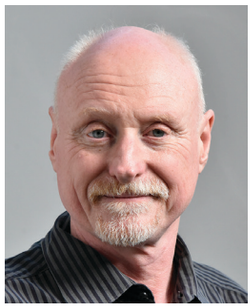

SAFETY 101 - ISSUES IN THE JEWELRY FIELD SINCE 1998

Charles Lewton-Brain
MFA/FGA/RCA/ZDF
President, Brain Press
Calgary, Alberta, Canada

INTRODUCTION: THE SCOPE

This paper is a basic one. It is from a studio jeweler's point of view, not a scientific or factory viewpoint, though all the information holds well there as well. It is aimed at the practitioner– a jeweler, a goldsmith. This paper is not about what specific parts-per-million or wavelength or which measured exposure will damage you, but more about what general principles of safety are on the things you should think about and consider in terms of safety as a worker, and new kinds of safety issues experienced in that field. As in the past, the best approach to safety is to determine what technology or chemical you are using and then examine it, asking your suppliers for the latest safety and operational information they can supply to you. This paper is aimed at the smaller shop.

HISTORY: THE SAFETY BOOK

In 1996 I gave a paper to the SNAG conference on safety in the jewelry workshop. This was followed in 1998 by the publication of 'The Jewelry Workshop Safety Report", 220 pages of carefully researched and distilled information for jewelers. It took three people and three years to do the research and write the book. It was a good snapshot at the time. But things have changed a bit since then in processes and procedures. The original book is available, and a free review of major issues is here: http://brainpress.com/Ganoksin.html#SafetyNotes.

LARGE AND SMALL COMPANIES ARE DIFFERENT

The difference between a small workshop and a larger plant is significant. Large companies will have embedded rules and protocols, safety committees, staff, segregated spaces, and resources to support a safe workplace. The processes, chemicals, and machinery used in larger production facilities are more

complex and hazardous than in a small studio. This paper is aimed at the smaller shop. Smaller companies (under the 10 employee OSHA limit)[1] will need to develop their own safety rules, systems, checklists and controls. There is no magic formula; one has to schedule time for safety discussion and analysis and improvements and then act on it.

SAFETY ISSUES- THE SAME AS THEY'VE ALWAYS BEEN

Every safety issue we were concerned with 20 years ago remains an issue today. Many processes have not changed that much. In casting, for instance, the hazards are very similar to the way they used to be. Bob Dixon of United Precious Metal Refining writes, "There really aren't new safety concerns in our [casting] business, as the technology hasn't changed that much." (Personal communication, 2023.)

Note: You can get injured quickly, as in a machine accident or a toxic chemical spill, or slowly as with silicosis, asthma, COPD, dermatitis, or lung or stomach cancer (professional polishers have increased rates of that).[2] Procedures that remain in common use for jewelers (with all the earlier safety hazards extant) include Casting, Burnout, Soldering, Etching, Hammering, Plating, Finishing, Setting and more.

I refer you to my *The Jewelry Workshop Safety Report* for a full overview of safety issues for jewelers.[3] It is a good idea to have regular safety meetings and discussion with all staff. Paying attention to safety fulfills your legal and moral responsibilities and paying attention to these will save you money over the long haul.

ACCIDENTS AND INCIDENTS

The average ratio of incidents (near misses) to injury accidents is 26-to-one. That means 26 near-misses result in one injury accident. Incidents should be logged in a safety logbook.

THE MAIN EXPOSURE ROUTES TO SAFETY HAZARDS

Inhalation: Breathing in hazardous particles (dusts), vapors and fumes, chemicals and solvents. 3D printers necessitate a new level of paying attention, especially when it comes to solvent exposure and particulates.

Ingestion: This is the eating and drinking of materials. But it can also happen when large particles are breathed in, brought into the throat by lung-clearing mechanisms, and swallowed. Don't ingest chemicals, smoke, eat, apply makeup, or bite your nails in the workshop. Have protocols for your shop.

Skin Contact: Dermatitis and absorption of chemicals is a major issue in shops. Dermatitis is a group of skin conditions that may often be contracted by exposure to chemicals (solvents) and metals. Symptoms may include scaling, splitting, eczema and so on. Dermatitis is a real hazard for jewelers. Metal workers suffer high rates of skin disorders.[4] About 65% of all occupational diseases are skin diseases[5] and most occupational dermatitis is from a toxic chemical exposure incident, with about 25% of it from long-term contact and exposure.

Wash your hands frequently and consider using a hand cream to counteract any loss of skin oils. The top materials for increased dermatitis risk include contact with chromium and nickel (and their salts), aniline and other dyes, epoxy resins, acrylate resins, formaldehyde and its resins, 3D printer resins, rubber chemicals, and certain pharmaceuticals. Other dermatitis causes include alkalies, acids, oils, solvents and degreasers, oxidizing agents, certain plants, and woods. Avoid touching toxic materials as there is chemical skin absorption and a danger of transferring chemicals around the shop when touching your face, etc. Use tweezers anytime you can in the shop.

Radiation: Jewelers have to pay attention to radiation in the forms of infrared (glowing materials) and ultraviolet, as both of these can cause cataracts. Sodium flare (the yellow flame that comes of glassy materials like borax) can contribute as well. Eye damage can easily happen, from infrared (red, glowing materials, melted metal, kilns). They cause a type of cataracts that used to be called "chainmakers' cataracts". Another eye-damaging cause is UV light, the blue from welding torches, and other sources including jewelry welding lasers, laser engravers and fusion welder work, which is relatively new to the field. Super rare today are antique 1950s irradiated green diamonds which give off damaging radiation; I have never seen one.

Physical Incidents: This includes slips, falls, injuries, strains, cuts of all kinds, physical eye damage (short- and long-term) and hearing damage. Many incidents occur when using machine tools. Long-term damage can include ergonomic issues (carpal tunnel, for instance).

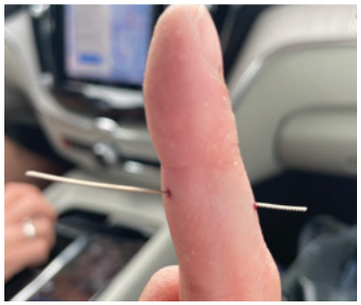

Figure 1: A workplace accident. Ouch!

