OSHA laboratory safety standard 29 CFR 1910.1450 and achieving compliance in the microelectronic laboratory

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ABSTRACT

OSHA LABORATORY SAFETY STANDARD 29 CFR 1910.1450
AND ACHIEVING COMPLIANCE IN THE
MICROELECTRONIC LABORATORY

by
Danielle M. Di Gironimo

This thesis is a practical application of occupational exposures to hazardous substances in a microelectronics laboratory. The Occupational Safety and Health Administration (OSHA) standard for the safety in laboratories is (29 CFR 1910.1450). The application is a demonstration of the implementation of the standard in a university setting. Hazards that exist in laboratory settings are very complex and the task of providing a safe workplace can become increasingly complicated. A laboratory can and does impose different health and safety concerns that a standard industrial workplace setting might not have. The need for a laboratory safety standard program to be implemented is key to the safety and well-being of the people that work on a daily basis within the labs.

As a focus in this paper, a special look at the inherent dangers associated with one of the labs has been analyzed. The microelectronics laboratory possesses a fascinating mix of hazardous chemicals that can affect the people working in the lab in ways that are not acceptable. Implementation of the standard will be conducted in a step-wise function. At present time the university is attempting to meet mandates of the order to comply. Training has been conducted and attended by a majority of the employees in conjunction with the laboratory safety standard and reports have been completed to fulfill the obligation of the standard. Senior administration is attempting to expedite the process to insure total compliance.
OSHA LABORATORY SAFETY STANDARD 29 CFR 1910.1450
AND ACHIEVING COMPLAINCE IN THE
MICROELECTRONIC LABORATORY

by
Danielle M. Di Gironimo

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OSHA LABORATORY SAFETY STANDARD 29 CFR 1910.1450
AND ACHIEVING COMPLAINECE IN THE MICROELECTRONIC LABORATORY

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This thesis is dedicated to my parents Frank and Cathie and my love Christopher. Each of you in your own ways have helped to make me the person I am today. Dad you have given me the enthusiasm and knowledge to question the world around me. Mom you have given me the confidence I need to tackle any obstacle that is in front of me. Chris you have taught me to care for someone in a way I have never cared for anyone before.

Without all your support, encouragement, and reassurance I would not be where I am today. For this I thank you each of you, and though I do not say it often please know that I love you. Finally, I would also like to dedicate this thesis to the loving memory of John Henderson who left us too soon, and has taught us all the most valuable lesson of all, not to take each day for granted.
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"Scientist study the world as it is, Engineers create the world that has never been."

Theodore Von Karman
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CHAPTER 1
LITERATURE REVIEW

Chemical properties will dictate as to what types of protective supplies and equipment that will be needed in the event of an emergency. Policies, procedures, and relevant training will need to be incorporated into the overall operations of the lab. The Occupational Safety and Health Administration has instituted (29 CFR 1910.1450) which is the Laboratory Safety Standard. Before this act, labs where exempt from many of the regulations regarding compliance. The reason for such an exemption was that labs used small quantities and not the bulk amounts, used in industrial chemical processes that were associated with the need for compliance regulations. The Hazard Communication Standard (29 CFR 1910.1200) was designed to give people specific safety information on the various chemicals that they are exposed to, but this also was directed at industries that use large quantities of chemicals. Labs may only use small quantities of chemicals but the toxicological effects are the same. As a result of this, the laboratory safety standard was developed. The standard requires that labs develop emergency and operational plans, train people to handle routine and emergency situations, and appoint a Chemical Hygiene Officer. The chemical hygiene officer will enforce the plan and will also institute safety policies and procedures within the lab area. The safety information will then be passed on to the people within the lab along with the proper training on how to handle the substances safely within the lab.

The Chemical Hygiene Plan covers the general activities of chemical safety, but what needs to be taken into account, especially in a university setting, is a laboratory
specific chemical hygiene plan. At the university a general chemical hygiene plan exists and within that plan are provisions for the different instructional labs and research projects that going on daily at the university. Each of the laboratory specific plans consists of a list of individuals who are trained in the procedures. They describe a brief description of the activities that are carried out, and a list of yes and no questions that help to determine the needs of the specific plan. This approach is something that is seen on a larger business scale plan for other laboratory facilities. One such example is in an article entitled "Case Study of Effective Leadership, Planning and Implementation" (Brown, et al., 2004). In the article it states that a successful program is not just writing and putting a policy into place it involves the people that the plan will effect. Everyone involved in the day-to-day operation of a lab are responsible for their safety as well as the safety of the people around them. The key to getting a program to be approved and implemented is to get the backing of senior management. If there is no support from the top, then others will not see the importance of what is being accomplished. There are many different ways to create a laboratory specific chemical hygiene plan. It all depends what is best for the type of facility that you are working with. In this case study it was determined that a narrative should be written to describe the operations that take place in the microelectronics lab. Also a safety analysis of the procedure and maps of the lab area were included. Once the documents were put together it was necessary to train the people in the Chemical Hygiene Plan and how to implement it.

From the laboratory's specific chemical hygiene plan, you can determine where in the institution the greatest risk lies, and from these risks questions will arise. To narrow into a focused area, a risk assessment can be performed on each lab. On a college
campus there are many different hazardous substances that can harm an individual, a determination of what the most dangerous grouping of chemicals was made. At the university, there is a microelectronics laboratory that is operated by the Physics department. Within the lab there are many inherently dangerous substances. The specific substances used in the manufacturing of microelectronic chips have hazards associated with them. The problem is to experiment and theorize on how these reactive and explosive substances would behave when combined. A cleanroom is a very specific and specially occupied environment. The people working in the lab “need to be committed to implementing safety protocols in accordance with the high tech industry’s hazardous production materials and safe handling standards” (Jensen, et al., 1997). Safety measures need to be put in place to insure the safety of the lab and the people operating in the lab. It can be assumed that most of the chemical substances found within a clean room can be considered hazardous production materials. Many of these materials are reactive, explosive, flammable, toxic, and corrosive. To determine what chemicals possess these properties, the material safety data sheets must be utilized. In an article entitled, “Safety protocols for renovations in controlled environments,”(Jenson, et al., 1997) many different steps are discussed on how to make sure that safety is looked at in the best way possible. It is important, that when designing a cleanroom, all the appropriate steps are taken to insure that the building is constructed to meet the specifications of the lab that it will house. A cleanroom requires constant attention to safety, because of the inherent dangers associated with the chemicals involved in the process.
As stated in the article, emergency procedures must be in place and understood by all. It is not in the best interests of the lab or the people working in the lab to not have an appropriate understanding of the dangers that they will encounter. Within a cleanroom area there are many chemicals that are in liquid form and possess the danger of causing a chemical spill situation. The people working in the lab must be able to take care of these spills immediately or know whom to contact to take care of the situation. Another danger that exists is the hazards associated with gases. Gases that are involved in a cleanroom range in hazard level. Some of them are very common to any lab like nitrogen and oxygen and others are very common to clean rooms in particular. An example of this is phosphine and silane. Every gas has its own particular handling requirements that must be followed to insure that all the appropriate precautions are taken into account. What must be remembered is not only are the gases a danger within the cylinders but the fact that the gases are under pressure posses a high risk to the lab personnel. Simple errors in a persons judgment in regards to safety, can result in serious injury to that person and the people around them.

Safety is important in all that we do. In a laboratory setting safety is particularly important. In an article entitled, “Safety: Avenues to a safer working environment,” (Walker, et al., 2000) the author discusses the many steps that need to be taken to insure a safe work environment. As discussed before, cleanrooms possess certain unique safety concerns. These concerns must be evaluated and dealt with by the environmental health and safety professionals and the primary contact personnel within the lab. To insure a safe environment for the workers, it should not be a one sided look into the safety of the laboratory environment. The article discusses steps that must be taken to ensure a safe
environment. One of the steps is to identify the hazards. It is important to look at the hazard characteristics, the form of the hazard, where and when the hazard is present, the probability of an incident occurring, and under what conditions the incident might occur. Another important aspect of a laboratory is to look at the engineering controls that are put into place to insure safety. The engineering controls can range from ventilation systems, gas monitoring alarms, fire suppression systems, and emergency showers to name a few. One of the most important alarms in the microelectronics lab is the alarm to alert the workers of a nitrogen leak. One of the characteristics of nitrogen is to displace oxygen. If the worker is not aware of a nitrogen leak, then the oxygen can be displaced in the room and the person can become unconscious do to lack of oxygen and eventually can lose his or her life. Normal oxygen levels are 21% and the OSHA action level for an oxygen deficient atmosphere is 19.5%. It is very important to consider the consequences of an accident if one was to occur. Consequences should be based on a worst-case scenario that can be proven to be credible. As an example though it is a worst-case scenario that the university would be hit with a tidal wave and the microelectronics lab would be washed away, it is not a credible scenario. The author also points out that it is important to conduct a “what if,” analysis. This analysis can be conducted on any and all parts of the lab. The analysis can be “what if the valve on the silane tank was to fail?” From the material safety data sheets (MSDS), it is know that silane is a pyrophoric gas and it is colorless, air reactive, and will have a choking effect on persons exposed to this gas. The exposure to silane gas can result in several sever burns to the body and depending on the severity the burns can be fatal.
The answer to the "what if" question posed can be that the release of silane can cause a flash fire that burned the employees which resulted in the death of the employees. This scenario is not a very pleasant scenario, but it is one that is very possible. Because of this situation, the lab supervisors and the environmental health and safety professional can design a system to help insure that this situation will not occur. This system could include an engineering control to alert workers of a situation that is occurring so that appropriate actions may be taken.

In an article entitled "Silane gas use poses challenge for clean room design team," (Novak, 1999); the author discusses the challenges that a worker in a clean room faces. Silane gas is used in the manufacturing of silicon wafers. The microelectronics lab should be located in an isolated part of a building. The microelectronics lab is located at the end of the main academic building (see Appendix J). This building is not isolated from any of the other buildings but the lab is the last room in the building. The cleanroom has been designed to fit into this building to have the least effects on the rest of the university. One of the measures that can be taken to insure that a silane release does not occurs it to install an automatic purge of the air in the building or an individual vent line to insure that no air is backed into the system. Alarms must be installed to allow for warnings as to when and if a problem occurs with the silane gas. Gases can cause a very serious situation to occur if the appropriate measures are not taken.

Training is an essential element in the development of an effective cleanroom program. Wallis discusses how it is important to make sure that the people who maintain the cleanroom are trained as well as the people who work in the cleanroom (Wallis, 1997). The lab personnel who work within the cleanroom know what they are dealing
with, but the personnel assigned to clean the room might not know. Throughout the cleanroom, at the university, there are many material safety data sheet binders available for anyone that might enter into the lab and want to know what they are being exposed to. In a cleanroom, the idea is to keep the particulates down in the atmosphere. The particles travel through the air currents in a cleanroom and are carried back out of the system through a filtration system. Some particles may settle on the equipment within the lab and this is where proper maintenance is needed. A class 10-cleanroom means that the particulates within the room are controlled within a certain parameter, the parameter being that there is only 10 parts per cubic meter of dust in the air. It is important to instill good personal hygiene habits and teaching the proper gowning procedures is a very important part of the safety training. It is important that workers know how to protect themselves and the environment that they will be working in. The lab personnel need to select the appropriate apparel for their work environment.

There are many resources to help cleanroom workers select the appropriate garments, which will protect the products that they are making. Not only is it important to protect the products it is also important to protect the worker from the hazards that they may encounter. An article entitled, “Selecting apparel for worker safety,” (Galatowitsch, 2000) states that much of the guidance available for selecting the appropriate clothing comes from different government agencies that are responsible for workers safety. These agencies will inform the worker as to what type of clothing will help protect them from the dangers that they may encounter. The article advises selecting a garment by considering the workers risk factor to the hazard that they will be working with. The risk factor will determine the level of protection and the type of personal protective
equipment (PPE) that is required for the job. The article calls this method working backwards. Initially you design the process, evaluate the hazards, and then decide on the appropriate personal protective equipment. The National Institute of Occupational Safety and Health (NIOSH) has a guide for evaluating the performance of the chemical protective clothing. Picking the correct chemical resistant clothing will help to minimize the potential or the severity of a disaster.

"Disaster in the Cleanroom: Damage Control, Contamination, and Recovery," (Williams, 1995) takes a closer look at the recovery process associated with the process and the equipment within the cleanroom. The company's main responsibility is the safety and well being of the workers. A company's responsibilities may also lie in insuring the safety of the people that will respond to the situation at hand. At the university, the first line of defense in a disaster is Campus Public Safety. The people able to respond to a situation in a cleanroom are very few. Campus Public Safety will then contact the campus hazardous material response team (HazMat) that has been established as a result of the microelectronics lab. Most universities do not have such a team but the university with the microelectronics lab does have an actively trained HazMat team.

Cleanroom recovery is a unique situation. After the workers have been checked and treated for any problems that may have occurred the next focus is to control the particulate contamination in the lab.

During a situation within the microelectronics lab, a variety of chemical reactions can take place within the lab. It is important to identify the potential reactions and take the appropriate measures. An example of a reaction that was mentioned in the article is the reaction associated with fire suppression. One of the active chemicals in a fire
extinguisher is halocarbon. The chemical is very effective but once the fire is suppressed the chemical by products left create hydrobromic acid and hydrochloric acid (Williams, 1995). Both acids are very corrosive and will then damage the equipment within the lab. Another risk with fire suppression is that water will be added and then an electrical hazard can occur. In a disaster it is very important to make sure that someone is there to manage the situation. There needs to be a well-defined chain of command to insure the safety of the workers that are responding to the situation. All the dangers that can arise within a lab setting are associated with risk and proper risk management techniques.
CHAPTER 2
INTRODUCTION

2.1 Background
The university is under an order to comply by the State Department of Health, Public Employee Occupational Safety and Health Administration (PEOSHA) section. The lab standard was issued in 1991 and subsequently adopted by New Jersey in accordance to PEOSHA. The first draft of the plan was written and submitted for approval. The university was initially inspected in 1995 (see Appendix C). The university was found to be in non-compliance of OSHA regulation 29 CFR 1910.1450, which is entitled the Occupational exposure to hazardous chemicals in laboratories, and an order to comply was then issued. The inspection took place in June of 1995 and the university was given to November of 1995 to make the necessary changes. Training was put into place for the Chemistry and Chemical Engineering departments and a printed plan was sent to the Deans, Department Chairs, and also a letter was written to implement the plan. Nothing further came of the action until the university was inspected again in May of 2003 and was found that they were still not in compliance (see Appendix D). The university was threatened with fines and legal action bringing forth a renewed interest to bring the university into compliance.

The university has many labs within the campus, a lab that has some unique characteristics is the microelectronics lab. Within the walls of the microelectronics lab, there are chemicals that posses extreme dangers to the people that work within the lab. This lab as well as many other labs are covered under the base chemicals hygiene plan.
but to make the chemical hygiene plan more appropriate for this situation a laboratory specific chemical hygiene plan must be put into place.

2.2 Preface

The initial step in developing any health and safety plan is to determine the hazards that exist in the workplace. The hazards can range from physical, chemical, nuclear to biological hazards. By identifying the hazards in the laboratory, a health and safety plan can be implemented that meets the needs of the workers. “The hazard identification process requires a disciplined method of analyzing the product or system” (Roland and Moriarity, 1990, p. 5). One of the primary tasks of a health and safety plan is to evaluate, recognize, and identify the potential hazards of all the hazardous substances that the employees are exposed to on a daily basis (Stricoff and Walters, 1990, p. 1). Under the laboratory safety standard many other standards must also be recognized as part of the laboratory safety plan. Some of the key standards that need to be address in a comprehensive laboratory safety plan are: hazard communication (1910.1200), non-ionizing radiation (1910.97), radiological (1910.1096), personal protective equipment (1910.132), and noise (1901.95). Though there are many other standards that can be encompassed in a comprehensive safety plan these are the major standards that must be addressed. The key to any safety plan is that there must be a written program and training provided to the employees in order to make sure they understand what types of situations they are going to be involved in.

