymers are capable of a second reaction in which the long chains are linked together laterally (side by side). This reaction is called cross linking. For example, liquid polyester resin becomes a solid material when it is reacted with a cross-linking agent like styrene. These polymers are called “thermoset plastics” because they can’t be bent or melted. An example of a thermoset plastic is the polyester body filler used to repair cars.

**Initiators**

Initiators are chemicals that cause monomers and resins to react to form polymers or to crosslink are among the most toxic chemicals involved in plastics. Manufacturers may refer to these chemicals as activators, catalysts, curing agents, hardeners, or driers. In this book the term “initiator” will be used in most cases.
Natural Polymers
Natural substances also can function as polymers such as the complex proteins in rabbit skin or horse hooves or the rubber in rubber cement. The sap of the rubber tree contains a chemical called isoprene, a monomer that can react with itself to form a rubber-like polymer called polyisoprene.

Additives
Both natural and synthetic adhesives contain additives. Even a water-clear piece of plastic is not “pure.” In addition to the polymer itself, there are hosts of additives in plastics. These include antifoaming agents left over from manufacture, antioxidants to slow aging, ultraviolet light inhibitors to prevent yellowing in the sun, plasticizers to keep them soft, and more.

Some of these plastic additives have been in the news in the last few years. Some experts suggest that they are the cause of some reproductive health effects seen worldwide. Among these chemicals are the phthalate plasticizers and bisphenol A. They may act like female hormones.

Mother Nature also put a lot of additives in the rubber tree sap. Some of these additives are natural proteins that cause serious, sometimes life-threatening, allergies. Some natural substances also act like female hormones. For example, use of oil of lavender skin-care products was recently found to cause breast development in young boys.

Water-Based Polymer Emulsions
Many polymer adhesives are sold as water-based emulsions. There are a great number of additive ingredients in these products that will not be listed on the label or identified on the material safety data sheet (MSDS). And many of these chemicals are unstudied, so their toxicological effects are unknown.

Synthetic Rubber Latex
The word “latex” means any plastic or polymeric substance in an essentially aqueous medium or water dispersion. The polymer in the latex could be a polyacrylic plastic, butadiene rubber, urethane or any other synthetic or natural polymer. The term “rubber” is applied to any of these natural or synthetic polymers having unique properties of deformation and elastic recovery. The synthetic “rubbers” are chemically unrelated to natural rubber.

The hazards of synthetic rubber and plastic latexes are primarily attributable to their many additives rather than to the plastic itself. The additives often include glycol ether solvents, formaldehyde preservatives, and stabilizers that release ammonia.

Finished Plastics
Rather than working with resin systems, it is easier and safer to work with sheets, films, beads, or blocks of finished plastic. Even so, when plastics are cut or heated, decomposition products are released and these products can be hazardous. Processes during which this can occur include sawing, sanding, hot knife or wire cutting, press molding, drilling, grinding, heat shrinking, vacuum forming, plastic burnout casting, torching, and melting. In general, the gases and smoke produced from the finished plastics during high-heat processes are usually more dangerous than those produced at lower temperatures.
Some plastics are especially hazardous to cut or heat. Among these are polyvinyl chloride (which produces hydrochloric acid gas) and all nitrogen-containing plastics such as polyurethane, melamine resins, urea formaldehyde, and nylon (which produce hydrogen cyanide gas).

**Precautions for Working with Finished Plastics**

1. **Use good dilution ventilation or local exhaust ventilation.** Use water-cooled or air-cooled tools, if possible, to keep decomposition to a minimum. Use the lowest possible temperature and provide ventilation when heat forming or vacuum forming.

2. **Add vacuum attachments to sanders, saws, and other electric tools to collect dust.**

3. **Wear dust goggles and a dust mask** if static electricity causes particles to cling to face and eyes. However, no mask or respirator will protect you from all of the organic vapors, acid gases and other emissions from plastics.

4. **Do not sweep.** Clean up all dust carefully by wet mopping or by using specially filtered vacuums.

5. **Use precautions for solvents** when using plastics adhesives (see Chapter 11).
Most glues and adhesives are either synthetic or natural polymers. Most are inherently less hazardous than casting resins and they are used in smaller amounts. Some common ones are listed in the Table below.

**Cyanoacrylates:** The monomer usually is a chemical called ethyl cyanoacrylate. Trade names include Super Glue® and Krazy Glue®. The adhesives are potent eye and respiratory irritants. Fast curing-time can cause unplanned and inconvenient adhesion of your body parts.

**Glue sticks:** Plastic and/or mucilage materials. No known significant hazards.

**Hot melt glues:** These usually are vinyl polymers and release the phthalate plasticizers when heated. Provide some ventilation.

**Epoxies:** Epoxy resins can irritate the skin. Epoxy hardeners are usually chemicals (amines) which can cause allergies of the skin and respiratory system. Epoxies also may contain varying amounts of solvents. Provide ventilation and avoid skin contact.

**Poly vinyl acetate resins (PVAc):** Also known as white or yellow glues, polyvinyl acetate resins which may also be co-polymerized with other monomers. Common trade names for PVAC are Elmer's®, Sobo®, and White Glue®. When these emulsions are sold dissolved in solvents, the only hazards are the solvents. When they contain no solvents, they are of very low toxicity.

**Poly vinyl alcohol resins (PVA, PVAL, or PVOH):** Made by alcoholysis of a vinyl acetate polymer. These have the same hazards as vinyl acetate resins above.

**Rubber cement and synthetic rubber:** The hazards are primarily the solvents in which they are dissolved (see Chapter 11). See Chapter 8 for hazards of natural rubber and the text above for information on synthetic rubber.

**Silicones:** Two types of silicone resin adhesives are used in the crafts. The most common is a single-component product which cures by absorbing atmospheric moisture. The second is a two-component system (that is, part A and Part B are mixed first) which cures by means of a peroxide (see section on Organic Peroxides above). Both systems may contain substances which are volatile such as solvents or acids. Provide some ventilation and use material data sheets to avoid silicone containing a chemical called methyl ethyl ketoxime.

**Urea formaldehyde, phenol formaldehyde & resorcinol:** These resins can be used as adhesives from either solvent solutions or in water-based form. They are also the most common plywood and pressboard adhesives. They off-gas formaldehyde gas. Phenol formaldehyde is more stable and releases less formaldehyde. The urea and resorcinol adhesives have been largely replaced by epoxy, polyurethane and PVA glues.

**Urethane resins:** Single-component urethane adhesives are made in both water-based and solvent types. Read the MSDSs and provide ventilation accordingly. The two-component urethane resin adhesives, foams and casting systems are too toxic to use in ordinary craft shops.
**Wallpaper paste:** Usually made of wheat or methyl cellulose and preservatives. Wheat pastes in particular usually contain large amounts of pesticides and fungicides. Use methyl cellulose adhesives because they do not need protection from insects and are unlikely to contain pesticides. These should have no significant hazards.

**White paste, library paste:** no significant hazards except for the preservative. This is most often wintergreen which is not toxic in the amounts present in these pastes.
CHAPTER 13
METALS

Many metals are used by smiths, jewelers, stained-glass workers, welders, and foundry workers. Ceramicists, glass blowers, and enamellists also use many metallic oxides and other metal compounds. Painters use inorganic pigments which are metallic compounds and powdered metal pigments (see Chapter 10). People using these materials need to understand the hazards of working with metals.

What Are Alloys?
Metals can be heated and melted together into almost any combination. These combinations are called “alloys.” The reason the metals are mixed into alloys is to provide special properties such as specific melting points, hardness, or color. Almost all metals used in metalworking are alloys. It is rare to see a pure metal used in craft work.