MACHINE USAGE AND HAZARDS

Machinery and tool use exposes the user to all kinds of physical dangers. Machine hazards can be divided into the following categories: crushing, shearing, cutting or severing, amputation, entanglement, drawing-in or trapping, entrapment, impact, stabbing or puncture, friction or abrasion, ejection of material, or electrocution. Tools like lasers and fusion welders can generate eye-damaging light. Anything that can be done to reduce these hazards improves your shop safety.

Examine your tools for adequate machine guarding. Machine guards are generally additions to a machine that aim to stop any likelihood of pinching, crushing, or rolling damage to your hands and fingers, as well as stopping flying shrapnel or tool parts from reaching you. Maintaining machines properly and regularly is essential shop behavior.

It is a good idea to have a large, visible, lockable main "power on/off" switch if you have a number of electric machines in your shop, for emergency shutdown.

CHEMICALS

Jewelers use chemicals for cleaning, finishing, etching, plating, alloying, anodizing, pickling, sealing, enameling, wax working, casting, investing, patination and metal coloring, gemology, and so on. And don't forget that metals themselves and their salts and oxides are also chemicals. We also create new chemical compounds while working, by combining them or by adding heat to change existing ones. An example is the use of solvent-based (trichloroethylene) Whiteout® as a solder flow-retardant; heat breaks the solvent down into phosgene gas, chlorine gas, and hydrochloric acid fumes.

You are surrounded by chemicals in your everyday life, from ordinary table salt, baking soda, vinegar, and commercial cleaning products to solvents like acetone, alcohols, or D-limonene. Even water is a solvent– the most common of all in our lives. The sum total of exposure, at home and at work combined, can be important in figuring out what caused damage. Of course, it is smarter to avoid the chance of damage in the first place.[3]

One of the problems in jewelry making is that we use greases (lard or other greases, for instance) in procedures like polishing. These greases then have to be removed from the work using solvents that can range from the carcinogenic and nerve-destroying trichloroethylene in bigger shops, to alcohols (also used with 3D printer resins) to the dishwashing liquid and household ammonia in a water solution in the small workshop. Greases are sometimes burned off to remove them, a practice that is regarded as "the most dangerous of the various degreasing methods."[4]

Safety is dependent on dose. Paracelsus wrote in 1493, "All things are poison, and nothing is without poison; the dosage alone makes it so a thing is not a poison." Limit your exposure to harmful chemicals, processes and procedures.

That *Right to Know* binder, to keep chemical information current, is vital in your shop. Don't forget to include your normal household shop chemicals in the listing. And make a chemical inventory so you know what is in your shop, who you got it from, their contact information, know how much of it you have, how long it has been there, and obtain the Safety Data Sheet (SDS) information on the material, etc. Label all containers of chemicals with this information. The more you know about what you are working with, and the more you are aware of hazards, the safer you and your employees are.[3]

Chemicals can have immediate (i.e. burns), cumulative (i.e. poisoning), or synergistic effects (when you have been exposed to two or more chemicals which interact to produce new or enhanced effects). An example is that if you are exposed to toluene and then drink alcohol it can result in hearing loss, especially if you throw noise into the mix. Long-term damage like cancers can also result from exposures. Remember that metals and their decomposition products are chemicals. We encounter metals as pure elements, alloys, and compounds such as salts and oxides.

One of the big problems I see is that hobbyists and jewelers do not know what chemicals they already have in their homes and

workshops, and don't think about metals, cleaning products, shampoos, 3D printer fumes, pickles, patinas, etc. as being chemicals. Every year there are people who die in their homes because they mix household bleach and ammonia together, thus generating chlorine gases.

CHEMICAL STORAGE AND HANDLING

Chemical handling is an issue for jewelers. I have been consulted as an expert witness in a case where a mall jeweler opened the chemical cabinet in the shop on a hot day, and the bottle of nitric acid was stored at eye level and exploded, covering him with acid. Use proper eye protection and the appropriate gloves any time you are working with chemicals. Plans and protocols should be in place (and listed in your *Right to Know* book) for chemical handling and how to deal with spills. An example of a protocol is that an acid bottle should be carried in a rubber or plastic bucket, *not* in the hands. I know several nasty stories about sudden acid or chemical spills.[6]

INCOMPATIBLE CHEMICALS

It is very important that you do not store chemicals near each other that, when mixed together, can burst into flames, emit toxic or lethal gases, explode, poison, or have hazardous synergistic effects. It is important to store chemicals with intention and knowledge. In general, it is suggested that you store the chemicals according to hazard classes.

The major classes of chemicals, in terms of storage, are:

- acids
- bases
- flammables
- oxidizers
- water-reactive chemicals
- pyrophoric substances (catch on fire when in contact with air)
- light-sensitive chemicals
- peroxide-forming chemicals (they make their own explosives)
- toxic compounds
- carcinogens
- teratogens (cause birth defects and cell mutations)

Do not store the following chemicals next to, or bring them in contact with, each other. Some reactions are slow and others very rapid. There are, of course, other incompatible mixtures possible; these are just examples. Numerous sites on the internet and all university chemical labs will have lists of incompatible chemicals for you to refer to. The ones given below are likely inhabitants of jewelry shops.

Table 1: Do Not Store These Chemicals Together

Chemical	Do not store next to
Acetic acid	ethylene glycol, nitric acid, peroxides, bases, carbonates, hydroxides, metals, oxidizers
Acetone	concentrated sulfuric and nitric acid mixtures
Acetylene	chlorine, copper, mercury, silver (forms explosive acetylides with longer exposure)
Alkalis	alcohols, ketones, acids, halogens, hydrogen, plastics, sodium chloride, sulfur
Anhydrous ammonia	mercury, chlorine, iodine, acids, halogens, oxidizers, plastics, sulfur
Chlorates	ammonium salts, acids, metal powders, sulfur, combustible materials
Chlorine	ammonia, acetylene, hydrocarbons, hydrogen, turpentine, finely divided metals, alcohols, hydrogen peroxide, iodine, metals, sodium hydroxide
Copper	acetylene, hydrogen peroxide, calcium, hydrocarbons, oxidizers
Cyanides	acid
Flammable liquids	ammonium nitrate, hydrogen peroxide, nitric acid, halogens, alcohols, ammonia, ketones
Hydrofluoric acid	aqueous or anhydrous ammonia
Hydrogen peroxide	copper, chromium, iron, most metals or their salts, alcohols, acetone, organic materials, flammable liquids, oxidizing gases
Hydrogen sulfide	fuming nitric acid, oxidizing gases
Iodine	acetylene, ammonia, hydrogen
Mercury	acetylene, ammonia
Nitrates	sulfuric acid, acids, reducing agents
Nitric acid	acetic acid, cyanides, hydrogen sulfide, flammable liquids, flammable gases
Oxygen	oils, grease, hydrogen, flammable liquids, solids or gases
Potassium chlorate	acids
Potassium permanganate	glycerin, ethylene glycol, sulfuric acid
Selenides	reducing agents
Silver	acetylene, oxalic acid, tartaric acid, ammonium compounds
Sulfides	acids
Sulfuric acid	potassium chlorate, potassium perchlorate, potassium permanganate