A laboratory safety plan should not be written as a “cookie cutter plan.” Each university has its own needs and the plan must be tailored to that particular campus and
the laboratories that the university offers or endorses (see Appendix B). A preliminary hazard assessment must be conducted in order to become familiar with what the laboratories contain. A list of the potential hazards must be generated and evaluated for health and safety concerns that it may possess. As with any college laboratory, the procedures for the lab that is to be preformed should be known and evaluated for any dangers that the employees and students may be exposed to. A laboratory safety programs main objective "is to provide guidance to all laboratory workers who use chemicals, so that they can perform their work safely" (Prudent Practices for Handling, 1990, p. 5).

The development, implementation, and maintenance of an effective health and safety plan must first begin with the health and safety officer and be backed by the senior administration. There are many other key components to enforcing an effective laboratory safety plan. "First and foremost, the protection of health and safety is a moral obligation" (Prudent Practices for Handling, 1990, p. 6). The backing of the administration means that the president of the university must fully support the need and implementation of the plan. Also the heads of the departments that are effected by the plan must also be supportive and ready to provide any information or time that the health and safety office will need to implement the plan. The plan must also be enforced and followed by the employees. The employees and the students are the ones that are most effected by the chemicals hazards that they will be in contact with on a daily basis.

As part of the laboratory safety standard set forth by OSHA, it is required to have a Chemical Hygiene Plan (CHP). The CHP is required by the standard to specify the responsibilities of the health and safety program in detail (Stricoff and Walters, 1990, pp.
the dangers that exist in a college laboratory. Some dangers that exist in a lab are more serious than a chemical burn. The dangers that do exist on a campus are the risk of fires, explosions, in the worst-case scenario death. One lab on campus that is an integral part of the campus, faculty, and staff is the microelectronics laboratory that was fabricated within the campus. The microelectronics and semi-conductor laboratory has dangers that are unique to the process. The process that exists is combining various chemical substances together to form a silicon base and electronic components are imprinted on the base to create a computer chip. The process at the university takes place within a class 10 cleanroom. This is one of the highest rated labs that can be built. A class 10 cleanroom is comparable to clean rooms that are built and used by major business and government agencies like Motorola and NASA.

Many questions arise when looking at the processes performed by the microelectronics laboratory. What types of chemicals are used and what are the toxicological effects that are present? What impact would a chemical release cause within the microelectronics lab, the university campus, and within the city where the university is located? Before these questions can be answered, the main focus that looks at the microelectronics safety issues must be addressed. That beginning is the chemical hygiene plan that puts the main laboratory safety plan into place. Once in place, plans can be linked off of the main chemical hygiene plan and adapted to suit the needs of the particular lab. The plan can be implemented in many different ways. The most effective way must be decided on by the person that is to implement the plan and the senior administration of the university or company that the plan will affect.
university ignored the first order and allowed for the students and the researchers to be in danger. Of all the hazards that exist on campus which fall under the lab safety standard, the microelectronics lab possesses a unique situation at the university. The microelectronics lab is a class 10 cleanroom. One of the main substances used during the process to form a wafer that possesses a major threat to health and safety is silane. Many intrinsic uncertainties are prevalent on a campus of this size and magnitude. The question that must be posed is whether or not the university is doing everything it can to insure the safety of its employee's and students.

Like a puzzle many pieces must come together to create a picture. As with a puzzle that one would purchase in a store the picture that is to be created might be a snow covered mountainside or even a horse running in a field. On a university level, the picture that will be created is in regards to a picture of safety. The individual pieces of the puzzle may be the wearing of safety glasses, knowledge of the chemicals that an individual is working with, or the ability to know how to act during an emergency incident that has occurred. These pieces come together to create a safe environment for people to work in. For the pieces to be successful together there must be organization within the university community. The piece that helps the organization in a university laboratory is the chemical hygiene plan (29 CFR 1910.1450) that is mandatory as per the Occupational Safety and Health Administration (OSHA).

At the university, there are many different laboratories that co-exist. Each lab maybe different but most still has the same inherent dangers. Some of the dangers that exist are that substances can burn employees and students, some chemicals can cause them to become sick, and others can cause irritations. These are just a few examples of
Once a plan is in place training must be provided to insure that there is an appropriate level of understanding of the program. The main responsibility of a training program is to provide the workers with the knowledge and tools to protect themselves with a safe work environment. The training will provide the worker with the knowledge to recognize and evaluate a hazard and the ability to protect them from the hazard. “Documentation of training is critical” (White, 1996, p. 112). Once the training is preformed and completed the documentation will help to insure that only the people trained in that task are performing the task.

Protection from hazards may come in the form of but not limited to the wearing personal protective equipment (PPE). It is not only important to tell the workers about the equipment but also to train them on how to use and maintain the equipment. The administration should encourage proper training and safety attitudes among the workers. If the administration is not serious about a plan the staff will not be take the plan seriously. Any plan needs to be a balance between the workers and the administration.

2.3 Pieces of a Puzzle

Safety and the many aspects involved with it are all pieces to a large puzzle. When one piece is out of place, many uncertainties will arise. The campus in general posses many serious health and safety hazards to the researchers and students. All universities have to adhere to the lab safety standards set forth by OSHA. The university, unlike other universities does not have a chemical hygiene plan approved and in place making the university non-compliant with the regulation. Recently, the university was put under a second order to comply with the standard. The first order was issued in 1995. The
2.4 Steps to the Plan

In order to comply with the laboratory safety standard that is mandated by the New Jersey Public Employee Occupational Safety and Health Act the university must put together a chemical hygiene plan. There have been four steps identified that will allow the program to be implemented in a timely manner at the university. The steps that are needed to implement the plan are as follows:

1. Planning
2. Implementation in a step or phase manner
3. Initiating compliance factors with individual departments
4. Auditing to insure compliance

The planning stage involves setting up a university wide chemical hygiene plan. Further involvement in the planning stage is to make an agenda on how and when the steps that are needed to be implement will be accomplished, and in what order. In this phase the departments will be contacted and notified of the chemical hygiene plan and will be given a brief description of what to expect during the implementation phase of the program.

The program is then to be implemented in a step or phase manner. This will allow the program to be brought in gradually and effectively. During this step the departments will choose an individual on their staff that is qualified to be the chemical hygiene officer. "This is the person who oversees the implementation and maintenance of the safety regulations set forth by the university for all labs within a specific department" (Barrett, 1996, p. 4). The program will be written and appropriate training
will be put into place for implementing the chemical hygiene plan. The training will be for the chemical hygiene officer and then also for the laboratory assistants and faculty.

Initiation of the compliance factors will be directed to the individual departments. Each department will appoint a chemical hygiene officer (CHO) who will be in charge of updating and insuring the implementation of the chemical hygiene plan. The CHO will also be in charge of keeping the chemical hygiene plan up to date and insure that the individuals that are working in direct contact with the chemicals have received the appropriate training. The qualifications should be knowledge of laboratory procedures and the experiments being conducted. One of the key steps in this program is to make a chemical inventory of the substances being used in each of the lab experiments. This list will allow the chemical hygiene officer to see if there is any interaction between chemicals that might affect the safety of the laboratory workers or students. The laboratory experiments will be evaluated as a whole course. This will allow for one evaluation form per laboratory course taught. Any hazards that are identified will then be addressed in this phase of the planning. The department heads will receive a memo stating what the chemical hygiene plan is and how it will be implemented for each department and what is expected of that department.

One of the most important steps of this program is to audit the program to ensure compliance. The program is headed by the chemical hygiene officer for each of the departments and the Director of Health and Environmental Safety for the university. They must audit each department and the chemical hygiene plan for each department to ensure that the plan is being implemented and updated. This will insure that people are not becoming complacent and ignoring a very crucial safety item within their department.
The auditing will also be done by the University Safety Committee, which is comprised of members of the campus community. Each of the departments that make up the university are represented along with members of the administration.

This stepwise function of implementation of the program will allow the university to stay within compliance of the laboratory safety standard (29 CFR 1910.1450) by the Public Employees Occupational Safety and Health Act. The chemical hygiene officer will work closely with the Director of Health and Environmental Safety and will make sure that the chemical hygiene plan is enforced, up-to-date, and followed. The program needs to have the support of the Department Chairs and the University Administration in order to be effective. Any good plan needs the support of senior management in order for it to have the support of the employees.

According to the OSHA standard, each semester the laboratory classes that are being run must be re-evaluated and a list of the chemicals being used in that experiment must be generated. Following these steps will insure that the chemical hygiene officer is involved and knowledgeable with the experiments and any hazards associated with them.
3.1 Occupational Exposures to Hazardous Chemicals in Laboratories
(29 CFR 1910.1450)

Laboratory safety is not just housekeeping within the lab. It is more than just wearing the proper personal protective equipment. The OSHA laboratory safety standard (29 CFR 1910.1450) provides well-defined guidelines for laboratory safety. The main components of the standard are the Chemical Hygiene Plan (CHP) and providing the employees with the appropriate training and information to do their jobs safely and effectively. "The plan will help limit exposures and protect workers from chemical health hazards in the laboratory" (Laboratory Safety, 1995, p. 4).

For a laboratory to be governed by the standard, the lab must meet certain criteria. Covered under the standard are workplaces that use relatively small amounts of hazardous substances that are being used on a non-production basis and laboratories that use or handle hazardous chemicals and manipulate them on a laboratory scale process. Laboratory scale is defined as work with substances in which the containers used for reaction, transfer and other handling of substances are designed and can be easily and safely manipulated by one person. Employers work with multiple chemicals and chemical procedures in the lab. Also, a laboratory would fall under this standard if the procedures being preformed were not part of a production process. Another part of the criteria is that PPE is available for the employees, which will minimize the likely hood of exposure to any hazardous chemicals.
The definition of a hazardous chemical has been defined and regulated under, 29 CFR 1910 subpart Z, which is for toxic and hazardous substances, and it also includes those chemicals meeting the definition under the Hazard Communication Standard 29 CFR 1910.1200 (c). Defined by OSHA a “hazardous chemical is any chemical which has a physical hazard or a health hazard.” (29 CFR 1910.1200 (c)) Laboratories that fall under the laboratory safety standard must also assure that the lab employee’s exposure to the hazardous chemicals does not exceed the permissible exposure limits (PEL).

3.2 Chemical Hygiene Plan

“In every laboratory, there should be a document that describes the recommended ways of carrying out typical procedures, the housekeeping rules that all employees must follow, how to order new chemicals, and how to perform just about every laboratory activity” (Alaimo, 2001, p. 38). The chemical hygiene plan is to be written by the employer and it will describe the practices and procedures that are needed to help keep the employees safe from hazards. A chemical hygiene plan will also outline the measures to prevent the over exposure of the employee to chemical hazards. In the act, it is also stated that a chemical hygiene officer (CHO) must be designated and be responsible for the implementation of the chemical hygiene plan. The plan should be evaluated and updated annually. There are several major components that must be included in the chemical hygiene plan. Within the plan there must be, a section that includes employee exposure, training of the employees, medical consultation, hazard identification, respiratory protection, and record keeping. The plan needs to be adapted to fit other parts of the lab that may be similar in the chemicals they use but the process might be different.
"The lab standard also permits different workplace rules in different locations. One size need not fit all" (Alaimo, 2001, p. 40).

### 3.3 Employee Exposure

It is the responsibility of the employer to measure the employees' exposure to chemicals and situations that are regulated by OSHA and the standards set up by OSHA. It is very important to measure exposure when there is considerable reason to believe that the exposure levels exceed the permissible exposure level (PEL). If monitoring has shown that the exposure exceeds the PEL, the monitoring requirement needs to be followed and it will then be necessary to conduct additional monitoring on a continuous basis. OSHA has also set up a list of the PEL's for many specific substances. The level of exposure is calculated as a time weighted average (TWA). The time-weighted average allows the monitoring to be conducted over the time of the workers day taking into consideration times when the employee might not be exposed. Records must be kept of any exposure monitoring or medical consultation that may have resulted from an over exposure (1910.1200).

### 3.4 Training

Through the OSHA standard the employer must provide training and information on the chemical hazards and any other hazards that the employee may encounter in the work environment. "The OSHA requirement for training employees exposed to a given substance depends on the standard for that substance" (Green and Turk, 1978, p.151). The information regarding the chemicals is to be provided to the employee when they first begin working and must be updated when situations change or if it is determined that
the employee did not fully understand the training that they have received. The training that is to be provided to the employee must cover certain topics. One topic must be the methods and observations that are used to detect the presence or the release of hazardous chemicals. This would include odor detection, monitoring devices, and testing to name a few.

The employees should be trained on the physical and health hazards of the chemicals in the workplace. Employees should be trained on the specific procedures, appropriate work practices, emergency procedures, and the appropriate personal protective equipment that they will need to protect themselves. The employee should be trained on the location, contents, and details of the chemical hygiene plan and the laboratory standards. The employee should be notified and trained when ever a new hazard is introduced in the workplace. Training must also be given as to the permissible exposure limits for the hazardous substances present in the workplace. Another important topic is for the employee to recognize the signs and symptoms that are associated with exposure to the hazardous chemicals that are used in the lab. In a book entitled Safety in Academic Chemistry Laboratories (1985) it is stated that within labs “there has been an increased recognition of health effects of prolonged, low exposure to many chemicals” (Safety in Academic, 1985, p. 3). To help the worker become more aware of what they are working with a material safety data sheet needs to be provided for each chemical in the lab. The employee should know where to locate the material safety data sheets (MSDSs) within the workplace. Also, they should be trained in the handling, storage, and the disposal of the chemical hazards.
3.5 Hazard Identification

Hazard identification involves the user posing all the information needed to be knowledgeable in what chemical, biological, physical, or radiological hazards he or she is going to be in contact with. The identification can come in the way of a Material Safety Data Sheet (MSDS). They provide the person with valuable information regarding the dangers associated with the substance (see Appendix E). Another effective method in hazard identification is the use of labeling. OSHA has implemented a program called the Hazard Communication Standard (1910.1200) “under HazCom, the employer must inform the worker of the hazards at the workplace” (Hazard Communication, 1995, pp. 4). The standard requires that all chemicals in the workplace be labeled in order to warn of any hazards the substance may exhibit. The substances must be labeled with the common name of the chemical and its corresponding chemical abstract service (CAS) number.

3.6 National Fire Protection Agency 704M

One very common and effective label is the National Fire Protection Agency (NFPA) Fire Diamond 704M. The NFPA Fire Diamond uses a color-coded array of five numbers. A hazard diamond is usually seen on trucks, storage tanks, drums, bottles of chemicals, and in various other places throughout the workplace or on a college campus. The blue, red, and yellow areas represent health, flammability, and reactivity, respectively. They are categorized using a number scale from zero to four. A value of zero means that there is essential no hazard whereas a rating of four would indicate extreme danger or risk.
The other section of the diamond is white and will let the user know of any special precautions that needs to be taken in regards to handling or storing the substance.

![NFPA Fire Diamond](image)

**Figure 3.6 NFPA Fire Diamond.**

In this example the fire diamond alerts the worker that the health hazard, which is 3, means that the substance is extremely dangerous to health. The fire hazard is categorized as a 4 indicating that the chemical is extremely flammable. The reactivity assigned to this chemical is a 3 meaning shock or heat may detonate. The white area having a W means that no water should be used with this substance, because it is water reactive. “National model building codes and the NFPA define the criteria for low-hazard, intermediate hazards, and high-hazard laboratories” (Alaimo, 2001, p.530).

### 3.7 Respirators

“A longstanding hierarchy of controls requires employers to use engineering and work practice controls as the primary means to protect an employee’s health from contaminated or oxygen deficient air” (Hagan, Montgomery, and O'Reilly, 2001b, p. 195). One of the ways to protect an employee is through the use of respirators. Respirators (1910.134) are a very important part of training with employees. To insure that exposures to the substance(s) are not exceeded or the PEL is exceeded, the use of respirators may be necessary. Respirators are selected according to the specific hazards of the materials used and by the guidelines that are mandated by the OSHA standard.
Sometimes employees have to work in areas where the atmosphere is not safe. The reasons for the dangerous atmosphere could be due to "airborne particulate contamination, which can include dusts, fibers, vapors, or mists" (Alaimo, 2001, p. 327). When a worker breathes contaminated or low-oxygen atmospheres it can cause serious illnesses, injuries, and even death. In their situations, special air supplied equipment is needed to help employees breathe and stay safe. Respiratory protection equipment allows employees to protect their lungs against workplace hazards. Because many potentially dangerous places can exist in the work place, it's important to make sure that all employees understand the risks of oxygen deficiency and air contamination, have proper respiratory protection equipment, and most importantly, take personal responsibility for their respiratory safety. By understanding the hazards, selecting the proper respiratory protection, and training employees in their use, you can keep everyone safe and avoid costly injuries and illnesses.