Metal workers must know the composition of their alloys in order to work safely with them. For example, brass is primarily an alloy of copper and zinc. But it also may contain harmful amounts of lead and arsenic. Silver solders contain toxic metals such as cadmium or antimony in order to lower the solder’s melting point. Material safety data sheets or complete ingredient information must be obtained on all metal products.

<table>
<thead>
<tr>
<th>TABLE 8</th>
<th>COMPOSITION OF COMMON ALLOYS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Brass:</strong></td>
<td>a copper/zinc alloy which may also contain smaller amounts of tin, lead, arsenic, manganese, aluminum, and/or silicon.</td>
</tr>
<tr>
<td><strong>Britannia metal, pewter, white metal:</strong></td>
<td>There are two basic types of alloys: 1) tin/lead/copper or 2) tin/antimony/copper.</td>
</tr>
<tr>
<td><strong>Bronze:</strong></td>
<td>copper/tin alloys that may contain smaller amounts of lead, phosphorus, aluminum, and/or silicon.</td>
</tr>
<tr>
<td><strong>Gold:</strong></td>
<td>alloys of gold and other metals to produce white gold, yellow gold, and other colors.</td>
</tr>
<tr>
<td><strong>Lead:</strong></td>
<td>lead used to make type, pipes, and car batteries may contain antimony and other metals.</td>
</tr>
<tr>
<td><strong>Monel metal:</strong></td>
<td>nickel/copper alloys with small amounts of carbon, manganese, iron, sulfur, and silicon.</td>
</tr>
<tr>
<td><strong>Nickel silver:</strong></td>
<td>alloys of nickel/silver/zinc.</td>
</tr>
<tr>
<td><strong>Silver:</strong></td>
<td>sterling is silver alloyed with at most 7.5 percent other metals, usually copper. Other silver alloys are usually even less pure.</td>
</tr>
<tr>
<td><strong>White metal:</strong></td>
<td>see Britannia metals.</td>
</tr>
</tbody>
</table>
Metal Dusts and Powders

Fireworks contain metal powders, so it should come as no surprise that metal dusts and powders are explosive and/or flammable in air. Aluminum powders are particularly reactive. Bronze, copper, and many other metal powders are also flammable.

In general, the more finely divided the powder, the faster the material will “burn” in air -- and the more explosive it is. But even large particles will ignite under the right conditions. Metal dusts can be created when metals are ground, polished, and cut.

Metal Fumes

Welding, casting and soldering creates tiny, invisible metal oxide particles called “fumes.” When fumes are created in large amounts in welding, they may appear to be a bluish-colored smoke because the particles are so small that they bend light to appear blue. These tiny fume particles can float for hours in the air, then settle into surface dust which can contaminate the entire workspace.

Inhaling Metal Particles

In general, the smaller the particles, the deeper they can be inhaled, and the more toxic they are liable to be. For this reason, metal fumes and fine dusts (particles under 10 microns in diameter) are often more toxic than larger particles of metal dust. These very small particles are often called “respirable” particles.

When inhaled, respirable metal particles of metals such as lead and zinc will dissolve in the lungs’ air sacs and then pass through the air sacs’ membranes into the blood stream. These metals then are free to travel throughout the body.

Other metals, such as cerium, beryllium, or titanium, dissolve very slowly and cannot pass through the air sacs’ membranes. These particles will remain in the lungs a long time, perhaps a lifetime. Their effects are on the lungs themselves.

Larger particles are referred to as “inhalable” dusts (10 to 100 microns sized particles.) These will deposit in mucous lining in the various sizes of bronchial tubes in the lung. These dusts will be raised by the lungs’ clearing mechanisms (the cilia) and swallowed. In this way, these metal dusts are ingested and the body can extract the toxic metals and pass them into the body through the intestine.

Metal-Containing Gases

Some metals, such as arsenic and antimony, emit highly toxic gases when in contact with acids. For example, this could happen when acid fluxes, cleaners, or patinas (metal surface colorants) are used with arsenic/antimony contaminated metals or solders. When inhaled, metal gases pass easily through the air sacs’ membranes and into the blood stream.

Metal Compounds

When metals combine with other elements they become metal compounds. The most common example is when iron metal combines with oxygen to create rust which is a compound called iron oxide. Rust is not very toxic. But iron could also combine with cyanide to become ferric cyanide and this chemical would be highly toxic. The toxicity of metal compounds depends on the toxicity of both the metal and the substance with which it combined.
Exposure Standards
The toxicity of various metals and metal compounds has been quantified by the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs) and the German Workplace Airborne Concentrations (MAKs). (Read Chapter 2 for a more complete description of these standards.) The table below provides a comparison of these standards for a few common metals. The table also demonstrates how the finer particles (respirable) are usually more toxic and have more restrictive standards.

<table>
<thead>
<tr>
<th>Substance</th>
<th>TLV-TWA (mg/m³)</th>
<th>MAK-TWA (mg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plaster (calcium sulfate)</td>
<td>10 (inhalable)</td>
<td>4.0 (inhalable)</td>
</tr>
<tr>
<td>Plaster- Fine Dust</td>
<td>None</td>
<td>1.5 (respirable)</td>
</tr>
<tr>
<td>Aluminum Metal Dust (large particles)</td>
<td>10 (inhalable)</td>
<td>4.0</td>
</tr>
<tr>
<td>Aluminum Metal Dust (fine particles)</td>
<td>5 (respirable)</td>
<td>1.5</td>
</tr>
<tr>
<td>Tin Metal Dust</td>
<td>2</td>
<td>No Standard</td>
</tr>
<tr>
<td>Copper Dust (all particle sizes)</td>
<td>1 (inhalable)</td>
<td>0.1</td>
</tr>
<tr>
<td>Copper Oxide Fume</td>
<td>0.2 (respirable)</td>
<td>No Standard</td>
</tr>
<tr>
<td>Arsenic</td>
<td>0.01 (inhalable)</td>
<td>MAK-1*</td>
</tr>
<tr>
<td>Cadmium Dusts</td>
<td>0.01 (inhalable)</td>
<td>MAK-1*</td>
</tr>
<tr>
<td>Cadmium Fumes &amp; Dusts</td>
<td>0.002 (respirable)</td>
<td>MAK-1*</td>
</tr>
<tr>
<td>Beryllium</td>
<td>0.00005 (inhalable)</td>
<td>MAK-1*</td>
</tr>
</tbody>
</table>

*Considered a carcinogen for which there is no safe level. Keep exposure as low as possible.

Skin Contact Hazards
When metals are first cast or cut, they are shiny and clean. Soon their surfaces may become dull, rusted or tarnished. This is caused when the metal combines with chemicals found in air or water such as oxygen or sulfur dioxide. This also is why merely touching or handling some toxic metals can be harmful if these corrosion compounds are transferred to the mouth by eating or smoking.

Some metals also cause skin allergies. Many people are sensitized to nickel, chrome and cobalt. Nickel is especially known to cause such allergies. Recently it has been found that many people have developed rashes on their ears and face from their nickel-coated cell phones. European countries have instituted a regulation called the “Nickel Directive” which requires manufacturers of jewelry or any other metal product that contacts the skin to document with laboratory tests that nickel will not be released in significant amounts.

A few metals can damage the skin because they are either radioactive or unusually toxic. For example, beryllium can produce skin tumors if it penetrates broken skin, and uranium and arsenic can cause skin cancer.
Some metals also absorb through the skin and into the blood stream. A study in 1988 proved that powdered lead, lead oxide, and lead nitrate will absorb through the skin. A follow-up study in 2002 showed that this lead eventually gets into the blood stream just like inhaled or ingested lead.