If you see the following terms in a chemical's name, realize that these terms are linked with chemicals that have the potential to be explosive: acetylide, hypohalite, amine oxide, nitrate, azide, nitrite,

chlorate, nitro, diazo, nitroso, diazonium, ononide, fulminate, perchlorate, N-halomine, peroxide, hydroperoxide, and picrate. Common materials known to be shock-sensitive and explosive (can detonate when touched) include ammonium perchlorate, ammonium nitrate, copper acetylide, dinitrotoluene, fulminate of mercury, lead azide, nitroglycerine, dry picric acid, trinitrotoluene and dried crystals of perchloric acid.

SUBSTITUTION

The power of using an effective, safer substitution for a chemical or procedure is enormous. If you don't use a particular chemical or process or procedure, then you can't be injured by it. Solvents are a major cause of injury to jewelers, with dermatitis as well as long-term injuries. There are often safer alternatives available to the solvents in your shop. Use water-soluble materials when possible. Water-soluble polishing compounds help reduce dependence on solvents for degreasing after polishing. If you can avoid using greases (like most paste/bar polishes are), then you don't have to try and remove them by using solvents. Work with detergents and water to replace organic solvents for degreasing.[7]

According to Michael Hutt (Health and Safety Advisor of the Ontario Ministry of Agriculture, Food and Rural Affairs), the first rule of industrial hygiene is "eliminate or substitute with a less hazardous substance" (HSC list, Jan. 10/98). If you can identify a hazard, then look for alternatives that perform the desired function and produce the same or similar results as the procedure being done, then you automatically remove a chance of damage by the original hazard. The U.S. military has done a great deal of work on substitutions and shares this information for free on the web. They are, for instance, pioneers in solvent replacement by using carbon dioxide blasting and other approaches.

SOLVENTS

As Rossol says, "all solvents are toxic".[8] Waller points out that this is not quite true, since the most common solvent is water, but I still like the authoritative ring of Rossol's statement. Waller does, however, go on to say that one should assume that all organic solvents (let's say most of them) can cause "both acute and chronic damage to the nervous system, can damage the liver, can degrease the skin...and are flammable."[9]

Many, such as the 'aromatics' are carcinogenic. As well, many organic solvents interact with other chemicals in one's life (aspirin and other drugs, cleaning supplies, etc.) to synergistically cause more damage than mere exposure to the solvent alone. Drinking alcohol after work, for instance, can interact with some chemicals (such as carbon tetrachloride and perchloroethylene, among others) to cause permanent liver damage.[5] The flammability of many solvents is a real issue, and most should be stored in self-extinguishing safety cans. Even fairly innocuous solvents like acetone are extremely flammable.[3]

Here are some workshop solvent substitutions that are useful to know about for smaller shops.[10]

- Methyl alcohol: try ethyl or isopropyl alcohol
- Aliphatic hydrocarbons (petroleum distillates): try isopropyl alcohol, acetone or terpenes
- Aromatic hydrocarbons (toluene, xylene, etc.): try isopropyl alcohol, acetone or terpenes (do not use at all)
- Ether: try ethanol or isopropyl alcohol
- Gasoline: try: ethyl or isopropyl alcohol or acetone
- Kerosene: try: ethyl or isopropyl alcohol or acetone
- Ketones: try: acetone or terpenes
- Hexane (do not use at all): try heptane (rubber cement solvent)
- Lacquer thinner: try ethyl or isopropyl alcohol or acetone
- Methyl ethyl ketone: try acetone or terpenes
- Methylene chloride: try benzyl alcohol (US Air Force/EPA)
- Paint thinner: try terpenes– citrus-based solvents, make sure there is no benzene in them; use the de-odorized types like Turpenoid® or benzyl alcohol
- Styrene (do not use at all): try isopropyl alcohol or acetone
- Toluene: try isopropyl alcohol or acetone
- Trichloroethylene (do not use at all): try alcohols or acetone
- Turpentine: try VM&P naphtha, de-odorized mineral spirits, Turpenoid® or D-limonene
- Xylene (do not use at all): try isopropyl alcohol, acetone or de-odorized paint thinner

LIST YOUR HAZARDS

It is useful when examining a process, procedure, equipment (machine entrapment, ejection, etc.), chemical, new technology use, etc., to evaluate it. This works well when brainstorming with others on your team; a group mind will often pick up things that

a single mind does not. Think of as many hazards as possible, explore the implications of using a technique, process, chemical etc., and look for substitutes.

Questions to ask yourself might include:

- What manufacturing processes do you do?
- What do you use for those processes?
- What materials, procedures, machines, or equipment do you use?
- What chemicals, working methods, or ergonomic and physical dangers exist in your shop for your workers?
- What are the implications and hazards related to these activities?
- Can you make anything safer by substitutions in your procedures or processes?

HAVE PROTOCOLS

Milt Fischbein, an engineer with 18 years of experience in gas, oil, and chemicals, writes that, "Industrial experience shows that the vast majority of safety incidents are a result of human error and, of the human error incidents, the bulk of those are a result of not following established procedures." (Personal communication, 10 January 1998). Safety issues can be addressed in different ways: universal shop rules, procedure rules, machine rules, chemical handling and storage rules, etc. These all need to be regularly reviewed with staff and reside in the *Right to Know* book. Each different procedure will require its own safety evaluation and set of rules and guidelines. Often the manufacturer of the equipment used can supply you with safety advice for the machine or process you are using. I suggest contacting several information sources. This is not magic, it takes slow work and commitment. You move the mountain a bit of gravel at a time. A simple protocol example is a shop rule to not dip your hands in liquids or touch chemicals; make tweezer and glove use mandatory when necessary.