As a result of the hazards to the respiratory system, OSHA has established a standard regarding respiratory protection (1910.134). "The respiratory protection program must consist of worksite-specific procedures specifying the selection, use, and care of respirators" (Hagan, Montgomery, and O'Reilly, 2001b, p. 195). The standard calls for the employer to monitor hazards in the workplace and determine if a need for respirators exist. If a need exists then the employer must provide the appropriate respirator to the employee and also provide the training needed for the employee to effectively use and care for the respirator. "The proper selection of respiratory protective equipment involves three steps: (1) identifying the hazard, (2) evaluating the hazard, and (3) finally, selecting the appropriate, approved respiratory equipment based on the first
two considerations” (Hagan, Montgomery, and O’Reilly, 2001b, p. 197). The topics that should be covered in a training program is how the recognition of respiratory hazards in the workplace. They should be taught how and why the appropriate respirator is chosen. Proper fit testing should be conducted. There is no one respirator that works for every worker. The worker needs to be taught how to properly use and maintain the respirators.

“A medical evaluation to determine the worker’s ability to use the respirator must be completed before the worker is fit tested or required to use the respirator” (Plog and Quinlan, 2002, p. 669). As part of the standard the employer is to provide medical testing to the employee, which will qualify them for wearing a respirator. Not all individuals can wear respirators. “Respirators can impose several physiological stresses ranging from very mild restriction of breathing to burdens of great weight and effort” (Plog and Quinlan, 2002, p. 668). Wearing a respirator put demands on ones respirator system. Some people can feel claustrophobic and the psychological strain on the body may be too much to handle. In a situation where not wearing a respirator may be life threatening this would not be a good situation. Employers need to identify the people that are in good respiratory health and have the mental well being to wear a respirator. Once the worker has been trained and the appropriate fit for the respirator found then the employee can then perform the task that is required by their job.
CHAPTER 4
RELEVANT STANDARDS

4.1 Hazard Communication (29 CFR 1910.1200) “Right to Know”

Hazard communication is a very important part of a health and safety program. Hazard communication involves keeping the employees informed of what hazardous substances exist in the workplace. "A hazardous material is any substance that the U.S. Department of Transportation (DOT) has determined capable of posing an unreasonable risk to health, safety, and property when transported (The Waste Management, 1990, p. 26). The main goal of an effective hazard communication program is to ensure that the employer and the employees know the hazards in their work place and how to protect themselves from the hazards. If implemented effectively there should be a reduction in the incidence of illness and injuries due to chemical exposure. In the workplace and in our lives chemicals pose a wide variety of hazards. Some of these hazards can include irritants, sensitizer, and some chemicals are carcinogenic. Also associated with the chemical hazards are those that pose a physical hazard rather then health hazards.

Physical hazards associated with chemicals are flammable, reactive, and even explosive. The hazard communication standard was put in place to help insure that the hazards in a work place are known and proper measures are taken to protect the workers. One of the requirements of this standard is that chemicals that are brought into the workplace are evaluated for the hazards that that chemical may possess. This information is then passed on to the user of the chemicals. The information can be provided in many ways. One of the ways includes labeling the container that the chemical is in. Another
very effective method is through material safety data sheets (MSDS’s) (see Appendix E). MSDS’s provide the user with all the necessary information about a chemical. “You wouldn’t begin a long journey without first figuring out where you’re going, and you shouldn’t handle chemicals without first looking at the label and appropriate MSDS” (Hazard Communication, 1995, p. 14). Some information that is included on an MSDS is the composition and ingredients, hazard information, the first aid treatment, accidental release measures, handling and storage, exposure control and personal protective equipment (PPE), and toxic information to name a few.

In an effective hazard communication program the chemicals within the facility must be labeled, there must be MSDS’s on each of the chemicals that are used, and finally the most important part of the program is that all employees that have the potential for exposure be trained. The training, as with all training, will make the employee aware of what is around them. The training will help the employee to recognize a hazardous situation and be properly taught how to handle such a situation. If PPE is required for handling the chemical, training will be given on how to properly use the equipment and how to care, store, and decontaminate the equipment. The hazard communication program gives the employers the information they need to design and implement the appropriate program for the workplace. Another phrase associated with hazard communication is “Right-to-Know”. All employees have the right to know what chemical substances they are coming into contact with on a daily basis and how to protect themselves from these hazards. With all the necessary steps in place there will be a reduction in illness and injuries associated with chemical exposure in the workplace.
The hazard communication standard requires the company to provide a complete list of all the hazardous chemicals in the workplace. This list would be included within the written program that the company will have in place. All companies that have hazardous substances in the workplace must have a written hazard communication plan. The list can then serve as an inventory of chemicals in the workplace. The list can also be cross-reference to insure that the appropriate MSDS’s are on file for the chemicals at the job site.

The standard states that the “employer shall ensure that laboratory employees are apprised of the hazards of the chemical in their workplace in accordance with paragraph (h) of this section” (1910.1200 (b)(3)(iii)) of the standard. New Jersey is one of the many states that have adopted the “right to know” laws. What this means to the employee is that they have the right to know what hazards exist in their workplace. The New Jersey Community and Workers Right to Know Act requires that all public and private employers provide to the employees any information regarding hazardous substances in the workplace. This act provides many people with valuable bits of information. Not only is the employee informed of what they come into contact with but in case of a fire or other situation the police and fire departments know what can be expected in the way of hazardous substances during an emergency response that particular lab or company. This also helps to provide information that is needed to track and monitor the hazardous substances that are in use within the facility. As with the OSHA standards, the Right to Know standard also mandates that the employees must be trained of the hazards that they might encounter.
4.2 Hazardous Substance Fact Sheet

The State of New Jersey, as established by Public Employee Occupational Safety and Health Act (PEOSHA), that employees have the “Right to Know” what hazardous substances they are being exposed to and what the specific hazards are. The “Right to Know” Act is a subset of the federal Hazard Communication Standard. As part of the 1910.1200 each manufacturer is required to provide the purchaser with a material safety data sheet (MSDS) upon request. Each chemical substance that is manufactured has a MSDS associated with it. The manufacturer can list more than one chemical on the MSDS that has been sold to the customer. There is a specific format mandated for the MSDS and it is required that it be written in English. There are eight components that must be included as per 1910.1200. The chemical must be identified with all physical hazards, health hazards, which must include if the chemical is a carcinogen, and the primary routes of entry, are to be included in the MSDS. Precautions regarding the safe handling of the substance along with any emergency and first aid procedures are to be included. The date of preparation of the latest revision name, address, and telephone number of the manufacturer, importer, or other responsible parties are also to be included. The eight requirements are key to an effective MSDS but more information can be included in the MSDS as deemed necessary by the manufacturer.

In addition to the MSDS the New Jersey Department of Health (DOH) developed a standardized form, the Hazardous Substance Fact Sheet (HSFS). There are HSFS’s for 2,051 hazardous chemicals. Each sheet contains the information for only one chemical, unlike the MSDS that can list multiple substances on one sheet. The fact sheet is a standardized form, which allows anyone to be able to pick up a HSFS and be able to read
and understand what the hazards are and how to protect him or her self. An example of a hazardous substance fact sheet can be found in Appendix F. The components of the HSFS are the hazard summary, identification of the substance, and the reason for the citation. Also the HSFS will list the methods to determine if you are being exposed, the workplace exposure limits, and ways to reduce exposure. Heath hazard information along with medical testing information that might be needed is included in the HSFS. Workplace controls and practices regarding the use of the chemical and a list of the appropriate personal protective equipment to be used will be identified. There is also a section from commonly asked questions and answers and a list of definitions that are associated with HSFS.

4.3 Personal Protective Equipment (29 CFR 1910.132)

Personal protective equipment (PPE) is a very important part of any safety program. PPE should be the last resort in any situation. Before PPE is used other methods of control should be designed and implemented. “Personal protective equipment is the last line of defense” (Konz and Johnson, 2000, p. 479). The other methods of control that should be used are engineering controls and administrative controls. PPE includes protective equipment for the face, eyes, ears, head, feet, hands, and other body parts. Personal protective equipment also includes protective clothing, respiratory equipment, and devices that can act as barriers or shields. Personal protective equipment is to be provided to the employee and the equipment should be reliable and sanitary. Hazards that PPE can be used for to protect the employee is for chemical hazards, radiological hazards, and when hazards due to the hazards from process or from the environment.
PPE can also be used when any part of the body can come into contact with irritants through absorption, inhalation, or physical contact.

It is the responsibility of the employer to assess the workplace to determine if hazards are present or likely to be present. They must also assess if it is necessary to use personal protective equipment. If hazards exist, that require PPE, then the employer must select the appropriate equipment that will protect the worker from the hazard. Employees must be notified of the appropriate equipment to be used and must be trained on how to use, care, and store the equipment. The equipment must be properly fitted to the employee. Not all equipment will fit all employees.

The employer has to provide the employee that has been found to require the use of PPE the necessary training. The training should teach the employee when PPE is necessary and what equipment is necessary for the job or task. The employee should also be taught how to put the equipment on and off and the proper care that the equipment needs to maintain its integrity. The employee should also be well aware of the limitations of the equipment and when the equipment should not be used. Employees must be re-trained in the proper use of the equipment when and if the job changes or new hazards are introduced into the workplace. The employer must verify though records that the employees that are affected by the hazards requiring PPE have received and understand the training that they have received during their training. The record of the training should be in the form of written certification, which will contain the employees name, date of training, and the specifics of the training that took place. Training must be re-enforced whenever the protective equipment being used has changed and if the employee
has forgotten the training or has any misunderstandings in regards to the training that they have already received.

4.4 Occupation Noise Exposure (29 CFR 1910.95)

Noise issues are a very serious concern in the workplace. The OSHA permissible limit for an 8-hour workday before hearing protect is required is 85 decibels. The employer will provide the protection against the effects of over exposure to noise when the sound levels set by OSHA are exceeded. The level of sound is determined by using the “A” scale of standard sound level meter at slow response. When the employees are subjected to sounds that exceed the OSHA levels the appropriate action must be taken to correct the situation, this is called a hearing conservation program (see Table 4.4).

**Table 4.4 Permissible Noise Exposures**

<table>
<thead>
<tr>
<th>Duration per day in hours</th>
<th>Sound level dBA slow response</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>90</td>
</tr>
<tr>
<td>6</td>
<td>92</td>
</tr>
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<td>105</td>
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<td>0.5</td>
<td>110</td>
</tr>
<tr>
<td>0.25 or less</td>
<td>115</td>
</tr>
</tbody>
</table>

Citing from OSHA 1910.95

The first line of defense in noise control is to put into place administrative or engineering controls. Administrative controls can range from rotation of schedule to limit the amount of time people are exposed to the noise. Through engineering control, the equipment in question can be designed to limit the amount of noise coming from the equipment. Sound barriers can be installed to limit the noise levels. Also sound damping blankets or
mufflers can be used to control sound. The way that noise exposure is calculated depends on how many hours the employee is exposed to the level of noise in question. When the noise exposure is composed of two or more time durations of different levels their combined effect is then considered. (OSHA Standard 29 CFR 1910.95) If the noise levels are exceeded over the designated time set forth by the OSHA standard then steps must be taken to insure the workers hearing.

4.5 Hearing Conservation Program

Whenever the noise level is equal to or exceeds the 8-hour time weighted average sound level (TWA) of 85 decibels the employer is required to administer a continuing and effective hearing conservation program. The hearing program should consist of a monitoring program, audiometric testing, fitting of hearing protection, and training on how to use the hearing protection and how to perform the maintenance on the equipment. The monitoring program will be developed and implemented when information indicates that an employee exposure to noise is equal to or exceeds the TWA of 85 decibels over an 8-hour workday, which is the OSHA action level. The monitoring program should be used to isolate who is effected by the over exposure and what equipment is causing the noise levels in question.

The audiometric testing will consist of a baseline test, followed by annual testing, and then a follow up examination at the end of the person's employment. The testing must be conducted by an individual certified to do so. The person should be a licensed or certified audiologist, physician or a technician who is certified by the Council of Accreditation in Occupational Hearing Conservation to perform the audiometric
testing. After the baseline audiogram to determine the persons level of hearing and annual examination is to be administered. The annual examination will be compared to the baseline and any shift in the persons hearing should be evaluated and noted. If a significant difference is noted, then the employer must take action to determine what has caused this, and to take the appropriate measures to minimize or alleviate the situation.

Once it has been established that a noise problem exists, the employee must be fitted for the proper hearing protection and trained to use and care for the hearing protection. They must be required to use the hearing protection that they have been trained for. If the employees are already using hearing protection then they are to be refitted and retrained in the use of hearing protectors and provided with hearing protectors offering greater reduction if necessary. Hearing protection is to be replaced as needed and with no cost to the employee.

**4.6 Ionizing Radiation (29 CFR 1910.1096)**

Radiation includes alpha rays, beta rays, gamma rays, X-rays, neutrons, high-speed electrons and protons, and other sub-atomic particles. Radioactive material is any material that emits corpuscular or electromagnetic discharge through spontaneous nuclear disintegration. Radiological hazards fall under the umbrella that is 29 CFR 1910.1450, on this campus due to the different equipment used in the laboratories. "Two types of ionizing radiation are of concern; they are the external sources produced from X-rays and internal sources produced from the intake of isotopes (Green and Turk, 1978, p. 124).

Under this standard the campus has set up, a Radiological Safety Plan that designates a Radiation Safety Officer (RSO) to monitor the sources on campus and to
make sure the appropriate measures and precautions are taken. A designated radiation safety officer must supervise all work that is done using radiological materials. The vessels in which the radiological material is stored, or used in the laboratory, and in which the experiment is being conducted must be properly signed to alert people of the radiological danger. Different forms of radiation have different effects to the person exposed, and also, to the different target organs. The standard exposure to radiation is 5 rems/year. Roentgen equivalent man or REMs are units of measure, which help to put the biological exposure to all forms of radiation into one number unit that can be evaluated more easily (Green and Turk, 1978, p. 124).

Employees that come into contact with radiation on a daily basis should be monitored for exposure. The monitoring can take place in the form of a dosimeter. This is a device that the employee wears over a period of time. The badge is sensitive to the amount of radiation that the person is exposed to. As the person wears the badge, the radiation is absorbed into it then the badge can be analyzed for the amount of radiation that the person is receiving over a workday called the dose rate. Other dosimeters can give the wearer an instantaneous reading to alert them when they are being exposed.

4.7 Non-Ionizing Radiation (29 CFR 1910.97)

There are three types of non-ionizing radiation. They are ultraviolet radiation, visible, and infrared radiation, which are lasers, and microwave radiation (Green and Turk, 1978, pp. 121-124). The first type of non-ionizing radiation that will be discussed is ultraviolet radiation. Over exposure to ultraviolet radiation will produce similar symptoms as an over exposure to the sun. This over exposure would be in the form of sunburn to the
skin. Ultraviolet radiation can also affect the eyes and the person’s vision causing serious
damage to the person’s vision. Eye damage is one of the most serious effects that
someone would experience in a laboratory situation when dealing with ultraviolet
radiation in a laboratory setting. The effects of ultraviolet radiation to the eye might not
be felt for many hours. The person will experience a felling of pain in the eye as if there
were grains of sand in the eye. If there is a chronic exposure to ultraviolet radiation then
the person may experience vision loss. To insure that this exposure is limited, if not
completely eliminated, the ultraviolet source must be totally enclosed. This will insure
that no accidental exposure occurs (Green and Turk, 1978, pp. 121-122).