Skin absorption of other metals and dusts is unstudied and unknown. But, given the studies of lead, the assumption that other metals do not skin-absorb is unwarranted at this time.

**Metal Fume Fever**
Fumes of metals such as zinc, copper, magnesium, and iron, can cause metal fume fever. This disease resembles the flu. It usually onsets 2 to 6 hours after exposure and symptoms may include a fever, chills, and body aches. There appears to be no long term damage to the body from episodes of metal fume fever caused by metals of low toxicity. However, when toxic fumes such as cadmium are inhaled, the early symptoms may be similar, but serious consequences or even death may result.

**Nervous System Diseases**
A number of metals are known to affect the brain and other nervous system tissues. For example, lead, mercury, and manganese can cause effects ranging from psychological problems at low doses, to profound retardation and paralysis at higher doses. Chronic manganese exposure can cause a disease similar to Parkinson's disease.

**Cancer**
Some metals and/or compounds containing metals are known or suspected of causing cancer. Included are the metals or compounds of metals that contain arsenic, beryllium, cadmium, chromium (VI), cobalt, lead, nickel, rhodium, selenium, and uranium. It is fortunate that these metals, with the exception of cobalt, can be eliminated from jewelry, ceramic, and other crafts without damaging the quality of the product and only slightly limiting the colors achievable.

**Reproductive Effects**
A number of metals are known to affect human reproduction at various stages. For example, the ability to impregnate or conceive may be impaired, pregnancy can end in miscarriage, the fetus may be affected, or birth can be complicated. Metals which are known to cause such effects include antimony, arsenic, cadmium, lead, manganese, mercury, and selenium.

**Respiratory System Diseases**
The respiratory system diseases usually are caused by irritation or allergy to metals. Asthma-diseases have been noted in workers grinding metals containing cobalt and chrome. Lung scarring (fibrosis) is associated with metals such as cerium or beryllium. In fact, a progressive and incurable lung disease called “beryllium disease” has been seen in dental technicians who grind tiny dental prostheses made of an alloy containing only 1-2 percent beryllium. Beryllium is also a lung carcinogen.

**Lead: A Special Problem**
Some of the most hazardous activities in the metal crafts involve lead exposure. Examples include welding junk metals painted with lead paint, “burning” battery lead to obtain lead oxide for ceramic glazes, lead soldering, and casting lead-containing alloys. All of these practices should cease. They are not only hazardous to the worker, the products they produce are not safe for consumers. Most countries have banned lead-containing products such as jewelry, trinkets and toys. Most countries
also have banned metal, glass or ceramic dishes, cups, and cooking pots that will leach lead into food.

One reason for the strict laws is that recent research has increased our understanding of lead toxicity. It is now known that even the small amounts of lead we absorb from air pollution and contamination of food and water are causing health effects in us all and reducing mental ability in children. We cannot afford additional lead from sources such as craft products.

Although lead has been used in art for hundreds of years, it is time we reconsider its use. Even if we manage to set up ventilation systems that will remove lead fumes and dust from our studios, it will contaminate the environment. The soil where your lead dust has settled will remain contaminated forever. The answer is to immediately seek alternatives to lead.

General Safety Rules for Working with Metals

1. Identify the metals in your materials. Only use metals and alloys for which Material Safety Data Sheets are available. Recycled scrap metals are not acceptable materials for making crafts unless the craftsperson can be absolutely certain what the scrap contains to be sure that customers will be safe.

2. Eliminate highly toxic metals such as lead, cadmium, nickel, and beryllium from your work. Never use alloys containing nickel for items that will contact the consumer’s skin.

3. Use ventilation systems to capture dusts from grinding and polishing and fumes from welding, brazing, casting, or soldering. Clean up dusts that escape such systems daily.

4. Avoid use of metal powders if possible. If they must be used, be aware that they are flammable and/or explosive. Keep sparks or static discharge from contact with them, especially when you are transferring powder from one container to another. Store powdered metals in non-flammable storage cabinets or secure metal cabinets.

5. Avoid excessive skin contacts with metals. Wash hands regularly during and after work.

6. Wear protective clothing including a full length smock, shoes, and hair covering (if needed). Leave these garments in the studio to avoid bringing dusts home. Wash clothes frequently and separately from other clothes.

7. If lead is used in any form, blood tests should be done regularly (at least once a year). Follow the regulations regarding lead in the location in which you work.

8. Follow all other applicable general precautions in Chapter 7.

Welding

All methods of welding or cutting metal rely upon either heat from burning gas or from electric arc to do the job. Over eighty different types of welding exist which use these basic heat sources in various ways. But in the crafts, the types most commonly used are oxyacetylene welding, ordinary arc welding, gas metal arc welding (metal inert gas, MIG), and gas tungsten arc welding (tungsten inert gas, TIG). Some crafters also use welding machines that make repetitive small welds to join small pieces of jewelry or craft objects. All types of welding can be extremely hazardous.
Training
Safe welding requires knowledge, training, and comprehension of applicable health and safety codes and regulations. Neither this book nor any other secondary source of information should be considered inclusive of welding health and safety practices. Instead, welders and their employers must follow the precautions mandated by their federal, state, and provincial industry standards. The greatest risk to welders is lack of training.

Instead of getting formal training, most craftspeople pick up welding by observing other (usually unqualified) welders. In addition, they often weld with old, poorly maintained equipment housed in unventilated spaces, which are located near other activities and are not compatible with fire and electrical requirements imposed by welding.

Hazards
Hazards to welders’ health include all of the hazards of the metals discussed above. But in addition they are at risk from radiation, heat, noise, fumes, and gases from welding processes, and gases from compressed cylinders. (See Chapter 2 for more information on radiation, heat, noise). Protection against these hazards is an extraordinarily complex subject, and there are different rules for different types of welding. It is beyond the scope of this manual to cover this subject in detail. However, we will provide information general welding safety rules.

Welding Precautions
1. Get formal training, preferably by recognized schools of welding.

2. Plan welding shops for areas at least 35 feet away from all flammable and combustible materials.

3. Obtain material safety data sheet (MSDS) on all materials including compressed gases and welding and brazing rods. Obtain complete information on the composition of metals to be welded. Avoid materials which will emit highly toxic metals such as beryllium, thorium, cadmium, antimony, etc. Never work with metals of unknown composition, painted metals, or junk or found metals unless ventilation is certain to provide total removal of the welding fumes.

4. Provide ventilation for protection from gases, fumes, and heat buildup. Equip shops with local exhaust ventilation systems such as downdraft tables or flexible duct fume exhausts to capture welding fumes and gases at their source. Working outdoors may reduce exposure, but many documented cases of illness have resulted from cutting and welding outdoors, even in windy conditions.

5. Use respiratory protection if appropriate. Keep in mind that no single air-purifying respirator will protect wearers from all the contaminants in welding fumes. The HEPA filters will stop metal fumes, but they offer no protection from gaseous contaminants. Some air-supplied respirators can provide welders with fresh air. These are costly and they need constant maintenance and training to be used effectively.

6. Isolate the welding area. Isolation keeps other workers from being exposed either to direct or reflected radiation. Walls, ceilings, and other exposed surfaces should have dull finishes which can
be obtained from special non-reflective paints. Portable, fire-resistant, UV-impervious screens or curtains can be purchased to isolate welding areas and to separate individual welding stations.

7. **Use eye protection** such as goggles or face shields to protect each welder for the specific type of welding being done. Face and eye protective equipment should be cleaned carefully after each use and inspected routinely for damage, especially for light shield damage. A scratched lens will permit radiation to penetrate it and it should be replaced.