LOGGING, TRACKING AND RECORD KEEPING

In order to understand what the issues are in your shop you need to know what they are. This means an inventory of equipment, processes, procedures, chemicals stored and how they are used, dust-producing activities, etc. This is kept in a binder, perhaps along with a second binder with SDSs for each chemical in your shop. (Not that SDSs are perfect, but they are a good starting point. Most manufacturers will supply you with them or they can be downloaded from the web). This *Right to Know* binder is an essential tool for your shop and is often a legal requirement to have on hand. In the same way an equipment and machinery binder is necessary, it is important to log purchase dates and sources, costs, and maintenance requirements (say, how often to change filters in your portable ventilation extractor). This log includes how often maintenance is performed on a machine, what was done, what repairs were needed, and so on. This information is not just useful for safety reasons but may be useful for city and local taxation records for your business. Stewart Grice of Hoover & Strong suggests that the following tracking information is essential:

- SDS sheets all kept together in a single file with easy access (the *Right to Know* binder)
- Clear Safety labels for all equipment/chemicals that need them
- Reference websites for any rules or regulations needed listed in the binder
- If you have employees, make a safety manual of where everything is kept. Include do's and don'ts, and suggest giving examples, such as "always wear eye protection when grinding on metal" or "never solder in a closed room with no ventilation." (Personal communication, 2024.)

USEFUL STEPS: AGAIN

- Create a full inventory of all your processes, machinery and equipment, chemicals stored and how they are used, and examine dust and fume generation and extraction. List and add SDSs and protocol information to your *Right to Know* book.
- Identify the hazards for each activity you perform.
- Identify any substitutions possible to ameliorate those hazards.
- Identify all PPE and engineering controls needed to do the activity safely.
- Identify milestones to implement the safety guidelines. It is often a good idea to do this as a team, to dedicate some planning time with the group.

JURISDICTION

Laws and compliance regulations will vary considerably from state to state, county to county, and country to country. You will need to determine the laws that apply to your business and processes in your own local area, town, and country. Environmental rules can be dependent on the scale of usage, with small users being given leeway, or they may not. In the UK for instance, it appears that even very small manufacturers have to abide by all the compliance rules that larger ones do, and it varies across North America.

It is your responsibility to determine what the local rules and boundaries are that you need to pay attention to. Contact places like state authorities, the federal government, your town hall, Rotary clubs, the police, the fire department, the Better Business Bureau, your Chamber of Commerce, and insurance companies. Ask other businesses like yours what they have to do. Share information and questions with them. You are not on your own, there are others with your problems in your area. Talk to them, do your research for your particular business and location. Someone told me once, "the best way to make a friend is to ask them for advice."

THE ISSUES OF SAFETY FOR JEWELERS IN GENERAL

I think that a contemporary jewelry studio is a pretty safe jobsite. If particulates (dust, metals, chemical compounds), eyes and hearing protection, solvent use and ventilation issues are addressed properly, jewelry work is fairly safe. If you are thoughtful and careful, your risk may not be high. In general, with chemical and other exposures, the more you do something or are in contact with it, the more likely it is there will be trouble. Smaller exposures, in general, carry lower risk.[3] "The best way to eliminate a hazard is to eliminate its cause(s)."[11] The most common work-related problems in the arts reflect those of industry: rashes and other skin problems, lung disorders and back problems.[9] Again, the scale of the workplace makes a difference: big shops and small shops.

Here's something to aim for: a well laid-out, orderly workshop, well-lit from multiple, nonglare light sources, electrically and fire safe, with low dust and few procedures involving solvents. You should have excellent local ventilation at the appropriate workstations, use work clothing which is cleaned frequently, have lots of personal safety equipment (earmuffs, safety glasses, etc.), work at different jobs at varying heights over the day, use ergonomically considered working actions, and have a conscientious attitude and consciousness of safety. Choose procedures that don't involve exposure to risks. Set things up so that you can't hurt yourself.[3]

CHANGES IN THE JEWELRY WORKSHOP SINCE 1998

There have been a number of changes in the jewelry field over the last 20 plus years. There are new technologies such as CAD work, computer use, rapid prototyping/3D printing, fusion welder use, laser engraving, marking and cutting use, jewelry laser welders, as well as older technology that is using new methods and processes which may expose the jeweler to newer hazards. An example from a person I interviewed was the increase in silica particles, or chemical compound exposure from new polishing methods, bristle brushes, and similar, newer finishing tools for flex shafts.

New technologies can present variations of all the standard safety issues, and they need to be examined in light of existing safety hazards and categories. 3D printers for instance, present resin (chemical exposures), solvent (for cleaning), and air particulate issues (filament); they are just new sources for these issues in ingestion, inhalation, absorption, etc.

ERGONOMIC REVIEW

In the early 18th century, Bernardino Ramazzini wrote "So much for workers whose diseases are caused by the injurious qualities of the material that they handle. I now wish to turn to other workers in whom certain morbid afflictions gradually arise from other causes, i.e. from some particular posture of the limbs or unnatural movements of the body called for while they work. Such are the workers who all day long stand or sit, stoop or are bent double; who run or ride or exercise their bodies in all sorts of ways."[3]

Body position, repetitive movements, stresses, working height, and bad workplace and equipment design can all be significant hazards to the body. You need to pay attention to ergonomic issues. Examine the movements, body stresses, vibration, repetitiveness (change what you are doing every 45 minutes or so for ten minutes to reduce the hazard). Vibration such as polishers experience in their work can lead to "white finger," a kind of vascular damage that can be permanent.

Ramazzini writes rather cruelly (and remember that the man was a great humanitarian in his time) about the effects of working posture and position in regard to cobblers and tailors: "It is a laughable sight to see those guilds of cobblers and tailors on their

own special feast-days when they march in procession two by two through the city or escort to the tomb some member of their guild who has died; yes, it makes one laugh to see that troop of stooping, round-shouldered, limping men swaying from side to side; they look as though they had all been carefully selected for an exhibition of these infirmities."[3]

SAFETY CHECKLISTS

When examining a technology or process, after identifying hazards it is wise to list, create, and post checklists of the safety precautions to use. And build in a six-month review of all safety issues and precautions for all workers and users. Checklists work– that is why pilots and the military use them.