The next type of non-ionizing radiation that is of concern is visible and infrared
radiation, which is commonly known as lasers. Laser safety is a very important part of a
safety program. A serious problem can be present to the worker from the use of lasers.
The beam of light is very intense and can be focused onto the retina of the eye causing
serious eye damage, which included burns to the eye, and even causing permanent
blindness. The laser can be shielded to help protect against the laser beam. Proper eye
protection can be used to shield the eye from the beam. The eyewear must be chosen
correctly because each type of laser needs a specific type of goggle protection. There is
no one goggle that protects a person from all types of laser. The eye protection that is
needed is specific to the laser being used. There must also be appropriate sign to allow
people that walk into the laboratory to know that there are lasers in the laboratory and a
special sign should be posted to inform people of when the laser is in use within the
specific room. The university requires that all lasers are to be registered and kept in a
central file. The registration form includes information regarding the laser. The
information on what make the laser is, the strength of the laser, the person or persons authorized to use the laser, and where the laser is located to name a few.

The final form of non-ionizing radiation to be discussed is microwave radiation. The effects of microwave radiation can be serious in fairly low doses. The way the body is affected by microwave radiation is through the heating effect to the body. The most common effects of overexposure to microwaves are cataracts, male sterility, and birth defects in offspring. These effects can be seen in people that are exposed at low doses. Also at lower doses damage can be seen in organs that rely on electrical excitability. Examples of such organs are the heart and the nervous system.
5.1 Audit of Standards

All companies and universities that fall under the jurisdiction of OSHA need to conduct an audit of the 29 CFR 1910 regulations. An audit is a look at the company or university as a whole, and to identifying what regulations need to be complied with. Once the audit is conducted, and the regulations have been found to be deficient the need arises to decide what actions must be made in order to come into compliance with the standard. Some policies only require a written policy while some require a written program and training to be conducted. Table 5.1 illustrates what policies or procedures need to be in place in order to comply with the various standards listed. The following is a general audit of the regulations that need to be complied with and the appropriate response to each. The regulations listed are only an example and should not be considered a complete list.

5.1.1 Eyes and Face Protection (29 CFR 1910.133)

The employer shall ensure that each affected employee uses the appropriate PPE when exposed to eye or face hazards in the workplace (see Figure 5.1.1). The employer shall follow the provisions listed in 1910.132 as applied to this section. Protection for the eyes and the face can come in the form of safety glass and face shields. Safety glass and face shields can protect the user from hazards associated with flying debris, liquid chemicals, dust, fumes, and vapors. "Safety glasses are commonly required in most laboratory
situations, they do not provide adequate protection of workers for splash or vapor hazards to the eyes” (Alaimo, 2001, p. 325).

![Safety Glasses](image)

**Figure 5.1.1** Safety Glasses.

5.1.2 Occupational Noise Exposure (29 CFR 1910.95)

Protection for employees shall be administered when occupational noise levels exceed certain levels according to the labels listed in the act called a hearing conservation program. Medical testing, personal protective equipment, training and continuous supervision will be afforded during all work periods. “Personal hearing protective devices are acoustic barriers that reduce the amount of sound energy transmitted through the ear canal to receptors in the inner ear” (Plog and Quinlan, 2002, p. 230). Hearing protection can be in the form of earmuffs (see Figure 5.1.2.a) and earplugs (see Figure 5.1.2.b). Other hearing protection does exist and the protection needs to be picked based on the noise level and the duration of exposure.

![Earmuffs](image)

**Figure 5.1.2(a)** Earmuffs.

![Ear Plugs](image)

**Figure 5.1.2(b)** Ear Plugs.
5.1.3 Head Protection (29 CFR 1910.135)

The employer shall follow the provisions set forth in 1910.132 for this section and perform the assessment, training, and certify all areas. The employer shall provide the proper PPE for each employee. Hard hats (see Figure 5.1.3) must be worn in areas where there is a risk of falling or fly objects. Hard hats can be worn when there is a risk of coming into contact with electrical sources to prevent electrical shock and burn. “The specific type of protection necessary will depend on the nature of the inherent hazards and the tasks to be accomplished” (Alaimo, 2001, p. 323)

![Figure 5.1.3 Head Protection.](image)

5.1.4 Foot Protection (29 CFR 1910.136)

The employer shall follow the provisions set forth in 1910.132 for this section and perform the assessment, training and certify all areas. The employer shall provide the proper PPE for each employee. Steel toe shoes can be worn to prevent objects rolling over the foot or falling on the foot (see Figure 5.1.4). “Foot protection is not necessary for laboratories but may be required for some special operations and for pilot plans. Foot protection is necessary whenever there is a potential for injury to feet from falling or rolling objects, objects piercing the sole of the foot, electrical hazards, and other such hazards” (Alaimo, 2001, p. 326).
5.1.5 Hand Protection (29 CFR 1910.138)

"Gloves are probably the most common form of PPE used in laboratories" (Alaimo, 2001, p. 334). The employer shall follow the provisions set forth in 1901.132 for this section and perform the assessment, training, and certify all areas. The employer shall provide the proper PPE for each employee (see Figure 5.1.5). "Since skin contact is the primary route of entry for many toxic substances, gloves may often supply important protection" (Green and Turk, 1978, p. 113). There are many different types of gloves. The glove choice depends on the type of chemical that the person will be working with.

5.1.6 Respiratory Protection (29 CFR 1910.134)

An assessment shall be performed to determine what hazards exist that would require respiratory protection. The employer shall provide the proper PPE for each employee. The employee is to be trained in the proper use and care of the respirator. Medical surveillance shall be performed initially and annually for each employee and a medical determination shall be rendered for each person. The employer must ensure that the
respirator is the correct type for the situation (see Figure 5.1.6). "The respiratory route is one of the common routes of entry for hazardous materials in the industrial environment. NIOSH has estimated that as many as seven million workers use respirators at some time each year as protective devices against airborne contaminants" (Alaimo, 2001, p. 325).

![Figure 5.1.6 Half Mask Respirator.](image)

**Table 5.1** Compliance needs for various OSHA Standards

<table>
<thead>
<tr>
<th>Standard</th>
<th>Items needed to achieve compliance</th>
</tr>
</thead>
</table>
| 1910.133 Eyes and Face Protection | Workplace Assessment  
Policy Statement  
Training Program  
PPE supplied to employees |
| 1910.95 Occupational Noise Exposure | Written Policy  
Written PPE Program  
Medical Testing Policy  
Industrial Hygiene Testing Program  
Training Program |
| 1910.135 Head Protection | Workplace Assessment  
Written Policy  
Training Program  
PPE Program |
| 1910.136 Foot Protection | Workplace Assessment  
Written Policy  
Training Program  
PPE Program |
| 1910.138 Hand Protection | Written Assessment  
Written Policy  
Training Policy  
PPE Program |
| 1910.134 Respiratory Protection | Workplace Assessment  
Written Policy  
Written PPE Program  
Medical Program  
Training Program  
Record Keeping Program |
5.2 Benefits of Conducting an Audit

There are many benefits that can be seen when conducting a self-audit of the facility. In this instance, the audit of the regulations was constructed in order to see what specific regulations applied to the University. As stated before Table 5.1 is only a small example of the regulations that need to be implemented. Not only is it important to know what regulations need to be implemented it is also important to know how to implement the regulations.

Most industries and universities know that they need to follow the OSHA regulations but whether they do or not is another topic. When an inspector comes into a facility or university they want to see what the institution is doing to comply with the law. "There is no assumption that, just because a bad situation was recognized and a plan of abatement was set forth, the matter has been adequately addressed" (Kalentsky, 2004, p. 159). As a safety officer, an individual can have all the plans in the world written, but if they are not implemented and the training not conducted then the plans are no good to the company or university. The benefits are both for financial reasons, if you achieve compliance then you are less likely to be fined if an OSHA audit was to be conducted by OSHA themselves. The other reason for conducting the audit is a self-check of the facility, if you check your equipment and the area around the equipment you are more likely to catch a unsafe situation before it happens or in the early stages of the unsafe situation.
6.1 General Procedures Regarding the Safety Checklist

Checklists or inspections are a part of most people's daily operations. Checklists are used to make sure that we picked up the appropriate items from the grocery store. They are used by mechanics to ensure that the appropriate inspection was performed on a car before it is given back to a customer after a repair. A lab safety checklist is no different than any of the examples just given. A lab safety checklist helps to make sure that all the items within the lab are safe for the workers that will be conducting research and experiments in the lab. There can never be enough measures taken to ensure that a person arrives home safely at the end of the day. "Inspections should be conducted in an organization to locate and report existing and potential unsafe conditions or activities that, if left uncontrolled, have the capacity to cause injuries in the workplace" (Hagan, Montgomery, and O'Reilly, 2001a, p. 179). The checklist should be created in a way that the key points within the lab are touched upon.

There are two different categories of inspection that can be performed. First there is a continuous inspection, which is an inspection that is performed as part of a person's job responsibility. The inspection is a more of a general overview of the situations that take place in the lab on a day-to-day basis. The next form of inspection is an interval inspection. An interval inspection is a "planned inspection at specific intervals and are what most consider as a real safety and health inspection" (Hagan, Montgomery, and O'Reilly, 2001a, p. 180). This type of inspection is considered "a deliberate, thorough, and systemic procedure that permit examination of specific items or conditions (Hagan,
Montgomery, and O'Reilly, 2001a, p. 180). A safety checklist should be conducted during a specific time frame. They can be conducted day-to-day, week-to-week, month-to-month, yearly, or as the process changes. In a university setting it is wise to conduct an inspection on a month-to-month basis or as the chemical process within the lab area changes. "Periodic inspections are needed even if, at some particular time, it appears that the facility is in compliance." (Kalentsky, 2004, p. 159) A member of the environmental health and safety team or the laboratory supervisor should conduct the inspection with the help of a checklist. When items from the checklist are found to be lacking then the appropriate measures must be taken within a timely manner to correct them. If the lab is found to be deficient in many of the questioned areas, the lab may need to be shut down until the appropriate actions have been taken. "Immediate feedback is required at the time of the survey if exposure situations are evident from poorly designed or inoperative local ventilation systems or inappropriate personal protective equipment" (Passalugo, 1996, p. 61).

The safety checklist can be considered a form of self-audit for the environmental health and safety team and the lab supervisors. They are used to identify hazards within the lab area, "A hazard is an unsafe condition or activity that, if left uncontrolled, can contribute to an unintentional injury or illness" (Hagan, Montgomery, and O'Reilly, 2001a, p. 166). Without this tool situations might not be caught in time and a serious situation can occur. Lab checklist can be very generic and cover the basic operations and general equipment within the labs. Checklists can also be very site specific when they need to be. There is no steadfast rule as to how long or how detailed a checklist needs to
be. The checklist just needs to accomplish what it is meant to do, which is to call out potential problems within the lab.

To form an inspection checklist "areas of responsibility that could impact health and safety," (Hagan, Montgomery, and O'Reilly, 2001a, p. 181) need to be determined and addressed. "Checklist serve as a reminder of what to look for and as a record of what has been covered" (Hagan, Montgomery, and O'Reilly, 2001a, p. 183). In general people can become very familiar with their surroundings and overlook situations that might exist within their work area. To someone who works in a lab, seeing a stack of empty cardboard along a wall might be considered okay because it is put out of the way, but to a person conducting a safety checklist or audit it is seen as a walkway obstruction and fire hazard. The checklist helps to address these issues that might otherwise be overlooked. Checklists can be a general overview that can be used from lab to lab or a site-specific checklist that is intended for only one lab or area.

6.2 Microelectronics Lab Safety Checklist

The Microelectronics lab posses many inherent dangers to the people that work within this lab. Some of the dangers can be from spills, splashes, leaks, or basic human errors. For each lab on campus a generic lab safety checklist was designed (see Appendix G). The checklist is made to be a tool in assessing the equipment, and operating procedures within the lab. The microelectronics laboratory is a unique lab within itself. Since it has dangers that some of the other labs do not posse a unique safety checklist has been created for the lab and an inspection was conducted using this checklist (see Appendix
The checklist that has been created is not intended to be all-inclusive but it does touch upon the major points within the lab that need to be looked at on a regular basis.

The lab safety checklist is broken into different sections. Each section is broken down further to highlight key points that need to be examined closely. The topics that are included range from chemical safety to general housekeeping procedures. Each one of the headings is important and no one point is less significant than another. The first heading is for the general operating area. Under general safety heading the key points to examine are, if there are chemical spill kits available and whether or not they are stocked. Along with the spill kits it is important to check on the first aid kits that are used in the lab. Also under the general safety heading the safety showers and eye wash stations are to be examined. The next topic examined is the use and availability of personal protective equipment (PPE). As per OSHA it is the employer who provides the employee with any personal protective equipment that is needed for the task at hand (29 CFR 1910.132). “The overall requirements for personal protective equipment are described in the General Industry Standards, section 1910.132,” (Alaimo, 2001, p. 322). It is important to observe that the PPE is being used and that the equipment is being maintained and is in good working condition.

Housekeeping is another very important issue that needs to be addressed. “Housekeeping is a potential problem” (Konz and Johnson, 2000, p. 487) if the situation is not taken care of in a timely manner it can snowball into a bigger housekeeping issue. On the checklist a section is devoted to this issue. One of the items to look at is, if the walkways are clear of obstructions, and just important is whether the safety equipment, such as showers and eye wash stations, are free from obstructions. The lab must also be
checked to make sure that the floor is clean and free from spills, which will help to prevent slip, trips, and fall hazards. Along with housekeeping comes the category of lab waste disposal the waste should be a system in place that covers the “identification, classification, and segregation of wastes generated in laboratories” (Prudent Practices for Disposal, 1989, p. 27). It is important to check to acknowledge that chemical disposal is taken care of as per the university specifications. An example of this is if the university is a large quantity generator then the waste must be removed every ninety days.

Chemical safety is another issue that is very important to check. Under this heading things such as proper storage are examined, labeling of the chemicals, and have engineering controls been utilized when possible. Also under this topic it is important to look at the workers training methods. Have the lab workers been trained in the chemical hygiene plan and the hazard communication act? Flammable and combustible waste is another issue that arises within a lab area. Flammable waste should be disposed of properly and kept at a minimum. Flammable liquids should be stored in the proper containers that are meant for this type of task. “A flammable liquid is any liquid that having a flash point below 100°F” (A Guide to the Safe, 1983, p. 30). The waste should be stored in a designated area that insures that there are not large accumulations of waste all over the lab area.

Compressed gases are another issue that needs to be addressed in a lab safety checklist. The cylinders that are within the lab need to be secured properly, labeled as to their content, and tagged as to whether they are full or empty. It is necessary to note if the cylinders have been leak tested, this will help to insure that the cylinders are free from leaks before use. One important point is to check and make sure that the cylinders are
stored in an area that is free from damage and from falling objects. Since the pressure is so high in the cylinders, if something was to compromise the integrity of the cylinder it can rupture and the cylinder can become a torpedo like projectile through anything that is in its way.

Electrical safety needs to be addressed in a safety checklist. Is the access to the circuit breakers easily accessible and can anyone get to the breakers if need be. Another issues to look at here is if the electrical panels are closed. At the time of the inspection, the inspector also needs to look at the power cords that are in the lab, are they in poor condition. Also one must look to see if any of the cords are situated in such a way that would create tripping hazards. “Failure to establish or use safety practices for electrical equipment can result in property damage and serious injuries or fatalities,” (Hagan, Montgomery, and O’Reilly, 2001b, p. 284).