Visitors and other workers nearby should avoid looking at welding and should wear safety glasses. Visitors’ safety eyewear can be made from clear glass or a special clear plastic because UV is weakened by distance and can be easily stopped by clear lenses.

8. **Protect hearing** by wearing fire-resistant ear plugs, muffs, or other devices if needed.

9. **Wear protective clothing.** Pants and long-sleeved shirts can protect legs and arms. Many welders prefer wool fabrics because they insulate welders from temperature changes and because they emit a strong warning odor when heated or burned. Never wear polyester or synthetic fabrics that melt and adhere to the skin when they burn. Pants and shirts should not have pockets, cuffs, or folds into which sparks may fall.

Shoes should have tops into which sparks cannot fall. Wear safety shoes with steel toes if heavy objects are being welded. Hair should be covered or tied back. Wear gloves when arc welding. Leather aprons, leggings, spats, and arm shields may be needed for some types of welding. Do not use asbestos protective clothing.

10. **Follow all applicable general precautions in Chapter 7.**

**Compressed Gas Cylinder Safety**
Compressed gas cylinders are used in many metal working procedures. They are potential rockets or bombs if they rupture or if valves or regulators break. They can cause damage as far as 100 yards away. The different kinds of gases inside the cylinders are themselves hazards. There are three basic types of hazardous gases:

**Oxygen:** It will not burn by itself, but ordinary combustible materials like wood, cloth, or plastics will burn violently or even explode when ignited in the presence of oxygen. Never use oxygen as a substitute for compressed air.

**Fuel Gases:** Acetylene, propane, and butane are some fuel gases. They are flammable and can burn and explode.

**Shielding Gases:** These are used to shield processes such as MIG and TIG welding and include argon, carbon dioxide, helium, and nitrogen. They are inert, colorless and tasteless. If they build up in confined spaces such as enclosed welding areas, they replace air and can asphyxiate those in the area.
General Safety Rules for Compressed Gas Cylinders

1. **Accept only cylinders recently tested and approved** by the government agency responsible for such testing in your country.

2. **Cylinders too large to carry easily may be rolled on their bottom edge but never dragged.**

3. **Prevent cylinders from cuts, abrasions, drops or striking each other.** Never use cylinders for rollers, supports, or any purpose other than intended by the manufacturer.

4. **Do not tamper with safety devices on valves.**

5. **Return empty cylinders to the vendor.** Mark them clearly as being "EMPTY." Close the valves and replace valve protection caps.

6. **Always consider cylinders full** (even when empty) and handle them with due care. Accidents have resulted when “empty” containers under partial pressure have been mishandled.

7. **Always secure cylinders** by chaining, tying, or binding them, and always use them in an upright position.

8. **Store cylinders in cool, well ventilated areas or outdoors in vertical positions** (unless the manufacturer suggests otherwise). The temperature of a cylinder should never exceed 130 degrees Fahrenheit. Store oxygen cylinders separately from fuel cylinders or combustible materials.

Soldering
Soldering is a method of filling a joint or seam with metal alloys which will melt at lower temperatures than the metals being soldered. Tinning is a special kind of soldering in which areas of metal are covered with a solder surface.

Solders can contain a large number of metals including lead, tin, cadmium, zinc, arsenic, antimony, beryllium, indium, lithium and silver. Use material safety data sheets to identify all metal constituents in your solder so that highly toxic ones can be avoided.

Prior to soldering or brazing, the metal must be cleaned and degreased. Cleaners and degreasers usually contain toxic solvents, caustics, and/or acids.

Fluxes are products which help the molten solder adhere to the metal. Inorganic acid fluxes such as those containing zinc and other chlorides are use most widely. Organic solders containing fatty acids will work well on lead and copper. Rosin solders are used primarily for copper electrical work. Fluoride fluxes work very well on many metals and are usually used with tinning solders. However, fluoride-containing fluxes are very toxic.

During soldering a plume of smoke rises, and can be inhaled. The plume will contain a variety of decomposition products from materials in fluxes and metal fumes. These substances can cause eye and respiratory irritation, allergies, and, in some cases, metal poisoning. Open pot tinning in which metal objects are dipped in molten solders can produce very large amounts of metal fumes.
Once the metals are brazed or soldered, the seams are often cleaned of the residual flux chemicals. Cleaning products can contain toxic solvents, acids, caustics, or ammonia. Some cleaning products generate toxic gases when mixed.

Many different chemicals can be used to polish soldered or brazed surfaces. Two of the hazardous are putty (tin oxide) or whiting (calcium carbonate).

**Precautions for Soldering**

1. **Obtain material safety data sheets (MSDS)** and complete alloy composition for all solders. Avoid highly toxic metal-containing alloys such as those containing arsenic or cadmium.

2. **Avoid use of lead solder.** If lead solders are used on the job, employers must meet local regulations to protect their workers.

3. **Obtain ingredient information on fluxes.** Choose the safest flux for the job. Avoid fluoride fluxes. Do not mix fluxes.

4. **Wear goggles** that will protect the eyes from infrared radiation and irritating vapors. Use gloves when working with solvents, acids, or caustic cleaning agents. Minimize skin contact with fluxes. Wear clothing resistant to heat.

5. **Have first aid treatment, cool water, and ice on hand for minor burns.**

6. **Provide local exhaust ventilation.**

7. **Use gun or electric soldering iron methods** over open flame joining or heating of irons. Avoid open dip pot "tinning" unless excellent local exhaust can be installed.

8. **Obtain ingredient information on metal cleaners and degreasers and choose safest ones.** Provide local exhaust for products which emit toxic gases and vapors. Do not mix cleaning agents unless you are sure they cannot react adversely with each other. Use putty or whiting to clean when possible.

9. **Practice good housekeeping.** Wet mop floors and sponge tables and surfaces to control dust, which may be contaminated with metal fume particles.

10. **Follow all applicable general precautions in Chapter 7.**

**Metal Casting**

Metal casting involves forcing molten metal (by gravity or centrifugal force) into a mold. In the construction of some molds, a positive form of wax or plastic is burned out to leave room for the metal. Metals can be cast in any size from tiny jewelry pieces to large foundry-cast sculptures. Foundry work is especially hazardous. The hazards of all types of metal casting include exposure to mold materials, burning out patterns, and working with molten metals.

One of the hazards associated with casting are the hazards of different types of molds into which the molten metal is poured. Some of these include the following:
Channel Molds are made by carving into tufa (a soft porous rock) or investment plaster mixed with pumice. Free silica can be found in investment plasters, and in some pumice and tufa. These dusts can cause silicosis and cancer.

Cuttlebone Molds are made by pressing small shapes (usually jewelry pieces) into cuttlebone (the internal shell of the cuttlefish). The mold is then painted with borax flux and water glass (sodium silicate). All of these dusts are eye and respiratory irritants.

Sand Molds are made from foundry or casting sand which is usually silica and binders. The sands are very hazardous unless they are treated with binding chemicals, which also prevent respirable dust from becoming airborne. The binders in foundry sands can be organic chemicals such as glycerine and linseed oil which harden when heated. Cold-setting high silica sands also are used. The binders in these sands usually are synthetic resins such as urea-formaldehyde, urethanes, and other plastics. Toxic gases may be emitted when the resins burn off during casting (e.g. hydrogen cyanide and isocyanates).

Mold releases may include silica flour, French chalk (talc), or graphite. Silica flour is an especially toxic source of silica because of its small particle size.