RESOURCES

There are many resources for safety information, rules, and guidelines. There are books, but excellent information is available from many other resources, such as the Canadian Centre for Occupational Health and Safety (www.ccohs.ca), The National Institute for Occupational Safety and Health (NIOSH) (www.cdc.gov/niosh/index.html), the Bureau of Safety and Environmental Enforcement (US Department of the Interior) (www.bsee.gov/guidance-and-regulations/guidance/safety-alerts-program), and there are tons more.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

It is important to provide your workers with tools to help them avoid damage. This includes:

Eye protection: Have lots of it on hand, for radiation as well as projectile injuries. If it is within reach and easy to get, people will use it. I found that hooks every six to eight feet with earmuffs and safety goggles was a good distance– easy for the worker to access. Having a rule about using eye protection at all times in the shop is a good idea and is already mandatory in larger workshops. Draw a yellow line on the floor, and when you cross it your PPE is put on and you don't take it off until you leave.

Hearing Protection: Same thing– make it easy for the worker to find, use, and put away. Earmuffs are slightly better than ear plugs. I like earmuffs because you can take them off easily and replace them, whereas if you do that with ear plugs you can develop skin irritation.

Eyewash stations: These are a good idea for chemical splashes. The best kind of eyewash station is installed into your tap on the sink and is ready to use at any time. Make sure, however, that the eyewash station can actually be reached and used by everyone in your shop, including short people. I've seen more than one stupidly installed eyewash station that would clearly work only if you were six feet tall or more. A bottle on the wall is all right for washing out a bit of debris but cannot approach the 10-15-minute flushing required for chemicals in the eyes. Such bottles also need to be changed and maintained regularly to be effective.

Protective clothing as required: Work aprons are important. In Germany, where I learned, goldsmiths had shop coats (regular wore blue, stone setters wore white). Using casting aprons and shoe covers to avoid getting spilled molten metal in your shoes can be important (foot injuries from burns are much worse if the molten metal is trapped in your laces). You don't want to take your chemicals home and spread them to your family and pets, so the work clothing is kept at work and laundered there (also to retrieve precious metal residues).

Gloves: While it may seem obvious that gloves are used to protect your hands, it bears repeating. This means that you have to first define what the glove is for and then choose the right glove for the problem you have. You also have to watch out for the glove itself becoming a problem, such as winding your hand around a part of rotating machinery (I know a horrible story or two about polishing machine accidents with gloves). We use gloves to protect against heat (leather, Kevlar®, other materials), cuts (Kevlar, leather, cotton, plastics, knitted stainless steel, and others), chemicals and solvents of all kinds. The chemicals and solvents are complicated because not all gloves work with all chemicals. Latex is a reasonable starting point, but it is up to you to consult a glove chart and find out if latex, nitrile, vinyl, or some other glove is correct for your application. Gloves may have a short shelf life in storage or disintegrate after a period of time in the chemical they are intended for. As with respirators, don't let the safety equipment lead you into unsafe conditions because you think you are protected by the equipment. If you can do the job with tongs or another method, choose that safer approach first. Each glove material will decay in contact with a given chemical or solvent and you need to know what the glove will do.

RESPIRATOR USE

If you think you need a respirator to do something, red flags should

be waving in front of your eyes and alarm bells ringing in your mind. If you have to use a respirator, there is something really wrong with your ventilation system and working processes. And when you take it off, whatever it was you were afraid of will still be there, an invisible dust (such as cristobalite investment) on all surfaces, so that merely walking past later will stir it up into the air so you can breathe it in. Same for chemicals and metal fumes (which deposit as an extremely fine dust). If you are using a respirator in your normal working space, what you are admitting is that you desperately need a proper ventilation system. A respirator is a tool of last resort, a back-up, an emergency thing. And if you are using one, make sure it is correct for your face and for the chemicals and fumes you are protecting yourself from.

Talk to your safety supply company representative, or better still, several of them. Respirators interfere with communication which can be dangerous. In industrial situations they are only used for very short periods of time. Generally, in order to work, they have to be worn so tightly that they are uncomfortable.[12]

It is easy to use the wrong one or to have an imperfect seal when you use it. Most respirators do not seal well onto a bearded face and safety experts advise against using a respirator unless you are clean shaven, most workplaces where respirators have to be worn regularly are totally beard-, mustache-, goatee-, and sideburn-free by regulation. There have also been cases of facial hair being caught in the exhaust mechanism of a respirator, thus holding it open and allowing dangerous contaminants into the mask (Rory, HSC list, 28 Jun 1999).

Rossol[8] and McCann have good sections on which respirators serve which purposes, and there is a ton of information on the internet on the subject. Keep your respirator in a plastic bag when not in use, to help keep the filters' absorption in good shape. Wipe it with a damp cloth and put it away after use to keep dust off it. Change the filters by their expiry dates or more frequently, if they are used a lot. Use the correct filter for the type of material you are handling. Bear in mind that I think that if you need a respirator, your ventilation system is inadequate, and that you probably shouldn't be using the materials that make you think you need a respirator anyway.

One of the issues in the 1990s was the association of cadmium metal fumes with cancers. They are often used in older solders but this still remains an issue, to my mind. It should be noted however that Stewart Grice says, "Hoover & Strong are selling four times as much cadmium solder as those without cadmium." He says goldsmiths claim it flows easier and better than cadmium-free. It appears that melting pure cadmium is an issue but that there is no regulation or recognized problem with alloyed material of which cadmium is a part. (Personal communication, 2024)

NEW TECHNOLOGIES

With newer technologies there are materials which bring new issues with chemicals, fumes, generated particulates, dermatitis, and other hazards. There are new sources of light, to that can be damaging to the eyes.

LASER WELDERS FOR JEWELRY

Jewelry welding lasers are Class 4, which can be quite dangerous, but the enclosed cabinet helps a great deal. Philip Scott of Rio Grande writes, "When using the laser as intended, looking through the scope, there are several safeties in place. There is a filter glass that keeps the 1064 nm light from coming back into the eye. There is also a shutter that opens and closes instantly as the laser fires. It is so fast that you don't notice it. That also keeps the flash of light from being an issue when welding and helps protect the eyes if the first filter was compromised. This digital shutter is more noticeable when firing at high speeds. You can notice the shutter as the light starts to seem to get darker when welding. You may also notice more flickering. The lasers are a Class 4 laser which means that you can actually stick your hand in the path of the laser and get hit by the laser. Not lifting the fringe on the front where the hands go is essential when firing the laser. Never stick your head in there when the laser is hot and ready to fire or when firing. Eye damage is the biggest risk, but not if being used properly. So basically, looking through either the viewing window on the front of the laser while someone is welding or through the filter glass or through the microscope is totally safe." (Personal communication, April 1, 2024.)