Another issue that can be looked at is the ergonomics of the lab. “Ergonomics is the study of human characteristics so that this knowledge can be used to adapt a human-made environment to the people involved,” (Plog and Quinlan, 2002, p. 357). It is important to note if the workers are performing tasks that are repetitive, this can cause undo stress to their bodies. When the workers are lifting and carrying items and these items are too heavy for the worker are they using proper lifting techniques to insure that they do no strain themselves. The last heading on the checklist is in regards to recordkeeping. The recordkeeping involved is if there is a chemical hygiene plan for the lab. It is also to check to make sure that records are maintained of who enters and exits the lab since the microelectronics lab is a secure lab setting. The training that the workers receive to work in the lab should also be maintained within the lab.
All these topics help to build the lab safety checklist. More topics can certainly be added but then the task can become too overwhelming for the individual to perform. If the basic tasks that can become overlooked are addressed then the lab is that much safer for the worker. Once the safety checklist inspection has been conducted it is important to note the deficiencies and then to address each in a timely manner. It maybe important to shut down the lab if a situation is observed that can jeopardize the health and safety of an individual in the lab. This is also known as immediate danger to life and health (IDLH) conditions.

6.3 Comparison of the Two Checklists

The original checklist that is currently used by the university is a general checklist that can be used in any of the laboratories on the campus (see Appendix G). The specific checklist (see Appendix H) that has been created for the microelectronics labs is less general then the original document that is currently used. The specific checklist elaborates on items that the general checklist does not cover or if it does cover the item it might not be covered in depth. Table 6.3 summarizes the main differences between the two checklists.

Between the two documents the one difference that stands out is that the general checklist is very general in the wording used. The checklist is set up as a bulleted document. The laboratory specific checklist asks question of the person conducting the inspection. This allows for a more thorough inspection because you are not checking items but actually responding to the question that is posed to the inspector. The lab specific checklist addresses recordkeeping within the lab. This section insures that the
proper documents are kept within the lab, such as the chemical hygiene plan. This section is also looking for an up to date chemical inventory. With the chemical inventory it can be seen whether or not a process has changed or a new chemical has been added within the lab since the last inspection. This question will also address questions in two other sections of the lab specific checklist, which are, whether the process is using the last hazardous chemicals and also if the material safety data sheet binders have been updated to reflect the addition of the new chemical.

Another topic that is elaborated on within the lab specific checklist is the maintenance of the safety showers within the lab area. The general lab checklist asks if the eye wash stations are defective or missing but no reference is made to note if they have been inspected and tested. This same situation hold true with the safety showers they need to be inspected and tested periodically to insured that they operate properly in the event of an emergency. Also the lab specific checklist looks to see if there are any obstructions in front of these stations.

Exits from the lab are brought to the attention of the inspector conducting the general lab inspection. The lab specific inspection also brings to the attention of the inspector for him or her to check for the maintenance of appropriate aisle width within the lab area. The general checklist asks for the inspector to check for mechanical hazards such as the belt guard and sharp points and edges but it makes no mention if the equipment is maintained and operated safely by the workers within the lab. The lab specific checklist addresses this issue within the general housekeeping section.

The electrical hazards that are addressed in the general checklist are in regards to the wiring. The lab specific checklist looks to make sure that the panels are secured and
that there are no obstructions in front of the panels in case an emergency shut off is needed within the microelectrons lab. One topic that is addressed in the lab specific checklist is the use of personal protective equipment. In this type of lab the use and care of PPE is very important. The lab specific checklist addresses the question of whether the appropriate PPE is being used, is the equipment taken off when leaving the lab, and if the PPE is in the proper location designated for it. Another topic that is not addressed in the general checklist is the availability of first aid boxes within the lab area. Most labs have the boxes, which are stocked with general items such as band-aids, antibiotics, and other items that can be used in the event of a minor injury. If the kit is available in the lab it needs to be checked to insure that it is restocked as needed.

The general checklist touches on a lot of the issues that the lab specific checklist addresses but the lab specific checklist goes more into depth on most issues. The lab specific checklist gives the inspector a chance to question what they are seeing. The general checklist it just a quick check of the area not a fact finding inspection. The lab specific inspections has the inspector look for the records that are available in the lab regarding the maintenance of equipment in the lab, training the workers have received, and policies that are in effect both campus wide and within that specific lab. One item in particular that would not have been noted on the general checklist but was noted on the lab specific checklist is that the aisle ways need to be looked at within the lab. Some of the aisle ways are not three foot wide as they should be. Also accessibility to the eyewash station and the safety shower would not have been noted on the general lab checklist.
### Table 6.3 Comparison Various Points Within the Two Checklists

<table>
<thead>
<tr>
<th>General Safety Checklist</th>
<th>Laboratory Specific Checklist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimal wording (very general)</td>
<td>States questions to be answered by the inspector (more specific)</td>
</tr>
<tr>
<td>No reference to record keeping</td>
<td>Recordkeeping is addressed in regards to documents, training, and inventory.</td>
</tr>
<tr>
<td>Eye wash stations covered in the checklist but no mention of the safety showers</td>
<td>Eye wash stations and safety showers are checked for last inspection and if they are obstructed</td>
</tr>
<tr>
<td>Proper aisle width is not referenced</td>
<td>Aisle width is addressed to insure that proper spacing is maintained in the aisle ways in case of an emergency.</td>
</tr>
<tr>
<td>Mechanical hazards are looked at to see if there is belt guards and no sharp edges or points</td>
<td>Mechanical hazards are looked at to insure that the equipment is used and maintained to the manufactures specifications</td>
</tr>
<tr>
<td>Electrical issues such as defective wiring and circuit overload is addressed</td>
<td>More specific reference to the security of the electrical panels and if the panels are obstructed</td>
</tr>
<tr>
<td>Personal Protective Equipment is not addresses</td>
<td>Personal Protective Equipment is addressed as to whether it is the appropriate PPE for the lab, and if it is used and maintained appropriately</td>
</tr>
<tr>
<td>First aid kits are not addressed</td>
<td>First aid kits are inspected as to if they are there and if they are restocked as needed</td>
</tr>
</tbody>
</table>

#### 6.4 Conducting a Safety Inspection and the Findings

Once a checklist has been established and is in operation it is then important to utilize the checklist (see Appendix I). "The desire to work safely must be instilled in each person in the company. The desire should be fed and sustained by a well-established culture of safety that is evident throughout all company operations" (Kalentsky, 2004, p. 25). The checklist is used as a guide to pinpoint the safety related areas and issues in the lab that need to be addresses.
The first heading of the checklist is general safety, in this section the lab inspector will look at the general safety of the lab. This includes the spill kits that are provided for in the lab (see Figure 6.4(a)). The check for this issue is if the kits are available and are they fully stocked. In addition to the spill kits there is also a need for first aid kits within a lab setting. The kits should be readily accessible and fully stocked at all times.

![Image of Chemical Spill Kit](image1)

**Figure 6.4(a) Chemical Spill Kit.**

![Image of Emergency Phone](image2)

**Figure 6.4(b) Emergency Phone.**

Others issues that existed in the lab and needs to be corrected, is in regards to the emergency phone numbers. Though there were phones that are directly connected to the universities public safety department it appears that the phone has recently been moved and the sign never moved with the phone (see Figure 6.4(b)). Also there is an emergency number on one of the gauge panels that references and employees phone number to contact in the case of an emergency but the employee no longer works for the university. Another issue under the general safety heading are if there are safety showers and eyewash units accessible and checked regularly. Also if the equipment is available and it easily accessible. There should be no equipment in front of the station (see Figure 6.3(c)). At any time during an emergency a person should be able to make their way to the shower and not have to move any equipment.
The next heading is regarding personal protective equipment and the availability to the workers within the lab. One of the checkpoints is whether the appropriate equipment is supplied to the workers. During the inspection the suits appeared to be in good condition and all the necessary PPE was provided for the workers in the lab (see Figure 6.4(d)). Also, is the PPE removed when the employee leaves the cleanroom area and does the PPE meet the standards of the tasks that a microelectronics lab performs.

The suits are kept in a room that is separate from the clean room lab and from the outside lab area. The workers enter the sealed room and then put on the suit and other required PPE. Once they are “suited up” they then enter the clean room. A similar procedure is preformed when the worker leaves the lab area.
Housekeeping is also a very large issue in chemical laboratories. In the checklist the issue of walkways is addressed. Walkways should be clear of obstructions and easily accessible. The pipes within the lab also need to be identified as to their contents (see figure 6.4(e)). This will insure that if there is an emergency within the lab that, pipe can be identified and addressed in a timely manner. As per the OSHA standard 29 CFR 1910.36 a three foot aisle width needs to be maintained at all times. This is not the case in this instance (see Figure 6.4(f)).

![Labeled Pipes in the Lab.](image1)

![Obstructed Aisle Way.](image2)

It is important to dispose of lab waste in a timely manner. In most cases this is determined by the amount of waste a facility generates in a year. From that quantity the facility will be classified as a large or small quantity generator. The volume that the university handles puts it in the category of being a large quantity generator. This means that every 90-days the waste must be removed from the facility. An outside waste hauler removes the waste. The lab waste needs to be labeled properly. The example shown is a bladder bag that collects the hydrofluoric acid waste. "Hydrofluoric acid (HF) is extraordinarily corrosive to skin and mucous membranes, producing burns which are very
slow to heal" (Green and Turk, 1978, p. 63). The box that contains the bladder was built to insure that the bag was just not sitting on the floor. The labeling on the box needs to be addressed. The bag is the hazardous waste and not the box (see Figure 6.4(g)).

Figure 6.4(g) Hydrofluoric Acid Bladder Bag.

Chemical safety is a major issue within a lab area. The chemicals must be stored properly and all labels must be clearly visible. All the caps and seals on the containers must be secured and free from damage. In the example, there is chemical waste that is not properly labeled and in addition to not being labeled, it is stored next to cardboard, which is considered a fire hazard. In this photo, not only is improper waste disposal seen, but also improper labeling exists and improper storage is evident (see Figure 6.4(h)). This is a serious issue that needs to be addressed in a timely manner.

Figure 6.4(h) Improper Storage.
Flammable and combustible materials are another issue that needs to be handled properly within a lab. Combustible waste must be disposed of properly and in a timely manner. Containers and cabinets are specially designed to hold these types of chemicals. It is important to make sure that the container closes properly in order to insure that there are no leaks. Figure 6.4(i) is an example of a flammable chemical cabinet that would be used to house these types of chemicals. On top of the cabinet is a container that is used to store flammable and combustible chemicals (see Figure 6.4(i)). Both the cabinet and the container are currently not in use at the present time.

![Flammable Storage Container and Cabinet.](image)

Figure 6.4(i) Flammable Storage Container and Cabinet.

The processes that are conducted within the microelectronics lab utilize many different compressed gases. These gases must be handled properly in order to insure the safety of the workers within the lab areas. The cylinders must be secured properly. To be secured they must be attached to the wall or some other secure fixture. The cylinders on the floor in front of the larger secured cylinders where found to be unsecured. This is an issue that was noted and needs to be addressed (see Figure 6.4(j)). The cylinders should also be labeled as to what they are and if they are full or empty. The cylinders should not be secured to a table that is unanchored or near an area that they run the risk of being damaged by a falling object (see Figure 6.4(k)).
The electrical safety in the lab area is very important. If there is a spark from an electrical short it can then cause a fire in the lab. A fire in the lab is a dangerous situation to begin with, but with all the gas cylinders the situation intensifies. Electrical panels should not be left open but they should be easily accessible (see Figure 6.4(l)). The electrical panel is not organized in a way that allows for easy access and referral as to what is in the panel. The panel appears to be a tangled mess of wires. The panel needs to be secured to insure that the contents are free unsafe conditions. The panel should be void of any water leakage to insure that there are no electrical shorts that could be started from the water leakage.
As seen in (see Figure 6.4(m)) the plastic that was put above the panel is there to catch a water leak that has occurred. This is another issue that was noted within the checklist and needs to be addressed in a timely manner. Electrical cords should be free of any damage and not create a tripping hazard. The power strip that is attached to the computer and plugged into the wall is not secured properly and is hanging off the floor (see Figure 6.4(n)). Another outlet can be added to the wall, which will allow for the computer to be plugged into the wall directly. This is not appropriate and causes an unsafe electrical situation. Other means can be devised of in order for the power connection to be made.

The ergonomic issues within the lab are a very important part of the process. It is important to insure that the workers are not exposing themselves to any repetitive movements that can affect their musculoskeletal system. Also it is important to insure that if there is any lifting involved in the process they are performing the task properly.

Recordkeeping within the lab not only addresses any recordable injuries that might take place within the lab but also who enters and exits a lab or the materials and records of training that are appropriate for the lab and lab personal. The microelectronics
lab is a very secure area and it is important that the record of people coming in and out of the lab be logged in at all times (see Figure 6.4(o)). Also as per the hazard communication act it is necessary to keep all of the material safety data sheets in the lab and available for review at all times (see Figure 6.4(p)).

6.5 Pre-Qualification to Work in the Lab

Most labs on campus conduct a student orientation; this helps to prepare the students for what hazards they might come in contact with during their time in the lab. The microelectronics lab is unique in that before anyone is allowed to enter into the lab to work they must first pass a test regarding the hazards within the lab area. The test is based on the safety procedures for the lab and the person’s retention of what to do under certain circumstances that might arise within the designated area.

“In their commitment to improving the knowledge, skills, and attitudes of workers, safety and health professionals must also be willing to measure whether workers have achieved the training objectives (Hagan, Montgomery, O’Reilly, 2001a, p. 685). The questions on the pre-qualification test are in regards to the different safety issues in
the lab. The questions involve being able to call public safety if needed, and how to handle an evacuation. The pre-qualification questionnaire must be taken and a level of comprehension must be established.

If the appropriate level of comprehension is not attained then the person is a danger to themselves, other workers, and the lab. The people working within the lab are working in an area that cost over ten million dollars to create. The true cost comes in the form of human lives that can be affected, and by the lack of knowledge in an unsafe situation. When a persons life is potentially in danger there is not enough pre-qualification testing that can be done to insure the workers personal safety.
CHAPTER 7
CONCLUSION

The development of a successful and complete program takes time and the involvement of all laboratory employees. Implementing and communicating the safety guidelines specific to the laboratory's hazards and risks are important goals in preventing injury and controlling hazardous exposures in the laboratory. The overall objective of safety compliance is to reduce and eliminate the chance of pain and suffering in the workplace. The OSHA preamble: “The employer shall provide the employee, with a workplace free from recognized hazards”. The labs in a university setting possess many dangers to the employees and the students. The laboratory of focus within this thesis is the microelectronics lab. The risks associate with this lab can be catastrophic. The chemicals that are associated with this lab have the potential to be fatal to the people that are working in the area. Without all the risks examined, and actions taken to insure that all the appropriate safety precautions are made, then the university is at risk.

Training sessions and allowing people to understand the dangers that they face on a daily basis is the beginning to implementing a safety plan. At the beginning of the research a chemical hygiene base plan existed but that was all. Now a chemical hygiene base plan has been approved and is being implemented in the many labs. Laboratory specific chemical hygiene plans have been written for the many research labs and instructional labs on campus. The employees have been trained as per the laboratory safety standard and are now a bit more knowledgeable regarding their surroundings and what they are exposed to on a daily basis.
As a result of this thesis there is now a more specific laboratory safety checklist currently it is not an approved plan but it will be something the will be looked into for the future. During the unofficial inspection many different situations were noted that might cause a potential problem. Sometimes it is hard for people that work in an area day in and day out to notice something that is out of place. After the inspection the results were turned over to the department and the situations will be taken care of.

At present time the university is in the process of meeting the mandates of the order to comply. The anticipated conclusion of the order to comply is scheduled for June of 2004. Training has been conducted and attended by a majority of the employees in conjunction with the laboratory safety standard. The researchers are providing the Health and Safety Department with the necessary laboratory reports needed to fulfill their obligation to the standard. Senior administration is attempting to expedite the process to insure total compliance.

Any plan is a learning experience both for the writer and the people that the plan is written for. "The development and implementation of a university lab safety program is a many faceted, continuous process that requires patience, persistence, flexibility, and an awareness of changes in regulations and the needs of the campus scientific community" (Barrett, 1996, p. 6). The plan is similar to a jigsaw puzzle, there are many pieces but until they are put together you are not able to see the intended picture.
APPENDIX A

Time Line

- **January 1991** - OSHA implemented the Laboratory safety standard and adopted by New Jersey under the Public Employee Occupational Safety and Health Standard (PEOSHA)

- **1995** - Inspection by PEOSHA found that a Chemical Hygiene plan as per the standard was not in place and an order to comply was issued.