Molds for Lost Wax Casting are made with investment plasters which contain silica flour or cristobalite, plaster, grog (fired clay), and clay. In the past, asbestos was added to this material. Asbestos or ceramic fiber may be used to line investment containers. Shell molds are made with slurries of water and silica, fused silica, or zircon, and sometimes with ethyl silicate. The resulting mold is heated in a kiln to form a ceramic-like shell.

Cristobalite, silica flour, and fused silica can cause silicosis and cancer. Asbestos in any form can be a cancer hazard. Ceramic fiber also may cause asbestos-related diseases. Ethyl silicate is highly toxic by inhalation and eye contact. It is an irritant and may cause liver and kidney damage.

Burning Out Patterns
Patterns for metal casting molds can be made of wax, Styrofoam, and other plastics. All of these will release toxic substances when burned out to open the mold for the metal.

Melting and Pouring
Small amounts of metal for centrifugal casting can be melted with torches. Centrifugal casting equipment can be dangerous. If it is unbalanced, metal can be thrown out. Most shields around centrifugal casters probably would not be able to protect bystanders if the arm should break during casting.

Precautions for Casting

1. Be prepared to comply with all workplace safety and health regulations regarding foundry work and metal casting and obtain Material Safety Data Sheets and ingredient lists for all metals, molds, and pattern materials used.

2. Replace investment mold products containing silica flours and cristobalite with non-silica materials such as zircon when possible. Do not use asbestos. Choose foundry sands over cold setting sands and resin binders.
3. Work with local exhaust ventilation and wear eye protection if ethyl silicate is used.

4. Provide dust control, ventilation and/or respiratory protection against irritating, sensitizing, and silica-containing mold materials. Dust goggles should also be worn if dust is raised.

5. Use safe mold release agents such as graphite.


7. Provide exhaust ventilation for all pouring operations. Furnaces and ovens for mold-setting, burnout, and melting metal should be equipped with local exhaust ventilation such as a canopy hood.

8. Avoid casting in lead. If lead is used on the job, employers must be prepared to meet complex regulations, provide blood lead tests, etc.

9. Wear protective clothing appropriate to the type of casting done. For foundry work, follow protective clothing regulations. Wear infrared goggles whenever working with glowing materials. If molten metals may splash, wear a face shield, a long-sleeved, high-necked wool shirt, insulated leggings, jacket, apron, gloves and shoes (steel-toed if heavy materials are being lifted). Tie back hair or wear hair covering.

10. Have first aid treatment, cool water, and ice on hand for burns.

11. Post fire emergency and evacuation procedures and train workers in use of fire extinguishers (sprinkler systems cannot be used in foundries or other places where furnaces or molten metal are used). Hold regular fire drills.

12. Install carbon monoxide detectors in areas where fuel burning equipment is located such as furnaces and burnout kilns.

13. When centrifugal casting, make sure the equipment is well balanced and that the protective shield is in good condition.

14. Wear respiratory protection when breaking up and disposing of silica-containing molds. Practice good housekeeping. Wet mop floors and sponge tables and surfaces to control dust which may be contaminated with mold materials or metal dust.

15. Follow all applicable general precautions in Chapter 7.

Smithing Hazards
Smithing or forging is the process of hammering hot or cold metals into shape. Blacksmiths work with iron, silversmiths forge silver, and so forth. The tools used in these processes are hammers, mallets, metal blocks, and anvils. Furnaces used for hot forging burn coal, coke, oil, or gas.
Noise
Percussive hammering on metal produces noise which is very destructive to hearing. Even in the
1700s, Ramazzini (the father of occupational medicine) observed that tinsmiths went deaf from
hammering noise.

Combustion Gases
Toxic combustion products such as carbon monoxide gas are emitted by forging furnaces.
Ventilation systems such as canopy hoods only can provide partial protection from these gases
because the bellows used to fan the coals will also blow some emissions from the hood intake area.

Other Hazards
Additional hazards include infrared radiation given off by furnaces and hot metal, which can damage
the eyes and burn the skin. Heavy work in a hot environment can cause heat stress. Some kinds of
smithing also use acid pickling solutions to clean hot metal.

Fires are a constant threat. Train workers in fire emergency procedures and the use of extinguishers
(other controls such as overhead sprinklers cannot be used in hot forging areas).

Precautions for Smithing

1. **Install fireproof sound-absorbing materials** in floors and walls of the shop where possible.

2. **Provide good stack exhausts and canopy hood ventilation** for forges and furnaces. Additional
general shop ventilation will be needed for blacksmithing and other hot forging to reduce heat and
to exhaust toxic gases which are blown out of the hood's capture range by the bellows.

3. **Install carbon monoxide detectors** in areas where forges and furnaces are located.

4. **Plan fire protection carefully.** Eliminate all combustibles from areas around forges and furnaces.
Do not install sprinkler heads above hot processes. Consult fire marshals and/or other experts for
advice on appropriate fire-fighting systems and extinguishers.

5. **Provide bathroom facilities and separate clean rooms for work breaks.** It is necessary that smiths
be able to wash up and retire to a clean area to drink fluids to replace those lost through
perspiration, to have lunch, etc.

6. **Provide first aid supplies** and cold water or ice for treatment of minor burns. Water also should
be available to drink frequently, to quench metal, etc.

7. **Obtain ingredient information on all materials** used in the work and use proper precautions. For
example, if solvents are used, follow all solvent safety rules (see Chapter 11).

8. **Never allow clutter or trip hazards in the work area.**

9. **Wear earplugs** or other suitable hearing protection as needed.

10. **Wear goggles** to protect eyes from infrared radiation (see Chapter 2).
11. **Wear protective clothing**: long-sleeved, close woven cotton or wool shirts; leather gloves, and safety shoes. Tie back hair or wear hair covering. Leave clothing in the shop to avoid tracking dusts home. Wash clothes frequently and separately from other clothes.

12. **Wear gloves and goggles** when handling acids, caustics, or solvents. If hot metal is dipped or cleaned in acid or Sparex, provide gloves, goggles, protective clothing (e.g., rubber aprons), and ventilation to exhaust gases rising from the bath.

13. **Install an eye wash station** near areas where acids, castings, or solvents are used. If the smith is outside or in an area where there is no plumbing, use portable eye wash stations that supply 15 minutes of continuous washing.

14. **Follow all applicable general precautions in Chapter 7**.
Minerals are combinations of metals and other inorganic chemicals that are usually found in geological deposits such as rocks, ores, and clays. They can also be made synthetically. Minerals are the primary raw materials used in stone carving, lapidary work (precious and semiprecious stones), ceramic clays and glaze chemicals, most abrasives such as emery and tripoli, refractory brick for high temperature equipment, masonry cement and mortar, and more.

**Natural Minerals**
It took millions of years for geological processes to make our minerals. These processes rarely create “pure” minerals. Instead, minerals usually contain many contaminants. For example, fire clay minerals are usually contaminated with coal or asphalt. And minerals like talc (soapstone or talcum powder) usually contain silica and many minerals other than talc. Trace metal impurities are responsible for the unique colors of rubies, sapphires and other gems.

**Synthetic Minerals**
For thousands of years, potters have synthetically converted minerals from one form to another in their fires and kilns. Today, modern manufacturers can use more sophisticated processes to make minerals such as synthetic diamonds, opals and other gems. Mineral fiber insulation can be made synthetically to function just like asbestos. It should not be surprising then, that many synthetic minerals have health effects similar to those of natural minerals.

**Chemical vs. Mineral Hazards**
The inorganic chemicals in most minerals are arranged in a crystal structure. Crafters need information on both chemical composition (chemical analysis) and crystal structure (mineral analysis) of these materials, because both may affect health.