Hazards

Electrical and electrocution dangers are present (deaths have occurred, often during maintenance). It is the most common non-beam hazard,[13] causing serious eye damage (retinal injury and cataracts), skin damage (burns), fire, explosion (rare), and very importantly, metal vapors and particulate generation (including the nano-sized ones that injure you over the long term). As well, various chemicals can be altered and volatized creating new chemicals and compounds, each with specific issues.

The metal and other particulate generation is enough in laser engravers and cutters that recovery ventilation systems (often not included in the price but sold as a recommended extra) can result in serious amounts of precious metal debris and particulates reclamation– conservation at its highest. And again, you don't want to breathe the stuff that is generated from laser use on metals and other materials. That seems to be a big issue for engraving and cutting laser users; users don't always appreciate the importance of ventilation for the generation of new chemicals, metal particles and vapors from the laser use. Local ventilation is a key. Maintenance or non-standard operation can be a source of laser hazards.[14] Lung damage from particulates, metal fumes and chemical exposures leading to short- and long-term injuries are possible.

"Laser generated air contaminates (LGAC) exposure accounted for 9 percent of all non-beam accidents in a recent study of laser related accidents. The types of contaminates that are generated vary from toxic (methyl methacrylate) and carcinogenic (benzene) chemical compounds to hazardous biological agents (microorganisms)."[15] Please note that for jewelry lasers these hazards are much lower than experimental university labs. Local ventilation is required: where you suck the particulates and fumes from the place you are producing them, and either exhaust them or run them through a fume and particulate extractor that is regularly maintained and checked.

Laser Engravers, Cutters

Laser engravers, cutters and welders share a number of issues. Note that the design of jewelry lasers has taken account of safety concerns and if used according to the manufacturers guidelines that should resolve many of the issues described. There are differences between these technologies, but a number of dangers are shared. There are many makers of lasers, for jewelry and other uses. It is up to you to get all the information you need on safety from your laser supplier.

Eye damage is a real danger with lasers. Pay attention to possible light leaks.
Many sources state that only people with proper laser training should be allowed to use a laser.

A large percentage of laser accidents (electrocution for instance) occur during maintenance-establish procedures to follow for yourself and staff. This is another place where the use of checklists helps.

There are several types of engraving lasers, CO_2 (uses a mixture of carbon dioxide, nitrogen, and helium), and solid-state lasers which use a crystal or glass material as the lasing medium. Engraving, carving, and cutting lasers will emit significant amounts of particulates, metal fumes and decomposition products.

The particulates (metal and chemical decomposition products produced) need extraction from within the machine and your work area. It's best to have the extraction nozzle close to the laser contact point while working (local ventilation), and in larger machines or cutters the nozzle should, if possible, follow the path of the laser contact point as it moves. Some have enclosed cabinets that are vented. Whatever you are extracting needs to be captured or exhausted outside.

There is possible lung damage from particulates, metal fumes, and chemical exposures leading to short- and long-term injuries are. One laser engraver vendor told me that jewelers sometimes eschew the ventilation unit they recommend as too expensive, and they convince them to add it to their order by pointing out the material reclamation value of having one, that the value of the recovered precious metal particles and compounds is significant. This tells you how much metal gets vaporized in this process and launched into the air. Not to mention the other chemical dangers as a result of laser use.

PHYSICAL ISSUES

Damage to eyes can be a major danger with lasers, and the damage can occur instantly.

"Potential hazards to the eye depend on laser light wavelength, beam intensity, distance from the laser, and power of the laser (both average power over long intervals and peak power produced in a pulse). The wavelength of the laser radiation is significant because only light within the wavelength range of approximately 400 to 1400 nanometers can penetrate the eye sufficiently to damage the retina. Near-ultraviolet light of certain wavelengths can damage layers of the eye near the surface, and can contribute to cataract formation in the lens, especially in younger persons, whose eye tissues have greater transparency in this wavelength range. Light in the near infrared can produce surface damage as well, although at a higher damage threshold than for ultraviolet light."[16]

Ninety percent of all laser injuries result from one or more of:

- Unanticipated eye exposure during alignment
- Misaligned optics and upwardly directed beams
- Available laser eye protection not used

The remaining 10% of laser injuries are from:
Equipment malfunction, improper methods of handling high voltage, intentional exposure of unprotected personnel, operators unfamiliar with laser equipment, lack of adequate protection from non-beam hazards, improper restoration of equipment following service, inappropriate eyewear for laser in use, unanticipated exposure during laser usage, inhalation of laser-generated contaminants, fires resulting from ignition of materials, eye or skin injury of photochemical origin, and failure to follow guidelines and standard operating procedures (SOPs).[17]

Note that the only fatalities from laser use have been from non-beam hazards (electrocution, fire, asphyxiation). (LaserSafetyHandbook)

Burns are possible (jewelers know the whiff of burnt skin from lasers). The University of Illinois notes “even low-level exposures from scattered radiation can cause erythema (sunburn), skin cancer, or accelerated skin aging.”[18] Other tissue interactions with laser light can include photochemical reactions after absorbing high energy resulting in cataracts or even skin cancer.[13]

I came across this reference to acoustical issues, from Princeton University's "Laser Hazards and Control Measures": “Acoustical effects result from a mechanical shockwave, propagated through tissue, ultimately damaging the tissue. This happens when the laser beam causes localized vaporization of tissue, causing the shockwave analogous to ripples in water from throwing a rock into a pond.”[19]

There are ergonomic issues as well to consider for the user depending on the work being done, the equipment design and the workspace

“How much is your team exposed to risk on the job? Not only does a safety risk assessment identify potential issues affecting the staff, but this assessment is important to help you see how safety risks impact your business. The goal of this systematic procedure is to identify anything that might result in danger to any people involved, including employees, contractors, visitors, customers,

or the general public. Risk could also result in an otherwise undesirable outcome, with examples including bodily harm, legal or regulatory liability, or loss of property or productivity."[19]

FIRE

This does not seem to be a common issue for jewelry lasers, though it is a danger for other lasers near flammable materials. Note that Class 4 lasers can cause fires.

SAFETY PRECAUTIONS TO USE

Even though jewelry lasers are enclosed and so very safe, with some laser cutters or engravers it is necessary to wear appropriately rated laser eye protection goggles when using a laser outside an enclosed cabinet. Optical density (OD) is a consideration for laser use. It is possible to get goggles for specific wavelengths of the laser you are using but it is recommended to get a higher OD than you need. Make sure the glasses are stored carefully to avoid damage that can compromise them. Watch out for stray laser beam reflections. Do not wear jewelry like rings or watches that can reflect the beam. It is noted that curved surfaces as found on jewelry can increase the chance of stray laser radiation.