- **May 2003** - Campus was inspected and it was found that the University was still not in compliance with the Laboratory safety standard and second order to comply was issued.

- **June 2003** thru **August 2003** - Compile labs for the upcoming semester. Notify the administration of the actions that need to be taken and get their support in doing so. Fill out the "Safety Review and Approval Checklist for Instructional Laboratories" (see Appendix B) for each lab class and attach to the lab. A Chemical Hygiene Officer (CHO) will be picked for each department that is affected by the standard.

- **September 2003** - As per the order to comply the order is to be posted in the buildings that are not in compliance.

- **October 2003** - The Director of Health and Safety conducted training for the employees of that department that have been chosen to be the (CHO).

- **December 2003** - Re-inspection of the campus by PEOSHA to insure that the laboratory safety standard has been implemented on campus. Further inspection will be conducted in June after more training has been conducted

- **June 2004** - Re-inspection of the campus by PEOSHA to insure that the laboratory safety standard has been implemented on campus. The expected outcome is for final closure of the project due to fulfillment of the laboratory safety standard/

The process is ongoing and every semester the "Safety Review and Approval Checklist for Instructional Laboratories" will need to be filled out and the labs for that semester will need to be evaluated and modified if changes regarding the chemicals used have been made to the labs.
APPENDIX B
University Chemical Hygiene Plan
Sixth Edition -- July 2003
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Introduction

Purpose

In February, 1993, New Jersey's Public Employees OSHA adopted 29 CFR 1910. 1450, Federal OSHA's "Occupational Exposure to Hazardous Chemicals in Laboratories Rule", (also known as the Laboratory Standard). The standard provides for the health and safety of employees in the laboratory by generally requiring the following:

- Development of a laboratory Chemical Hygiene Plan.
- Designation of a Chemical Hygiene Officer.
- Standard operating procedures to be followed when using hazardous chemicals.
- Consideration for establishment of "designated areas", as well as other protective measures, when working with select carcinogens, reproductive toxins, or particularly hazardous materials.
- Procedures for the "prior approval" of hazardous laboratory operations.
- Training of laboratory workers.
- Medical consultations and examinations for employees with hazardous chemical exposures.
- Identification of hazards.
- Recordkeeping for any measurements of employee exposure and medical consultations/examinations.

An overview of the Laboratory Standard, as well as a full copy of the regulation is given in Appendix 1.
Scope / Applicability

At the university, the Laboratory Standard applies to all employees and students engaged in the "laboratory use" of hazardous chemicals. It applies to research and teaching laboratories, which are carrying out small-scale operations (those which can be handled safely and easily by one person) using multiple chemicals and procedures, where the procedures are neither a part of, nor simulate, a production process.

Designation of Responsibility

The following designates responsibility for implementation of the Laboratory Standard at the university:

- **LABORATORY WORKER** - Follows safe work practices, attends required training and is familiar with the laboratory Chemical Hygiene Plan.

- **LABORATORY SUPERVISOR** - Assures that all employees/students in the lab follow safe work practices, provides necessary hands-on training, develops the laboratory Chemical Hygiene Plan, ensures the Chemical Hygiene Plan is available to all occupants of the lab, and provides "prior approval", when necessary.

- **CHEMICAL HYGIENE OFFICER** - Implements the laboratory Chemical Hygiene Plan, provides guidance on safe laboratory procedures, and assists in the annual review and update of the Chemical Hygiene Plan.

- **DEPARTMENT CHAIR** - Designates the Chemical Hygiene Officer (either one for the department, or individual CHO's for each lab), assures department compliance with the standard, appoints department Unit Safety Committee.

- **UNIVERSITY LABORATORY SAFETY AND DESIGN COMMITTEE (Subcommittee to the University Health Safety Council)** - Serves as the University Chemical Hygiene Committee, reviews annually the Chemical Hygiene Guide, reviews and approves University policy on laboratory safety.

This Chemical Hygiene Plan encompasses the following area (to be completed by CHO):

Name of Department or Division

Name(s) of Chemical Hygiene Officer(s):

List building/room(s) covered by the Plan:
CHEMICAL HYGIENE PLAN ELEMENTS

The Laboratory Standard requires that the CHP, when implemented, be capable of protecting employees from health hazards associated with chemicals in the laboratory and that it keep exposures below occupational exposure limits. At the university, these occupational exposure limits include either Threshold Limit Values (TLVs), or Permissible Exposure Limits (PELs) promulgated by Federal OSHA, which ever is lower. The laboratory CHPs must be made readily available to all laboratory employees, and must contain the following elements:

A. Standard operating procedures for laboratory safety and health.
B. Criteria that the university will use to determine and implement control measures to reduce employee exposures to hazardous chemicals.
C. Documentation of requirements that fume hoods and other protective equipment are functioning properly, and measures that will be taken to ensure their adequate performance.
D. Provisions for employee information and training, as detailed in the standard.
E. Documentation of circumstances under which certain laboratory operations will require prior approval.
F. Provisions for medical consultations and exams, as detailed in the standard.
G. Provisions for additional employee protection when working with "particularly hazardous substances", as defined in the standard.

A. STANDARD OPERATING PROCEDURES

The following SOPs are generic, and apply to most laboratories where chemicals are used. They should be modified, as appropriate, for each specific laboratory. SOPs specific to procedures and operations in each laboratory must be developed and included in each laboratory's CHP.

1. Emergency Procedures

a. Priorities

An emergency is any event that requires an immediate stop in work and the following of a special procedure to protect life, health, and property. The best time to know what to do in an emergency is before, not after, it happens. The best time to read this Guide, then, is at your leisure -- before the fire begins, and before the chemical is spilled. Though no single guide can possibly cover the range and combination of events that can constitute an emergency, it is hoped that careful reading of the following emergency procedures will help you begin the planning process that will best fit your situation. Your experimental protocols or written procedures must always include safety measures, and at times may need to include specific emergency procedures. In any case, all such emergency procedures will need to be practiced and reviewed periodically.

Most emergencies will be small, consisting of a single unexpected event. More serious emergencies involve a series of events, which stem from an initial incident, expanding in unfortunate sequence. Under any circumstances, decisions may have to be
made quickly, often without adequate information, in a context that may have no precedent. Use the best and calmest judgment you have, and try to stay within the following general priorities:

1. **LEAVE** the area of danger. This is of paramount importance to enable rescuers to do what is necessary to sustain life. If the area includes other people's workspace, make sure they leave, too. If you can safely turn off equipment as you go, do so.

2. **CALL** the campus emergency number from the nearest safe area. Calling takes precedence over everything except evacuation in all emergencies. This also applies for seemingly minor emergencies; it is far better to make an occasional unnecessary call than to fail to call and needlessly endanger life or health. Calmly state: your name; the location and nature of the emergency; whether an ambulance or fire fighting equipment is needed; any hazards that might threaten persons on the scene or responding; and a phone number and location at the scene where you can be reached. After calling, stay off the phone. The only exception is in cases of poisoning, when you may need to call the Poison Control Center: 1-800-222-1222.

3. **PROTECT** the life and health of anyone who may be injured. The First Aid advice given in this Guide is contingent on rescue equipment and qualified personnel being 2 or 3 minutes away. In a number of isolated experiment stations this is not so; suitable modifications to the emergency procedures should be made.

After calling, do what you can to continue to preserve life, but do no more than the necessary first aid procedures unless you are specifically trained to do so. Subsequent steps will depend on the nature of the emergency and your assessment of its severity. In each of the following situations, be sure you are in a safe place, summon help quickly, and try to protect the lives of those involved.

**b. Injury**

Ideally, only people with first aid training should render first aid (In an emergency, however, untrained help may be better than none. Stay calm, do only what you must before help arrives, and follow these priorities:

1. **REMOVE THE VICTIM FROM THE AREA OF DANGER** -- fire, spill, fumes, etc. If the victim is not conscious - DO NOT ENTER THE AREA - proceed immediately to step 2, "Call for help." [NOTE: If the victim is in contact with electricity, he or she becomes "the area of danger". Avoid direct physical contact with the injured and the source of power; disconnect the power, or push/pull the victim away from the circuit with a non-conductive material (board, rope, etc.).]

2. **CALL FOR HELP:** Always initiate the process to get trained medical help before you take any other extensive action. For a serious injury (very heavy bleeding, chemical in eyes, etc.), you will often need to stabilize the situation briefly before calling. Common sense will dictate this potentially difficult decision,
but in no case should calling be delayed except for the most immediate life-threatening situation. If two people are available, one can go for help while the other begins first aid.

3. **REESTABLISH AIRWAY** for breathing, if breathing has stopped. Check for an object blocking the airway; remove it if possible. Only if there is no blockage should artificial respiration be attempted; otherwise the victim could be injured further. Lift the victim's neck and tilt head back to open airway. Pinch the victim's nostrils and cover the mouth with yours. Blow your breath into the victim's mouth until you see the chest rise. Remove your mouth and let the victim exhale while you breathe in. Repeat 15 times per minute until the victim starts breathing or help arrives. **DO NOT STOP,** even if you think there is no hope.

4. **CONTROL BLEEDING** by applying direct pressure to the wound, using a clean cloth or your hand. If possible, elevate the injured area above the heart. Keep the victim warm and lying down. **Never use a tourniquet except for amputated or crushed limbs.**

5. **REESTABLISH CIRCULATION** through cardio-pulmonary resuscitation (CPR). Only those trained in this procedure should attempt it. Training is available through the Dept. of Health & Safety.

6. Treat for **CHEMICAL CONTACT.** If the chemical was ingested, call the campus emergency number and then the Poison Control Center (1-800-222-1222). Follow their instructions. If for some reason you cannot reach professional advice, do not give the victim water, milk, or anything else unless so directed by a Material Safety Data Sheet (MSDS), Hazardous Substance Fact Sheet (HSFS), or other text. Do not induce vomiting if the victim complains of pain or a burning sensation in the mouth or throat, or if the ingested substance is known to be caustic, a cleaning fluid, or a petroleum product. Induce vomiting only if directed to do so by Poison Control. To induce vomiting, place the victim's head below the hips, mouth down or to the side, and place a finger at the back of the victim's throat. If the chemical was inhaled and the victim is conscious, call the campus emergency number and then carry or drag the victim to fresh air. Do not let the victim walk unassisted or engage in any unnecessary activity that will increase the circulation of poison in the bloodstream. If you need to use artificial respiration, be careful you do not inhale the poison from the victim. If the victim is not conscious, do not enter the area; the victim may have been overcome by gases in the area, or by a lack of oxygen in the space. There have been many documented instances, some on University campuses, of would-be rescuers becoming additional victims. If the chemical was splashed in the eye, immediately seek an eyewash, safety shower, or spigot. The eye must be washed for at least 15 minutes with the eyelids held apart to allow maximum exposure of the eyeball. While washing, check for contact lenses by looking into the eye, and by asking the victim (while contact lenses are prohibited in laboratories where chemicals are used, rules are sometimes
broken). Ask the victim to remove them if possible. Otherwise, contacts may be removed under gentle water pressure. Do not attempt to remove contacts by hand or with any other object. Emergency personnel are trained to do this. Be careful not to rub the eyes. If chemicals are on the skin, follow the recommendations under the First Aid section of the MSDS. If such information is not readily available, wash the affected area with continuous clean water for 15 minutes. Remove any clothing contaminated with chemicals; be careful that the rescuer does not become contaminated as well. Be aware of the possibility of inadvertent injection or unnoticed introduction of chemicals into the body. Many solids, oily liquids, or water solutions can enter through cuts in the skin. In addition, the skin will absorb many oily liquids and oil soluble solids. Keep victim quiet and wait for medical assistance.

7. Treat for SHOCK. Though in appearance less dramatic than the above injuries, shock can kill just as quickly. If a person goes into severe shock, treatment for shock takes priority over all first aid except for reestablishing airway, control of bleeding, and CPR. Symptoms of shock include paleness, cold and clammy skin, weakness, nausea/vomiting, shallow breathing, rapid pulse, cold sweat, chills and shaking. If possible, remove the cause of shock (e.g., control heavy bleeding). Keep victim warm and lying down. Elevate legs if no spinal or head injuries are suspected. Keep airway open and give non-alcoholic liquids if the victim can swallow and does not have a "belly wound."

c. Fires and Explosions

1. LEAVE the area of danger -- usually the building. When needed, use a fire extinguisher to clear a safe path, or "shoot your way out". Do not stay to fight large fires.
2. CALL the campus emergency number. The emergency number should be called, or the building alarm sounded, for all unintentional fires, without exception.
3. Be sure that others in the area of the fire are notified as well, whether verbally or through the fire alarm. If you hear a fire alarm (a loud bell or horn), immediately leave the building, making sure that others do too.
4. On your way out, turn off equipment and move explosive materials away from possible heat, ONLY IF THERE IS SAFE TIME TO DO SO. Your leaving quickly is THE HIGHEST PRIORITY.
5. In determining the nearest safe place, be aware of the possible spread of toxic gases and fumes, including the likely direction of spread (for example, gases heavier than air will accumulate in low places). When the Fire Department arrives, tell them which chemicals are involved.
6. If a person's clothing is on fire, he or she must not be allowed to run, as this will fan the flames and cause a more serious burn. Douse with water or wrap in a fire blanket, coat, or whatever is available to extinguish the fire. Roll the person on the floor if necessary. After calling the emergency number, place clean, wet, ice-
packed cloths on the burned areas, wrap the person warmly to avoid shock, and wait for assistance.

7. The primary purpose for fire extinguishers is to "shoot your way out" in order to reach safety; fire fighting is always better done by those with the equipment and training to do it. Know in advance which type of extinguisher is appropriate for which type of fire (consult the data on the extinguisher); be sure to use the appropriate extinguisher, and direct discharge at the base of the flames. Training on the proper use of fire extinguishers is available through the Dept. of Health & Environmental Safety at 3059 for more information.

8. A fire contained in a small vessel can usually be smothered by covering the vessel with an inverted beaker or watch glass. Do not use dry paper towels or cloths. Remove nearby flammable materials while the fire burns itself out.

d. Chemical Spills: Procedures for handling spills in laboratories are given in Appendix 2. The flow chart, which is included, should be copied and posted in the laboratory. If there has been any chemical contamination of personnel or clothing, follow Emergency Procedures for Chemical Contact (see section b.6, above).

e. Identifying Hazardous Substances in Emergencies: To help identify hazardous substances involved in an emergency, H&ES has established a Caution Sign program which provides for door signs bearing the room supervisor's name and phone number and a listing of potential hazards in the room. A copy of the Caution Sign program is given in Appendix 3.

f. Reporting Accidents: In the event of a laboratory accident, an Accident Report Form must be completed by the supervisor or instructor and sent to Risk Management and H&ES. This form contains valuable information to help determine causes and prevent future accidents in the laboratory, and should be completed for all laboratory accidents, no matter how minor. A copy of the form is given in Appendix 4. Anyone needing additional copies of the form can contact H&ES. Additional information is available in the University Health/Safety Manual.

g. Power Failures: If your laboratory loses power during an emergency, leave the building as quickly as possible by following your departments building evacuation plan. Call the campus emergency number from the nearest safe area to report the power failure and await assistance.