Some minerals contain very toxic chemicals. These toxic chemicals can affect the body if they are soluble – (released from the mineral into body fluids.) For example, a lead mineral called galena will release lead into your body to cause poisoning.

The mineral's crystal structure also may affect health. For example, asbestos minerals are made of harmless chemicals such as magnesium and calcium silicates. But the asbestos minerals have microscopic needle-like crystals which can penetrate lung tissues and cause cancer.

**Diseases from Inhaling Minerals**
Most minerals usually do not cause obvious symptoms when they are inhaled. Large amounts may cause only temporary dryness or irritation of the respiratory system. It is only years later that symptoms of serious diseases will occur.

The major diseases from inhalation of minerals are 1) lung scaring and 2) cancer.

**Lung Scarring**
Each mineral can cause its own unique kind of damage. Doctors will identify these diseases by the name of the mineral plus the ending: “osis.” For example, talcosis is caused by talc inhalation. Asbestosis is caused by inhaling asbestos.
**Cancer**
Small, sharp crystals of silica, long fibrous crystals of asbestos, and perhaps the little flat crystals of talc, can cause lung cancer when inhaled. These diseases do not develop until between 10 and 20 years after a person has inhaled the crystals.

Asbestos and other fiber-like minerals (e.g., erionite) can cause a special kind of cancer called mesothelioma. This is a cancer of the lining of the chest, abdomen or heart and it typically occurs 20 to 40 years after exposure. Mesothelioma is inevitably fatal and has been responsible for the deaths of three US craftspeople who were exposed to asbestos-contaminated talc in their clay – a ceramic doll maker, a potter, and a ceramic tile sorter.

**Kaolin and Other Clay Materials**
“Kaolin” is a term usually used to describe white clays containing the clay mineral, kaolinite. However, the term “clay” refers to any of over 30 different minerals that form a plastic mixture with water and can be fired with high heat into a durable substance. The ones most commonly used in ceramics are minerals whose crystal structures are built on aluminum oxide, silica, and water. Other metals can be present in the structure of some clays.

Since clays are mined from the earth, they usually contain many impurities. The major hazard associated with clay is the common presence of significant amounts of silica contamination. But some clays themselves can cause lung-scarring diseases.

**Synthetic Mineral Fibers**
Synthetic mineral fibers include ceramic fiber, and glasswool, slagwool, and rockwool. Research is beginning to show that microscopic needle-like inert materials whether of asbestos, glass, or ceramic origin may cause lung diseases and cancer. The International Agency for Research on Cancer (IARC) classified refractory ceramic fibers as “possibly carcinogenic to humans.” And many experts suspect that all of these fibers can cause cancer.

**Frits**
Frits are synthetic minerals used in ceramic glazes, enamels, and glass colorants for stained and blown glass surfaces. Frits are made by melting metal compounds, silica, and other ingredients into a glass and reducing the glass to a powder. This is done in the mistaken belief that fritting makes the metals in them insoluble and safe. This theory is wrong. It is now known that lead frits will release lead to the body when their dusts are inhaled or ingested.

Lead-free frits may contain barium, lithium, and other toxic metals. Prudence dictates that all frits be treated as if their metal ingredients are a source of exposure.

**Glass Work**
Glass is made from the same substances that constitute glazes and frits, but they are in a non-crystalline or unstructured form. Glass can be manufactured in an infinite variety of compositions. Natural glasses, like obsidian and pumice also can vary in composition.

When glass is polished or ground, the dust created will release the metals in the glass just like ceramic frits will. The toxicity of powdered glass will depend on the metals it contains. Powdered or ground glass can also mechanically irritate eyes, skin and the respiratory system. Dust from grinding lead glass, for example, can be both irritating and toxic.
Ceramic Working Hazards

Occupational illnesses, such as lung disease (silicosis) and lead poisoning, have been associated with pottery-making for hundreds of years. Unfortunately, these illnesses and others still are seen in ceramic artists and hobbyists and their families. The exposures which cause these and other ceramic-related illnesses can occur during three basic processes: working with clay, glazes, and firing kilns.

Clay
The hazards of the clay minerals are covered above under kaolin. However other health problems noted among clay workers include chapping and drying of the skin, and bacterial and fungal infections of the skin and nail beds. Since wet clay commonly harbors bacteria and molds, some people may develop allergies to clay dust, and people with preexisting asthma and allergies may find that their conditions worsen with exposure to clay.

Glazes
Common glazes are a mixture of minerals and water that are painted on unfired ceramic ware. The water dries leaving the powdered minerals on the surface. These are then fused or fired under high heat into a glass-like material. See Table 10 at the end of this chapter for the hazards of some of these glaze minerals.

Commercial glazes usually contain frits and additives such as gum stabilizers (e.g., gum arabic) and preservatives. Preservatives in commercial glazes are usually small amounts of toxic pesticides or bactericides. Gum stabilizers are not very toxic but some people are allergic to them.

In general, metallic elements function in glazes function both as colorants and as fluxes that cause the glaze to melt at the right temperature. Their toxicity varies greatly. Some very safe fluxes are calcium, sodium, and potassium. Some low toxicity colorants are iron and copper. Toxic fluxes include lead, cadmium, and antimony, barium and lithium. Toxic colorants can include chromium, cobalt, manganese, nickel, vanadium, and uranium. Some luster and metallic glazes also contain highly toxic mercury and arsenic (and may also contain solvents and oils).

There are excellent substitutes for lead glazes. Those who choose to continue using lead should consider the health and environmental effects of lead. Lead can also leach from glazes into the food of customers who use these lead-glazed products.

Firing
When clays and glazes are fired, they release various gases, vapors, and fumes. Some common emissions from kilns include carbon monoxide, formaldehyde and other aldehydes, sulfur dioxide, chlorine, fluorine, metal fumes, nitrogen oxides and ozone.

For this reason, all firing processes require ventilation. One of the best types of ventilation for electric kilns is the negative pressure system. These systems draw small amounts of air from the bottom of the kiln to keep the kiln under negative pressure so that nothing leaks out during firing except where the duct from the kiln exhausts the emissions.

Different types of firing need different types of ventilation. Some types of firing such as salt firing can be done safely only outdoors.
Fire/Electricity Safety
Fire hazards should be considered when planning pottery or ceramic studios. Consult local fire officials or other experts to be sure your studio meets all local fire regulations and electrical codes.

Large kilns should be located in areas in which there are no combustible or flammable materials. Even small electric kilns should be at least three feet from combustible materials such as paper, plastic, or wood. Electric kilns also should be raised at least a foot above the floor to allow air to circulate underneath. Cement floors are best for kiln rooms. Wooden floors under small electric kilns can be protected by cement board, refractory brick, or other heat-resistant substances.

To prevent fires and damage to ware, electric kilns should be equipped with two automatic shut-offs in case one fails. (Three types to choose from are pyrometric shut-offs, cone operated shut-offs, and timers.)

Infrared Radiation is produced in significant amounts whenever metals or ceramic materials are heated to the point where they glow (see also Chapter 2). The hotter they are, the more infrared radiation is produced. Infrared radiation can damage the eye and can cause a type of cataract and retinal damage.

Kiln Building
Many potters choose to build their own kilns. This process may expose potters to many hazards including asbestos-substitutes (some are suspect carcinogens), fire brick dust (usually contains silica), heavy lifting, and noise (if hard bricks are wheel cut). If dust-producing tasks cannot be done in local exhaust or outdoors, respiratory protection approved for toxic dusts should be used. Hearing protection should be used if brick cutting or other noisy processes are done.

Connecting kilns to gas or electric lines should be done or approved by licensed electricians and/or gas company employees.