Specular viewing: This can be intrabeam/direct, and comes from reflections off of smooth or mirrored surfaces, such as stainless-steel work surfaces, watch faces or jewelry. Specular viewing can be as dangerous as direct or intrabeam viewing.”[20]

Isolate the laser area with screens or curtains if there is any chance of stray reflections from the tool. Adhere carefully to maintenance schedules with lasers. Take care with electrical components– a number of sources said there had been deaths associated with the high electrical currents used in lasers, especially during maintenance.

Consider adequate local ventilation for the particulates and fumes your laser is generating. Victor Gaouni of VTron Lasers wrote on Facebook, “I use a high-velocity vacuum system with carbon, HEPA and MERV 18 filters that can capture 99.999% of all fumes.” Keep a clean workspace. This avoids fire and other hazards.

Burns: Don’t put your hands or skin in the laser crosshairs. If argon or nitrogen is used, then compressed-gas safety protocols need to be followed.

FUSION WELDERS

While the high current used might be concerning, Orion, a fusion welder maker, says the arc is designed to only arc to very conductive metal parts (not to a human body). Eyes can be damaged if exposed to the weld arc (do not look at it without eye protection).[21] Use only the microscope or the self-darkening lens that comes with the Orion. It can be useful to place the tool in a corner or to shield to limit unprotected viewing. IR safety glasses are available for fusion welders, especially as 'permanent jewelry' is now installed using them. Burns are possible if the metal gets hot; they suggest starting low on the power and then increasing it to the optimal setting. There are also puncture hazards from the sharpened electrode wire. There was a question on Ganoksin.com that arose about pacemakers and fusion welders, and Patrick Sage[22] from Rio Grande basically said to talk to your doctor.

The PUK welding device manual suggests keeping children away from the equipment, and that electric shock can cause severe injury, especially if incorrectly installed or grounded. They suggest using dry insulating gloves, and not touching the work or ground. Ventilation is suggested. Fire is possible if flammable vapors are present. There might be some interference with computers and communications equipment from the welder. If argon is used then compressed-gas safety protocols need to be followed.

CAD

Jewelers today spend much more time working with computers than they did twenty-five years ago, not merely running their business and marketing, but doing CAD work as an essential and vital part of jewelry designing and making, commissions, and customer interaction. Many of the hazards are ergonomic: posture, back, neck, shoulder pain, headaches. Eyestrain is common because of the concentration required looking at the screen, which slows the blink rate and so dries out the eyes which can stress pre- and post-cataract surgery eyes (aka "dry eye).

Other issues include repetitive strain and incorrect screen settings. Pay attention to furniture, posture, breaks, and physical work in addition to the computer and so on. Incorporate stretches and gentle twisting into your day, walking around every 40 minutes or so and keeping your eyes level with the top of your monitor can help. When typing, keep your wrists straight, bending your wrists upwards can lead to a repetitive strain injury (RSI).

3D PRINTING

3D printing is now a necessity for jewelers and presents a number of safety hazards. To my mind, it is preferable if the printing is outsourced to a professional skilled in the process, the equipment, current in the ever-changing advances in technology and printing materials, with a good knowledge of printer types, feedstock, resins, the safe dissolving of support materials, the safe reclamation of chemicals (solvents) and disposal methods and legalities. There are serious issues with vapors, fumes, particulates, chemical exposures, dermatitis, and other physical issues. This is one of the reasons to consider outsourcing. There is an enormous amount to know, and because of proprietary chemistry, there can be some issues with knowing how to approach and perform a specific process safely. Ventilation, handling and safe disposal protocols are essential. I know of a professional jewelry CAD and printer specialist with six different printing machines for different problems, and they're good with multiple programs to tweak the model to the best advantage in the output, quality of print, engineering of micro details on the CAD. When people send a file off to a printer or caster there is a lot of fixing of problematic CAD files going on that jewelers may not be aware of when they send the file off.

So, if you do 3D printing yourself, this means a bunch of research, ongoing learning and study, communication with your equipment and printing suppliers, and close attention to regulatory and compliance issues such as environmental compliance, ventilation, chemical exposures, and its related dangers. Even filament printers are considered serious emitters of respirable particles and chemicals that are hazardous. The type of resin, wax or printer material you are using makes a big difference. Filament printers are in general not fine enough resolution for jewelry purposes but work well for prototyping, ideation and designing. I had a student once who I challenged to create injection molds for complex catch systems using a filament printer and he made a great injection mold for a working hinge-based catch that produced excellent results; he was seeing the object in the negative (the hole) for wax injection.

Because there are so many versions of 3D printing, resins, proprietary approaches, different chemical exposures– each specific to the printer– and printing products, it is necessary to take control of your own usage and exposures. It is clear from conversations with jewelry manufacturers that safety protocols are lax in our industry, with untrained people tending the printer, removing support materials with alcohols and other chemicals that

cause lots of unwanted exposures, and there is a lack of proper protocols for printing safety in the jewelry field. If we go wider, there are thousands of hobbists and other users doing 3D printing without attention to safety, and this is a real issue, prompting the 2023 NIOSH 3D printer paper. The adoption of the technology is outpacing the regulation, and the safety issue knowledge in society. And for jewelers this is true, too.[23]

MAKING THE METAL OBJECT

A secondary large issue is actually turning a CAD printed model into metal. This usually involves casting, with all its traditional attendant issues and precautions. At the beginning of CAD in jewelry there were only resins, most of which did not burn out well, and when they did, had decomposition products what were toxic, carcinogenic, and more. This led to systems of molding resin originals and injecting those molds with wax to cast the object. Then came better wax, and wax-like castable materials that could be printed in various ways. Each approach has specific issues that the user should ascertain from their equipment supplier, and all require excellent ventilation and material handling systems. While there are increasing (and expensive) options for direct-to-metal printing methods (see Cooksons in England), most general jewelers use castable waxes (and some resins as well).

So, if you are casting your 3D printed objects, whether done in-house or outsourced, you need to pay attention to what decomposition products and chemicals you are producing. It is up to you to take responsibility to understand what you are doing and what the safety implications are (a reason to consider outsourcing). Consulting with your suppliers is important. Local, effective ventilation appears to be essential.