2. General Laboratory Behavior

a. Safety Rules

1. Know the location of laboratory exits.
2. Know the location and use of the safety showers and eyewashes.
3. Know the location and use of fire extinguishers.
4. Know the location and use of spill kits, when available.
5. Know the location of a phone, which can be used in an emergency.
6. Know the potential hazards of the materials, facilities, and equipment with which you will work. If you are uncertain ask your instructor, your supervisor, or H&ES.
7. Use the proper safety equipment for your procedure. This could include a fume hood, glove box, biosafety cabinet, shield, or other equipment.
8. Do not wear contact lenses in laboratories where chemicals are used.
9. Wear eye protection in the laboratory. Splash goggles are required for wet chemical work or work with dusts and powders.
10. Wear other personal protective gear where laboratory or experimental conditions dictate. This includes laboratory aprons, lab coats, gloves, gauntlets, glass blowers' goggles, face shields, dust masks, respirators, and other equipment. Anyone requiring respiratory protection must participate in the university Respiratory protection program.
11. Wear clothes that protect the body against chemical spills, dropped objects, and other accidental contact. Thus, bare midriffs, shorts, open shoes, sandals, and high heels are prohibited.
12. Confine long hair when in the laboratory. Remove or secure ties or other articles of clothing or jewelry that might become entangled in equipment.
13. Do not eat, drink, smoke or apply cosmetics in the laboratory. Do not store food or drink in the laboratory, or use laboratory equipment for eating or drinking.
14. Do not pipette by mouth. Use only mechanical piping devices.
15. Wash hands frequently when handling chemicals and before leaving the laboratory. Beware of contamination of clothing or of doorknobs, frames, etc. Remove any protective gear before leaving the laboratory; this includes gloves and laboratory coats.
16. Follow written protocols or instructions. Perform only authorized experiments. (See Sec. E, "Laboratory Operations Which Require Prior Approval").
17. Do not move or disturb equipment in use without consent of the user.
18. For reasons of safety and security, it is prudent to avoid working alone in the laboratory, particularly after hours. The laboratory supervisor is responsible for determining and implementing procedures to provide for emergency notification and periodic checks of an individual working "alone" in the laboratory. The extent of the procedures is dependent on the nature of the laboratory work and the degree of potential hazard.
19. Do not play in the laboratory.
20. Follow good housekeeping practices -- clean up as you go, and keep work areas, aisles and exits uncluttered.
21. Do not deface labels on chemical containers. Make sure all container labels correctly identify their contents.
22. Report all accidents and injuries immediately to your laboratory instructor, supervisor, or Chemical Hygiene Officer.
23. Report unsafe conditions to your instructor, supervisor, Chemical Hygiene Officer, or H&ES.

b. Additional Rules for Students

1. Read and follow the Safety Rules listed previously.
2. Know who is in charge of your laboratory.
3. Perform only authorized experiments, and be sure you understand the procedures involved before you begin. If anything unexpected, dangerous, threatening, or unmanageable happens, immediately call your instructor.
4. Do not use unfamiliar equipment without instruction and permission.
5. Behave and dress appropriately for conscientious work in a potentially hazardous place. Never play in the laboratory.
6. Report all accidents and injuries, however small, to your instructor.

c. Additional Rules for Instructors and Supervisors

1. Take responsibility, in attitude and action, for the safety conditions of your laboratory.
2. Observe all rules and see that they are enforced.
3. Set an example by wearing protective equipment and by following proper laboratory procedures to promote safe work habits.
4. Carefully review all laboratory experiments for possible safety problems before the experiments are assigned to students.
5. Make both preventative and remedial safety measures part of your instruction. Be sure all students and laboratory workers are familiar with emergency procedures and equipment.
6. Be alert for unsafe conditions. Inspect often and intelligently; take effective corrective action promptly.
7. Assume responsibility for visitors and require that they follow the same rules as students and other laboratory workers.

d. Rules for Custodial Workers

1. You may sweep, mop, wash the floors and remove normal trash from any laboratory, including a radiation laboratory.
2. Rooms, which have a Caution Sign and any of the nine different stickers on the door, may contain materials or equipment, which may cause harm.
3. Do not touch any material, container, or waste container with a biohazard symbol or radiation symbol on it.
4. You must not touch, disturb, move, or handle any containers of any chemicals or materials except those issued to you by your department. If you need chemicals or other laboratory materials moved in order to perform your duties, have the room supervisor arrange for this to be done, or contact your supervisor.
5. If the contents of any containers (other than those issued to you) are spilled, DO NOT TOUCH THEM OR ATTEMPT TO CLEAN THEM UP. Tell your supervisor, who will then contact emergency personnel.
6. Wear safety glasses if there are persons working in the laboratory.
7. Do not eat, drink, smoke, or apply cosmetics in a laboratory.
8. If you have any questions, contact the room supervisor first, your supervisor next, or finally, H&ES.
e. Rules for Maintenance Workers

1. Before working in a laboratory, in a chemical fume hood, inform the room supervisor what you will be doing, and when you will be working. The room supervisor’s name should be posted on the main laboratory door.

2. The room supervisor is responsible for assuring that your work area within the room is free from physical, chemical, and/or biological hazards. Your work area may include hoods, sinks, cabinets and benches, bench tops, floors, and/or equipment. You may be required to repair, move, remove, replace, paint, etc. as part of your duties.

3. Do not handle or move chemicals in the laboratory. If you need chemicals moved, have the supervisor arrange for this to be done.

4. Generally, you should not move or handle equipment in the laboratory. If your work requires you to move, remove, or replace a piece of equipment, have the room supervisor assure you that the equipment is free of any physical, chemical and/or biological hazards.

5. Do not eat, drink, smoke, or apply cosmetics in the laboratory.

6. In situations where the hazard cannot be totally removed, specific work procedures will be developed in conjunction with the room supervisor, and H&ES. If there is a chance your work may bring you in contact with chemical hazards (e.g. working on laboratory sinks, working in areas where there is a chance of chemical contamination) or when working in rooms where chemical experiments are taking place, have the room supervisor provide you with the necessary protective equipment, including gloves, goggles, etc.

7. When working on a fume hood, ask the room supervisor if the hood was used for perchloric acid or radioactive materials. Contact H&ES before performing maintenance on any part of a perchloric acid or radioactive materials fume hood system (including: hood, base, duct, fan, stack, etc.). Lubricate perchloric acid hood fans with fluorocarbon grease only.

8. If you are working in a room labeled with a radiation symbol, refer to the handout "Maintenance Staff - Procedures For Dealing With Equipment In Laboratories Using Radioactive Materials".

9. If you have any questions, contact the room supervisor first, your supervisor next, or finally H&ES.

3. Safety Systems
   
a. Personal Protective Equipment

1. Eye Protection
   
   - *Splash Goggles*: Eyes are particularly sensitive to any contact with chemicals; therefore, splash goggles must be worn at all times in laboratories where liquid chemicals, dusts, or powders are being used. Safety glasses do not offer sufficient protection from fumes or particles entering from the side.
   
   - *Shields*: Standing shields and face shields protect the face and neck. Shields of good rigidity and strength, which protect the face and neck, should be used...
for vacuum work, when working with low or high-pressure systems, or where mild explosions may be anticipated.

2. Respiratory Protection
   • Dust masks, cartridge respirators, self-contained breathing apparatus, or any other type of respiratory protection should not be necessary in a properly designed laboratory. If you believe you may nevertheless require such protection, contact H&ES for information and recommendations.

3. Skin and Body Protection
   • *Gloves:* Gloves protect the hands against contact with chemicals and also against abrasion and extremes of heat and cold. Check gloves before use, for worn spots, cracks, and other signs of wear. When removing gloves, be careful to avoid touching the outside of the gloves with your bare hands; also avoid touching door knobs, light switches, etc., with the gloves. Always remove gloves (and all other protective gear) before leaving the laboratory. Different kinds of gloves offer different levels and types of protection. Gloves made of cotton or cotton with leather protect against abrasion, sharp objects, and glass; however, they offer virtually no wet chemical protection, and may actually absorb chemicals and keep them in contact with the skin. Surgical type gloves made of rubber or synthetics offer some hand protection and also allow dexterity. For more substantial protection against some acids and most other corrosives, heavy rubber gloves are available with various lengths of forearm protection. Heavy rubber gloves do not effectively protect against a number of concentrated acids, organic solvents, or PCBs. These substances require gloves made of a synthetic material, for example neoprene nitrile rubber or Viton, depending on the chemical being used. Insulated gloves should be used when dealing with temperature extremes. Proper fit and comfort must also be considered when selecting gloves.

   • *Aprons and Lab Coat:* Aprons and lab coats protect the body as gloves do the hands. Heavy-duty rubber aprons should be used for protection against strong acids and bases. As discussed above, heavy rubber will not protect against all materials, in which case a synthetic material must be used. Vinyl aprons are recommended for general use; cloth lab coats are also useful, but mainly for protecting clothing. As with gloves, lab coats and aprons should remain in the laboratory. Many of the substances, which are found in the laboratory, can be inadvertently taken home on lab coats and aprons.

   • *Shoes:* Sturdy closed shoes should be worn in the laboratory at all times to protect against spills and splashes which reach the floor. Leather shoes offer better protection against corrosion than canvas shoes; open-toed shoes are prohibited in the laboratory.

4. Hearing Protection
   • Standards for hearing protection and acceptable noise levels have been established by PEOSHA regulations. If you feel that a noise hazard is present in your laboratory, contact H&ES for evaluation and recommendations.
b. Fire Protection

- *Fire Extinguishers:* Everyone working in a laboratory must know the location and correct use of fire extinguishers. Although extinguishers are capable of putting out small, contained fires, their primary purpose is to allow you to "shoot your way out" -- to establish and maintain a safe exit path as you leave.

It is important to use the right kind of extinguisher for the fire. The classes of fires are identified by letter:

- A -- ordinary combustible solids including paper, wood, coal, rubber, and textiles.
- B -- flammable and combustible liquids, including gasoline, diesel fuel, alcohol, motor oil, grease, and flammable solvents.
- C -- electrical equipment.
- D -- combustible or reactive metals (such as sodium and potassium), metal hydrides, or organometallics (such as alkylaluminum).

Each fire extinguisher is clearly marked by the letter(s) of the class of fire that it can extinguish. Because using the wrong kind of extinguisher can be very dangerous, the time to read the extinguisher is before the fire, at your leisure.

c. Laboratory Equipment

1. Fume Hoods: Fume hoods are a common means of control of exposure to toxic substances. The variety of hood used should depend on the materials involved; for example, hydrofluoric acid will etch glass, perchloric acid requires a stainless steel hood interior and duct, and wash-down system and radioisotopes may require stainless steel ducts. H&ES can advise as to the variety of hood that will be appropriate, and will also perform periodic hood tests.

A chemical fume hood is designed to operate most effectively at an optimum air velocity, usually 80 - 100 linear feet per minute. While it is good practice to work with the sash as low as possible, this measurement is made with the sash fully open to ensure protection at any sash height. This air velocity will result in a laminar airflow pattern, which will capture most fumes and vapors likely to be given off within the hood. Lower air velocities may be insufficient to capture and remove most fumes and vapors. Higher velocities can lead to a turbulent airflow, which does not capture the fumes and vapors as well. Higher or lower air velocities may be acceptable in certain cases with H&ES approval. H&ES annually surveys all fume hoods within the University to determine if they are operating at acceptable levels. If your fume hood does not have an inspection sticker, or if you have a new hood, please contact H&ES.

The following are guidelines for safe fume hood use, and are to be followed when using a fume hood. All laboratory supervisors should periodically review these procedures with all laboratory personnel.
a. Use the fume hood with the sash as low as possible, at or below the indicated operating height. The operating height should be clearly marked by arrows on either side of the sash track. These marks are placed on a hood when it is surveyed by H&ES. If your fume hood does not have an operating height sticker on it, call H&ES as the hood probably has not been surveyed. If you need to move large pieces of equipment into or out of the hood, raise the sash for as long as is necessary, and lower it as soon as possible. Do not work on the hood with the hood sash fully open. The fume hood operates more effectively with the sash at the operating height. Additionally, this will allow the sash to serve as a physical barrier between your face and the contents of the fume hood.

b. Do not store chemical or equipment, which are not being used, in the hood.

c. Raise large pieces of equipment up on blocks approximately 2", to allow air to pass under the equipment and allow more even airflow through the hood.

d. Do not place equipment or chemicals very close to the slot openings in the baffles at the rear of the hood, or very close to the front edge of the hood. Putting items in those spots will interfere with even airflow through the hood. Keep materials at least six inches back from the front edge.

e. Keep the sash glass clean, and never obstruct your view through it with paper, notices, decals, or other items.

f. Avoid sudden movement past the face of the hood when it is operating. Simply walking briskly past the hood can disrupt air currents, and pull vapors out of the hood.

g. Keep your head outside the fume hood. Do not walk into a "walk-in" hood when it is operating. "Walk-in" hoods are designed to hold large pieces of equipment and are not to be literally "walked-into".

h. NEVER use perchloric acid in a fume hood not specifically designed for this purpose. A properly designed perchloric acid hood has a stainless steel liner, with a stainless steel duct that runs vertically to the roof. It is designed with a water wash-down system to periodically remove dangerous perchloric acid residues. Using perchloric acid in a conventional fume hood can leave explosive residues on the hood, duct, or fan.

i. If your hood is equipped with a flow-indicating device, check to see that it is functioning properly before use. If your hood is not equipped with a flow-indicating device, you can periodically check it with a hand-held velocity meter or by hanging a small (approximately 1" x 4") piece of tissue, Kimwipe, or similar lightweight paper from the bottom of the hood sash. This should be drawn in when the hood is operating normally and will hang straight down, when the hood is operating marginally or not at all. If your fume hood is not operating properly, first check to see that it is on and that the rear slots are not blocked. If that is not the problem, then call your campus Facilities Operations and Maintenance or Physical Plant immediately to arrange to have it repaired. Keep in mind that a chemical fume hood is an important piece of laboratory safety equipment. Using and maintaining a fume hood properly will help protect you and your fellow workers from potential chemical hazards in the
laboratory. If you have questions about fume hood use, or need training on the proper use of a chemical fume hood, please contact H&ES.

2. Glove Boxes: Where highly toxic substances must be contained, or reactive substances must be handled in an inert or dry atmosphere, it may be necessary to use a completely enclosed unit such as a glove box.

3. Eyewashes: An emergency eyewash unit should be located in every laboratory and should deliver a gentle flow of clean, aerated water. The eyewash must be kept free of obstructions. When a chemical has splashed into the eye, irrigate the eye immediately. Flush the eye with a copious amount of water under gentle pressure. If the victim is wearing contact lenses, have him or her remove them at once if possible. Forcibly hold the eye open to wash thoroughly behind the eyelids. The victim must be given prompt medical attention regardless of the severity of the injury. Continue irrigating for 15 minutes before transport to a hospital or health center. Eyewash units and safety showers are installed and maintained by Facilities Operations and Maintenance, and tested annually. H&ES and the using department determine the need and location for new showers and eyewash stations. If there is a need in your department, your Unit Safety Committee should contact H&ES.

4. Safety Showers: Each laboratory should have a safety shower in an easily accessible location, often in a corridor. The shower area must be kept clear of obstructions. In case of chemical contamination over a large part of the body, the contaminated clothes must be removed immediately and the person doused with water continuously for 15 minutes or until medical help arrives. A blanket can be used for warmth and modesty during dousing. Someone should be sent at the beginning of this procedure to summon medical attention.

5. Ground Fault Circuit Interrupters: A ground fault circuit interrupter is an electrical device that protects against leakages of electrical current to ground. If even a minor leakage is detected, the device opens the circuit, preventing possible electrocution. Ground fault circuit interrupters can be portable -- placed within the laboratory where needed -- or installed in the circuit box itself by Facilities Operations and Maintenance. These devices are required where damp or wet conditions are likely.