Finished Ware Hazards
Potters and ceramicists may be liable if the ware they sell harms someone. Potters and chinaware makers can be held responsible for injuries or damages to consumers if their ovenware shatters from heat, or if lead or other toxic metals from their glazes contaminates food.

The problem of glaze solubility (leaching) is complex. All glazes solubilize, slowly releasing all their ingredients into food. The difference between good and bad glazes is the rate at which the glazes solubilize. Many factors influence glaze solubility including composition of the glaze, small amounts of certain impurities, heating and cooling cycles during firing, fumes from other glazes fired in the kiln, and more. Commercial producers have found that sending samples of ware regularly to laboratories for testing is the only way to guarantee glaze performance. Potters and ceramicists should consider doing the same.

Working Safely with Clays and Glazes

1. Plan studios with clean up procedures in mind. Floors should be sealed and waterproof. Use non-slip coatings, flooring, or mats for areas of floor where water is likely to spill. Tables, shelving, and equipment should be made of materials which can be easily sponged clean. Enough space should be left between tables and equipment to make cleaning easy.
2. **Construct kilns from refractory brick and castables.** Avoid asbestos and ceramic fiber insulation.

3. **Install proper ventilation** for kilns (see Chapter 5, Ventilation) or fire outdoors. Install carbon monoxide detectors in indoor kiln areas.

4. **Keep all tools, machinery, and potters wheels in good condition.** Be especially vigilant about electrical equipment since water is always present. Place ground fault interrupters on outlets used for potter's wheels and other electric tools.

5. **Use hand grinders and dremel tools** for removing dripped glaze from pottery. Bench grinders should not be used for this purpose because the guards must be raised or removed to get the ceramic piece to the wheel.

6. **Plan fire protection carefully.** Locate kilns in areas free of combustible materials. Equip electric kilns with two automatic shut-offs in case one fails. Consult fire officials or other experts for advice on proper fire-fighting systems and/or extinguishers.

7. **Use proper personal protective equipment.** Wear infrared-blocking goggles (welding shade # 3 or 4) when looking into glowing kilns, asbestos-substitute gloves when handling hot objects, impact goggles when grinding or chipping, dust masks if needed, and so on.

8. **Obtain material safety data sheets on all materials** used in the studio such as clays, glazes, and grind wheels. In addition, obtain mineral and chemical analyses of clays, glazes, and other minerals from suppliers. Avoid materials containing highly toxic ingredients such as lead and asbestos, and treat dusty materials containing over one percent free silica as highly toxic, providing ventilation and/or respirator protection.

9. **Do not use lead.**

10. **Practice good hygiene.** Wash hands carefully and use a nail brush after glazing. Work on surfaces that are easily cleaned with a damp sponge and wipe up spills immediately. Don't eat, drink, smoke, apply cosmetics or store food in ceramic areas. Eating and recreating must be done in separate rooms maintained in a sanitary condition.

11. **Avoid skin problems.** Keep broken skin from contact with clay and glazes. Wash hands and apply a good emollient hand cream after work. People with skin problems can wear surgical or plastic gloves while working.

12. **Wear protective clothing** such as smocks, tightly woven coveralls, and hair covering. Avoid flammable synthetic fabrics. Change clothing when leaving the pottery rather than carrying dusts home. Wash clothing frequently and separately from other clothes.

13. **Avoid making repetitive or forceful movements** of the hands and arms during wheel throwing, wedging, lifting, or other tasks (see Chapter 6).

14. **Avoid dusty processes when possible.** Examine all dust-producing procedures such as mixing clay and glazes, sanding greenware, and reprocessing clay. Do these tasks in local exhaust or outdoors if possible.
15. **Install local exhaust systems** for processes that create toxic airborne materials such as glaze spraying, mixing powdered chemicals, for grind wheels, wax pots, and the like.

16. **Provide ventilation** if wax is melted for glaze resist (see Chapter 5).

17. **Respirators should be approved** for the contaminant and follow all rules regarding respirator use (see Chapter 4). Air-purifying respirators cannot be used for kiln emissions and wax decomposition (acrolein).

18. **Clean floors without creating dust.** Do not sweep. Use wet mopping and hosing methods. Ordinary vacuum cleaners will not collect the finest, most toxic dusts. Proper vacuums include those which pick up wet material from the floor, or those with high efficiency (HEPA) filters.

19. **Follow all applicable precautions in Chapter 7.**

**Lapidary and Stone Carving**

Many stones used in stone carving and lapidary are the same minerals that are used in ceramics, glass, and as abrasives. For example, flint, steatite, dolomite, and fluorspar stones can be used for sculpture. When these same stones are ground to a powder, they can be used to make ceramic glazes and glass. For another example, garnet may be used as both a gem and a sand paper abrasive.

Craftspeople are exposed to dust and flying chips when stones are shaped for sculpture or lapidary work by chipping, carving, grinding, and polishing. These operations can be done by hand or with electric tools. Electric tools produce large amounts of dust. Hand operations are the least hazardous, but flying chips still can damage eyes.

In addition, hand tools can slip and large stones can fall to cause injuries. Lifting heavy stones and tools can lead to strain injuries.

Electric tools also are associated with vibration syndrome or "white fingers" disease. It is a progressive circulatory system disease which constricts flow of blood to the hands (sometimes also to the feet) causing pain and numbness. Noise from percussive hammering, electric tools, and other equipment also can damage hearing (see Chapter 6).

The toxicity of dust from sculpture stones varies. Table 10 lists many common lapidary stones, gems, and abrasives. Choose the least toxic for the job.

**Precautions for Stone Carving**

1. **Wear impact/dust goggles** when shaping or chipping materials.

2. **Wear steel-toed shoes** if working with heavy stones.

3. **Follow correct lifting and carrying procedures** when moving all heavy stones and other objects (see Chapter 6).

4. **Obtain mineral and chemical identity** of carving and lapidary stones. Avoid stones containing asbestos or radioactive elements.
5. **Purchase electric grinding and polishing tools** that are equipped with local exhaust connections for removing dust from the studio. To control other sources of dust, practice good hygiene and clean up.

6. **Match respirator filters** to the type of dust produced (see Chapter 4).

7. **Purchase comfortable electric tools** with low vibrations amplitude to reduce risk of vibration syndrome. (See also Chapter 6).

8. **Purchase quiet tools and exhaust fans**, or wear hearing protection (see Chapter 6).

9. **Follow all applicable general precautions in Chapter 7**.
TABLE 10
CERAMIC, STONE CARVING, LAPIDARY, AND ABRASIVE MINERALS

African wonderstone (pyrophyllite, aluminum silicate) hazards are unstudied.

Agate (chalcedony, flint, silica) can cause silicosis and lung cancer.

Alabaster (calcium sulfate, gypsum, plaster) may cause eye and respiratory irritation. One of the least toxic stones unless it contains silica as an impurity.

Aluminum oxide (see corundum).

Amber (an organic fossil resin) no significant hazards.

Amethyst (quartz) can cause silicosis and lung cancer.

Azurite (see malachite).

Calcite (calcium carbonate, chalk) no significant hazards unless contaminated with silica.

Carborundum (silicon carbide) inhalation of large amounts may cause a type of lung scarring.

Cement (mixture of fine ground lime, alumina, and silica). Other chemicals commonly found in cement include various iron compounds, traces of chromium, magnesia, and sulfur compounds. The primary hazards are from silica and allergic reactions to chromium compounds including asthma and skin reactions.

Cerium oxide no significant hazards in dust form (fume can cause lung scarring).

Chalcedony (see agate).