NEW MATERIALS FOR OLDER TECHNOLOGIES

There have been some changes in how traditional processes are done. Some areas had not changed over the years. All the casters I spoke to said that things had not changed that much in the casting world, that no really new chemicals were present, and that the hazards were the same, particulates (silica), to use local ventilation, to use gloves in contact with the investments, not really any new chemical dangers, all the older precautions for casting metals held true.

One person commented that all the new silica-based and other abrasives in flexible shaft tools were a concern, that there are dusts

produced, and perhaps there are chemical exposures that were not present in the past. In a phone interview, Blaine Lewis, founder of the New Approach School, said that nanoplastics were a concern for him, and that not generating them in the shop was a safety concern.

AI USE

This is an interesting one, and this is just a note that AI is seeping into the culture, that the applications of trainable systems are still being imagined and developed daily, and that how people adapt it is in development. I would just suggest paying attention to changes and developments, and watch how it might affect safety in the jewelry field.

COMPLIANCE

When I was interviewing vendors at the 2024 March MJSA Expo in New York City one of the issues that came up frequently was compliance. Not so much for personal, individual safety, but for the corporate entity, the business. In general compliance costs (homeland security, environmental, and more) seem to be a big change from the past and is certainly a significantly increased cost to a business than in the past. These issues do end up affecting safety, not just to the individual, but to the attention paid to safety in the corporate entity as resources are strained.

SECURITY

In conversations with vendors and refiners at the 2024 MJSA Expo, one of the changes mentioned by several was that the gold price had risen so much over twenty years that they now had serious security concerns over their drivers who collected materials to refine, and that security for employees was now a bigger cost and concern than it was before. This is an increased resource cost as well as a safety issues for employees (and owners). The traditional jeweler's rules remain (things like: don't share your home address, vary your arrival and departure times from the shop and so on). See industry groups and insurance companies for details (the Jewelers Vigilance Committee, for instance).

CYBERSECURITY

A number of people I spoke to mentioned cybersecurity as a real issue for a corporate entity, with effect spilling over to workers in the field. Clients' personal information, and far more, can be

accessed by a hacker. Examine your exposure on the internet to cybercrime and hacking.

CONCLUSION

All the long-established issues of safety, exposure routes, short-term and long-term damage, ventilation requirements, physical damage and so on, remain true in our field. There are some new issues in the technologies jewelers now use, but they are specific to the new process, equipment and materials used. It is your own responsibility to research and learn about what you are doing, and what the dangers are. This paper has been a small glimpse into the kinds of issues that one should consider.

See this link for extracts from my safety book:
http://brainpress.com/Ganoksin.html#SafetyNotes

REFERENCES

1. https://www.osha.gov/laws-regs/regulations/standardnumber/1904/1904.1
2. P. Sparks and D. Wegman, "Cause of Death Among Jewelry Workers," Journal of Occupational Medicine Vol 22 No. 11 (November 1980): 733-736 https://www.jstor.org/stable/45013336
3. C. Lewton-Brain, The Jewelry Workshop Safety Report, (Brain Press, 1989, 1999)
4. Tver, David, and Kenneth Anderson. Industrial Medicine Desk Reference. (New York: Chapman and Hall, 1986).
5. Stellman, Jeanne M., and Susan M. Daum. Work is Dangerous to Your Health. New York: Vintage-Random House), 19 ,3.
6. C. Lewton-Brain, "Basic Chemical Storage Principles." Ganoksin, 2016. https://www.ganoksin.com/article/basic-chemical-storage-principles/
7. R. Carson, P. A. and C. J. Mumford. The Safe Handling of Chemicals in Industry. New York: Longman Scientific and Technical with John Wiley and Sons, 1988.
8. Rossol, Monona. The Artist's Complete Health and Safety Guide. 2nd ed. New York: Allworth Press, 1994.
9. Waller, Julian. Safe Practices in the Arts & Crafts: A Studio Guide. 2nd ed. New York: College Art Association of America, 198)
10. Spandorfer, Merle, et al. Making Art Safely. New York: Van Nostrand Reinhold, 1993.
11. Qualley, Charles A. Safety in the Artroom. (Worcester, MA: Davis Publications, 1986.)
12. Kinnersly, Patrick. The Hazards of Work: How to Fight Them. (London: Pluto Press, 1973.)
13. Laser Safety Manual for Columbia University, New York State Psychiatric Institute and Barnard College, October 2023
14. Johnny Jones, "Laser Safety in Jewelry Manufacturing," The Santa Fe Symposium on Jewelry Manufacturing Technology 2007, ed. Eddie Bell (Albuquerque: Met-Chem Research, 2007)
15. Laser Safety Manual, University of Victoria, Chemistry Department
16. T. J. Fellers, M. W. Davidson (National High Magnetic Field Laboratory), "Laser Safety," Nikon Microscopy U, https://www.microscopyu.com/microscopy-basics/laser-safety
17. Laser Safety Guidelines, University of Georgia, Office of Research, https://research.uga.edu/safety/laser2/safety/
18. "Laser Hazards and Control Measures," University of Illinois Urbana-Champaign, Division of Research Safety, https://drs.illinois.edu/Page/SafetyLibrary/LaserHazardsandControlMeasures
19. "Laser Safety Training Guide," Princeton University, Environment Health Safety, https://ehs.princeton.edu/laboratory-research/laboratory-safety/laser-safety/laser-safety-training-guide
20. (Lasersafetyindustries) https://lasersafetyindustries.com/blogs/laser-safety-articles/direct-vs-diffused-viewing-of-a-laser
21. Patrick Sage, https://orchid.ganoksin.com/t/pulse-arc-and-fusion-welding/46969/38
22. Safety Concerns, Sunstone Welders. https://www.sunstonewelders.com/pages/safety-concerns
23. "Approach to safe 3D printing; a guide for makerspace users, schools, libraries, ad small businesses," NIOSH. https://www.cdc.gov/niosh/docs/2024-103/default.html
24. CWRU EHS Laser Safety manual, (LaserSafetyHandbook) https://case.edu/ehs/sites/default/files/2018-07/LASER-SAFETY-MANUAL_2018.pdf

25. OSHA Good reference from OSHA https://www.osha.gov/laser-.hazards/hazards
26. OSHA. Good reference from OSHA https://www.osha.gov/laser-hazards/hazards
27. University of North London (UNL). “Safety. Bulletin no 21; Safe Use of Cyanide” (web article) 14 October 1998.