Cinnabar (mercuric sulfide, vermillion) can cause mercury poisoning.

Clay is a name applied to about 30 different minerals. Most are not very hazardous. But some are contaminated with hazardous amounts of silica.

Cornwall stone (a rock which contains feldspar, quartz, kaolinite, mica, and a small amount of fluorspar.) Can cause lung scarring.

Corundum (aluminum oxide) inhalation of large amounts is associated with a type of lung scarring called "shaver's disease."

Cryolite (natural or synthetic sodium aluminum fluoride, greenland spar.) Highly toxic due to the fluorine present. Used also as a pesticide.

Diabase (an igneous rock which contains various minerals.) The term refers to different rocks in different countries. May contain feldspars and other minerals which are contaminated with silica.
Diamond (carbon) no significant hazards.

Dolomite (calcium magnesium carbonate) may contain some free silica.

Erionite a fibrous mineral unrelated to asbestos which has clearly been shown to cause the same diseases as asbestos in humans.

Feldspars (a group of minerals that combine silica and alumina with many metal oxides.) Their major hazard is silica. The metal hazards will depend on the particular feldspar. Some contain non-hazardous metals such as potassium and sodium. Others contain barium, lithium, and other toxic metals.

Flint (quartz) can cause silicosis and cancer.

Fluorspar (fluorite, calcium fluoride) is a skin, eye, and lung irritant. Highly toxic due to the fluorine present. Chronic inhalation can cause loss of appetite, weight, anemia, and bone and tooth defects.

Galena (natural lead sulfide) can cause lead poisoning.

Garnet (any of five different silicate minerals) may contain free silica.

Glass beads (various types of glass) does not cause silicosis. The dust is mechanically irritating to eyes and respiratory tract. If the glass contains toxic metals such as lead (e.g., lead crystal), poisoning can result from exposure to the dust.

Granite (an igneous rock composed chiefly of feldspar and quartz with one more minerals such as mica included.) Contains free silica and can cause silicosis and cancer.

Greenland spar (see cryolite).

Greenstone (a basaltic rock having green color from presence of chlorite, epidote, or other minerals.) May contain free silica and can cause silicosis and cancer. Some stones sold as greenstone may contain asbestos minerals.

Gypsum (see alabaster).

Ilmenite (a titanium dioxide-containing iron ore.) Titanium dioxide is a lung carcinogen.

Jade Two common mineral forms of jade are: jadeite which has no significant hazards; and nephrite which is felted, intergrown, fiber-like crystals of tremolite and actinolite (forms of asbestos) which can produce a hazardous dust. The term “jade” also may be incorrectly applied to serpentine (see below).

Jasper (a black crystalline variety of quartz) can cause silicosis and cancer.

Kaolin (a very white clay) Miners develop a lung scarring disease called kaolinosis.

Lepidolite (a lithium-containing mica) See mica, below. Lithium is toxic in large doses.
**Lapis lazuli** (usually mixture of minerals with the principal mineral being lazurite which contains aluminum, silicon, sodium and sulfur) May cause skin and respiratory irritation. On ingestion, the sulfur in the mineral may be capable of forming highly toxic hydrogen sulfide gas with digestive acids.

**Limestone** (calcium carbonate) may contain significant amounts of free silica.

**Magnesite** (magnesium carbonate) no significant hazards.

**Malachite** (hydrous copper carbonate, azurite) can irritate the eyes, nose, and throat. Known to cause nasal congestion and severe exposure can cause ulceration and perforation of the nasal septum. Chronic exposure can cause anemia.

**Marble** (calcium carbonate) may contain some free silica. A nuisance dust if silica is not present.

**Mica** (any of several silicates of varying chemical composition having a similar crystalline structure composed of thin sheets) Some natural micas contain free silica. Synthetic mica is also available.

**Nepheline syenite** (a mixture of feldspars, free silica and other minerals).

**Ochres** (clays containing iron oxides and occasionally manganese oxides). Iron is of low toxicity. Manganese can cause nervous system damage similar to Parkinson’s disease.

**Onyx** (a variety of quartz) Can cause silicosis and cancer.

**Opal** (an amorphous silica) Should be of low toxicity to the lungs, but large amounts may cause some lung scarring.

**Opax** (a frit of 92% zirconium dioxide, 6% lithium dioxide, and smaller amounts of titanium, iron, sodium, and aluminum) May be of fairly low toxicity in this form.

**Pearl ash** (see potash).

**Perlite** (a natural glass-like material which expands when heated) May contain significant amounts of free silica.

**Petalite**, a lithium feldspar. (see feldspar above). Lithium is toxic in large amounts.

**Plaster** (see alabaster).

**Porphyry** (conglomerate rock containing some feldspar) may contain significant amounts of free silica.

**Potash** (potassium carbonate, pearl ash) is irritating and slightly caustic.

**Pumice** (a form of volcanic glass) may contain small amounts of free silica.

**Putty** (tin oxide) no significant hazards.
**Realgar** (arsenic disulfide) is a highly toxic mineral causing skin irritation and ulceration. Inhalation can cause respiratory irritation, digestive disturbances, liver damage, peripheral nervous system damage, kidney, and blood damage.

**Rottenstone** (a siliceous limestone which has decomposed and become friable.) Used for polishing. Contains free silica and can cause silicosis and cancer.

**Rouge** (iron oxide) is an abrasive and is usually contaminated with significant amounts of free silica.

**Sand, sandstone** (quartz) can cause silicosis and cancer.

**Serpentine** (magnesium silicate) usually is in the form of chrysotile asbestos and can cause lung scarring and cancer.

**Silicon carbide** (see carborundum above).

**Slag** (glass-like material from smelting operations) may contain small but significant amounts of highly toxic metal impurities. May be contaminated with free silica.

**Slate** (a rock formed from compression of clay, shale, etc.) May contain significant amounts of free silica.

**Soapstone** (see talc).

**Soda ash** (sodium carbonate) slightly irritating. No significant hazards.

**Soda spar** (sodium-containing feldspars) see feldspars.

**Sodium silicate** (sodium silicate or water glass) Some products contain free silica.

**Steatite** (see talc).

**Talc** (a magnesium silicate platy mineral responsible for the slippery feel of soapstone and steatites.) Talc causes a disease called “talcosis” when inhaled in large amounts. Many talcs, soapstones, and steatites are contaminated with many other minerals including amphibole asbestos and silica. Suspected lung carcinogen.

**Tiger's eye** (a compressed form of crocidolite asbestos) Can cause lung scarring and cancer.

**Tripoli** (primarily amorphous silica) Should be of low toxicity to the lungs, but most varieties contain enough quartz to cause silicosis.

**Travertine** (calcium carbonate, a form of limestone) See limestone.

**Tungsten carbide** (a synthetic mineral) Assumed to be very low in toxicity. Sometimes, however, needle-like fibers of tungsten carbide are created which may be hazardous.
**Turquoise** (mineral of copper aluminum and phosphate) may cause skin allergies and irritation of the eyes, nose and throat. It may be contaminated with significant amounts of free silica.

**Vermiculite** (plate-like, hydrated magnesium-iron-aluminum silicate mineral capable of being expanded (puffed up) with heat. Some deposits are contaminated with tremolite or chrysotile asbestos.

**Vermillion** (see cinnabar).

**Whiting** (calcium carbonate). No significant hazards unless it contain free silica.

**Wollastonite** (a fibrous mineral unrelated to asbestos) May have some potential to cause cancer. Not well studied.

**Zircon oxides** (zirconia). No significant hazards.

**Zirconium silicate** (zircon). No significant hazards.

**Zonolite** (see vermiculite).