6. Spill Containment: Use absorbent paper on the bench top to contain small spills. Absorbent paper will also help reduce possible contamination of the laboratory furniture and apparatus. Procedures using larger amounts of liquid should be performed in or over spill trays. Spill kits of absorbent material should be available for containment and neutralizing of large spills. Be sure to use each kit only for the materials designated on the kit container. All spills requiring the use of a kit should be reported to the campus emergency number.
4. Preparing For Laboratory Work

Before beginning any laboratory work, a plan should be made describing: goals; chemicals and equipment needed; and the sequence of steps to be followed, including safety measures.

a. **Chemicals:** Full descriptions of chemicals used in the laboratory can be found on Material Safety Data Sheets (MSDSs) or Hazardous Substance Fact Sheets (HSFSs), which contain information on physical characteristics, hazards, disposal, and routine and emergency precautions. There is a sheet for virtually every chemical marketed, available from chemical suppliers, University RTK Central Files (available in Police Dept.), H&ES, and a number of computer based information systems. HSFSs are available from the NJ Department of Health for each of the substances regulated by the New Jersey Worker and Community Right-to-Know law. The Right-to-Know law requires, among other things, that persons who may be exposed to chemicals be trained in general and specific chemical hazards and chemical safety. MSDSs and HSFSs should be used as part of this training. An MSDS or HSFS should be acquired for every chemical used and should be kept on file for reference. The information on the MSDS or HSFS should be given to every laboratory worker who will be handling the chemical in question. Design your procedure to use the least hazardous chemicals and the minimum possible quantity of each chemical that will still allow meaningful results. Using smaller quantities of chemicals means that less can be spilled or volatilized, and that less must be treated and/or disposed as hazardous waste.

b. **Equipment:** Specific information must be obtained about any equipment to be used. Most equipment is sold with this information, ranging from one-page instruction sheets to complete books. This information must be read thoroughly and followed exactly for safest use of the equipment. When used equipment is sold or donated to the University, recipients must obtain operating instructions if at all possible.

c. **Written Procedures:** Developing a protocol is basic to the experimental process, and should result in a written set of procedures. Writing the procedures allows the researcher or instructor to go through the experiment in the planning stage, and identify areas where special precautions may be necessary. The written protocol will provide workers with step-by-step instructions, minimizing the chance of errors. A good written protocol will allow for modifications and will include safety precautions (e.g., "wear splash goggles," "pour acid into water," "perform this operation in fume hood"). Written procedures should also include MSDSs or HSFSs for all chemicals used in the experiment. In addition, a laboratory notebook should be kept during the procedure, documenting each action and its result. In the event of an accident, a set of written procedures and laboratory notebook may indicate what went wrong, and possibly why.
d. **Setting Up:** Just before beginning the work, review the written procedures, following the expected sequence of the experiment. Review the materials to be used as to their degree and nature of hazard, including flammability, volatility, reactivity, etc.

All equipment and supplies should be in place before actual work begins, including proper protective equipment (e.g., hoods, glove boxes, gloves, aprons, safety goggles, shields, and lab coats). The work area should be uncluttered and orderly. Where areas of possible contamination and exposure might exist, take precautionary measures, such as lining the work surface with absorbent paper. Also, have on hand all the necessary equipment to deal with a spill or accident (more absorbent paper, spill-control kits, etc.)

5. **General Laboratory Equipment Setup**

a. **Preparing the Work Space**

- Workspace should be uncluttered. Only necessary materials, equipment, protocols, instructions, notebook, and pen or pencil should be present. Books, unnecessary materials, and scraps of paper should be removed and stored properly. Keep measuring equipment, such as glass cylinders, where it will not be easily knocked over. Do not place equipment on the floor of a working area where it may trip others or be knocked over.

- Use only equipment that is free of flaws (cracks, chips, inoperative switches, frayed cords, etc.). Ensure that all necessary guards are in place before using equipment. Examine glassware carefully. All defective glassware should be returned to the stockroom for replacement, or should be discarded safely. All defective electrical equipment must be repaired before use, or discarded.

- Set up clean, dry apparatus, firmly clamped and well back from the edge of the laboratory bench. Keep burners and open flames a safe distance from solvents and reagent bottles. Allow enough space for the equipment used, and enough working space to avoid crowding other workers and disturbing their apparatus. Select vessels of the proper capacities for each experiment.

- Place a tray or absorbent paper under the apparatus to confine spilled liquids.

- All equipment must be properly supported to prevent unnecessary movement and to maintain proper alignment during the experiment. Apparatus attached to a ring stand should be positioned so that the system's center of gravity is over the base and not to one side. Securely attach clamps to stands. Set up the equipment with adequate space and configuration for removing burners or baths. Orient equipment so that stopcocks, hoses, and other attachments will not be loosened by gravity. Use a retainer ring or spring where necessary.
• Use a fume hood if the experiment is expected to evolve noxious odors, or toxic or flammable gases, vapors, or fumes. Do not use perchloric acid, hydrofluoric acid, or radioisotopes in hoods that are not specifically approved for those materials.

• Use a protective shield when conducting a reaction, which may result in a mild explosion, or when using a vacuum system (which may implode). Use a face shield that is sufficiently large and strong to protect your face and neck, or use a standing shield. A standing shield is indicated if an explosion is likely. Standing shields must be adequately stabilized with weights or fasteners to prevent their being knocked over by an explosion, and should be secured near the top. Eye protection must be worn even when using the shields.

b. Glassware

• Pyrex or borosilicate glassware is recommended for all laboratory glassware except for special experiments, which use ultraviolet or other light sources. The only soft glass provided in the laboratory should be reagent bottles, measuring equipment, stirring rods, and tubing. Any sizable non-spherical glass equipment to be evacuated, such as suction flasks, should be specially designed with heavy walls. Dewar flasks and large vacuum vessels should be taped or otherwise screened or contained in a metal jacket to avoid flying glass from an implosion. Thermos bottles, with thin walls, are not adequate substitutes for Dewar flasks.

• Large bottles and jars containing acids or corrosive chemicals should only be moved in suitable acid bottle carriers, such as those made of rubber.

• Cuts from glass constitute the most common laboratory accident, and potentially one of the most dangerous, as the open cut provides a way for toxic chemicals to enter the bloodstream directly. Do not begin any operation of cutting, bending, or inserting glass into a stopper or hose without understanding the complete procedure and each separate step.

1. When cutting glass tubing, be sure to hold the tubing firmly, and to make a single steady stroke with a sharp file. When breaking the tubing at the cut, cover the tubing with cloth and hold it in both hands, well away from the body. Push out on the tubing but do not deliberately bend the glass with your hands. Wetting the nick will help open the fracture. Be sure that you are well away from others in the laboratory. Be especially careful in cutting a short piece from a long piece of tubing, since the long end may whip around and injure a nearby person.

2. When boring a stopper, be sure the borer is sharp and one size smaller than that which will just slip over the tube to be inserted. In the case of a rubber stopper, lubricate with water, or preferably glycerol or ethylene glycol. Holes should be
bored by slicing through the stopper, twisting with moderate forward pressure, grasping the stopper only with the fingers and keeping the hand away from the back of the stopper. Place the stopper on a wooden board or block to avoid damaging the cutting edge of the borer. Keep the index finger of the drilling hand against the barrel of the borer and close to the stopper in order to stop the borer when it breaks through. Preferably drill only part way through, and then finish by drilling from the opposite side. Discard a stopper if a hole is irregular or does not fit the inserted tube snugly, if the stopper is cracked, or if it leaks.

3. Stoppers should fit so that 1/3 to 1/2 of the stopper is inserted into the joint. Corks should first be softened by rolling and kneading. With hands close together to minimize being cut in case the vessel breaks, gently but firmly twist the stopper in place. Avoid exerting any pressure on inserted glass tubes. When available, ground glassware is preferable. Glass stoppers and joints should be clean, dry, and lightly lubricated. Stuck glass stoppers can be removed using commercially available bottle stopper remover. Students should ask instructors for assistance when glass connections, stoppers, or corks are stuck.

4. Fire polish all glass tubing and rods, including stirring rods. Unpolished glass has a razor-sharp edge which will not only lacerate the skin, but will cut into a stopper or rubber hose, making it difficult to insert the glass properly. After fire polishing or bending glass, allow ample time for it to cool; grasp it gingerly at first, in case it is still hot.

5. To remove a glass tube from a stopper, use a lubricated, dulled cork borer or the tang of a small file, inserted between tube and stopper. Lubricate as separation progresses. Sometimes it may be useful to roll the stopper with a block of wood under enough pressure to flex the rubber. If none of these procedures works, remove the tube by cutting the stopper with a single edged razor blade or an X-Acto® knife. If this is not feasible, discard the stopper and tube.

6. When inserting glass tubing or rods into rubber hoses, fire polish both ends of the glass to be inserted. Lubricate the glass with water, or preferably glycerol or ethylene glycol. Wrap a cloth around the glass and hold it close to the hose (not more than 5 cm). Protect the hand holding the hose with a cloth or glove. Insert the glass into the hose with a slight twisting motion, avoiding too much pressure and torque.

c. Electricity

Electricity becomes a hazard in the laboratory when the current passes through a person or through a flammable or explosive material. Care with electrical connections, particularly with grounding, and not using frayed electrical cords can reduce such dangers.

Equipment in the laboratory must have grounded (three-prong) plugs or be double insulated. Temporary wiring and the use of extension cords should be avoided. All wiring
must meet the National Electric Code specifications. Where wet conditions are likely, ground fault circuit interrupters must be installed. All switches that are not directly and obviously attached to a piece of equipment should be labeled to show the equipment they control; in-line cord switches are discouraged.

If, when you touch a piece of electrical equipment, you feel a shock or "tingle," you should disconnect it and report it for repair immediately. Shorts in circuitry get worse, and delay greatly increases the hazard. If you suspect a piece of equipment to be electrically dangerous, have it checked by a qualified electrician. Never attempt to repair any electrical equipment with the current on. Equipment that is faulty or broken must be unplugged and moved or taped in such a way that it cannot be accidentally plugged in or turned on. The equipment should be clearly labeled as unsafe and not to be used while awaiting repair.

d. Vacuum Operations

Because of the pressures involved, equipment used in vacuum operations must be carefully inspected frequently and regularly. Apparatus must be assembled so as to avoid strain, and heavy assemblies must be supported from below as well as by the flask neck. Vacuum apparatus should always be placed well back from the edge of the bench top or hood sill, where it will not be accidentally struck. Inspect frequently for signs of fatigue or wear.

1. Shielding: Either standing shields or face shields should be used in all vacuum operations, especially when the apparatus contains flasks of 1 liter or larger.
2. Vacuum Desiccators: Vacuum desiccators should be enclosed in a box or approved shielding device (such as "desigard") for protection in case of an implosion. When opening a desiccator that has been under vacuum, make sure that atmospheric pressure has been completely restored. A "frozen" vacuum desiccator lid can be loosened by a single-edge razor blade inserted as a wedge and then tapped with a wooden block to raise the lid.
3. Water Aspirators for Vacuum: Water aspirators for vacuum are used mainly for filtration purposes; use only equipment that has been approved for this purpose. Never apply a vacuum to a flat bottom flask unless the flask is a heavy walled filter flask designed for the purpose. Place a trap and a check valve between the aspirator and the apparatus so that water cannot be sucked back into the system if the water pressure should fall unexpectedly while filtering. These recommendations also apply to rotary evaporation operations where water aspirators are being used for vacuum.
4. Vacuum Pumps: A cold trap should be placed between the apparatus and the pump so that volatiles from a distillation do not get into the pump oil or out into the atmosphere of the laboratory. Exhausts from pumps should be vented properly. All pumps must also have a belt guard to prevent hands or loose clothing from being pulled into the belt pulley.
e. Pressure Operations

As with vacuum operations, the equipment used in high pressure procedures must be regularly and frequently inspected for any signs of wear or fracture. Each pressure vessel should be clearly stamped or labeled with its basic allowable working pressure, the allowable temperature at this pressure, and the material of construction. Always use a pressure relief disk or other suitable device in pressure systems. The relieving pressure and setting data should be printed on a tag attached to installed pressure-relieving devices, and the setting mechanisms should be sealed.

Before any pressure equipment is altered, repaired, stored, or shipped, it should be carefully vented and cleaned. When assembling such apparatus, avoid strain and excessive force. Threads must match correctly. Never use oil or hydrocarbon-based lubricant on apparatus that will contain oxygen. Kel-F oils or greases (polychlorotrifluoroethylene oils or greases) are the proper lubricants for these systems. In assembling copper tubing, avoid sharp bends and allow flexibility. Check for hardening and cracking in the copper; renew if necessary.

All reactions under pressure must be shielded, and prominent signs should be placed to warn others of high-pressure hazard.

f. Heating

1. Open Flame: Wherever possible, use heating mantles, heating tapes, or laboratory hot plates in place of gas (Bunsen) burners. When using a heating mantle, always operate below the maximum allowable voltage for that mantle. It is obvious that open flame must never be used where explosive or flammable chemicals are present, but the presence of such chemicals may be unsuspected or sudden. If a burner must be used, distribute its heat with flame retardant wire gauze, or by moving the burner about underneath the container being heated. Test tubes being heated in this way should be held with a test tube holder at about a 45-degree angle and heated gently along the side, not at the bottom, to minimize superheating which may cause the contents to be ejected. Avoid pointing a test tube toward yourself or any nearby person.

2. Hot Oil Baths: Hot oil used for heating purposes is often overlooked as a hazard, yet it carries serious dangers: (1) spattering caused by water falling into hot oil, (2) smoking caused by decomposition of the oil or of organic materials in the oil, and (3) fire caused by overheated oil bursting into flame. Operating baths should not be left unattended unless a high temperature cut off is installed. Precautions should be taken to contain any spills of hot oil caused by breakage or overturning of the baths. Fiberboard, cardboard, or other combustible components must not be used in heated apparatus. In evaluating a hot oil bath setup, carefully consider the size and location of the bath, the operating temperature and temperature-control device, the type of oil used (silicone oil is suggested for most heating baths), the ventilation available, and the method of cooling the hot oil. A label on the bath
should include the name of the oil and its safe working temperatures. Silicone oil is a safe non-flammable fluid, which can be used in heating baths to 250 °C (about 480°F) without decomposition.

3. Temperature Control: The rates of all reactions increase as the temperature increases. Highly exothermic reactions may become dangerously violent unless provisions are made for cooling, for example, by bringing a cooling bath up around a flask. Virtually all reactions require some temperature control, and thus apparatus should be assembled in such a way that either heating or cooling can be quickly applied or withdrawn. A suitable thermometer should be used in a boiling liquid where a strong exothermic reaction is likely so that there will be warning and time to apply cooling. Boiling stones or boiling sticks should be used in unstirred vessels of boiling liquid (other than test tubes) to prevent superheating and "bumping". Do not reuse boiling stones or sticks. Do not add them or any other solid material to a liquid, which is near its boiling point since this is likely to cause splattering or boil over.

g. Cooling

1. Flowing Water: When cooling with flowing water, beware of differences in water pressure when operations have to be left unattended for long periods, particularly overnight. In such situations, you may need to use an automatic water regulator installed in the line to keep the flow even, as well as a water flow monitor that will shut down all equipment if the flow is interrupted. Wire all rubber or plastic tubing to metal or glass connections to prevent the tubing from detaching, thus avoiding the risk of a flood.

2. Cooling Baths: When ice water is not cool enough as a bath, salt and ice may be used. For even lower temperatures, dry ice may be used with an organic liquid, such as acetone, ethanol, or ethylene glycol. Ethylene glycol, with a flash point 111 °C (230 °F), is the best of the three listed above, considering flammability. When choosing a liquid for use with dry ice, you must consider the viscosity, flammability, volatility, solubility in water, and the possibility of toxic vapors. Few, if any, liquids are free from all of these hazards. Your choice must also be made based on the temperature requirements of your procedure and the limitations of your equipment.

3. Cryogenics: Cryogenic equipment setups involve hazards due to extremely low temperatures, and also hazards associated with the high-pressure gases that are often part of such setups (see the following section on Compressed Gases). Be careful to control ignition sources and to monitor the formation of very high or very low concentrations of oxygen.

Safe management of the hazards associated with extremely low temperatures requires thorough understanding of the unique conditions created. For example,
the extreme cold of liquid nitrogen can make metals and other materials brittle. Uninsulated equipment can condense oxygen from the air to yield dangerously high concentrations of liquid oxygen, which can explosively ignite many combustibles. On the other hand, liquid nitrogen, left open, reduces the oxygen content of air as the oxygen condenses and the nitrogen evaporates. A person working in an inadequately vented area could lose consciousness without warning, and will die without rescue. Good ventilation is essential in all cryogenic operations, along with an understanding of the low-temperature behavior of the substances involved.

Contact of liquefied gases with eyes or skin produces serious burns. Damaged tissue should be flooded with a gentle stream of water, not warmer than body temperature (using an eyewash, for example). The affected area should then be dried very gently (excluding eyes) and protected until medical assistance arrives. To avoid contact with liquefied gases, wear goggles, face shield, and insulated gloves that fit loosely enough to throw off in case of a spill. The body should be completely covered, with no skin exposed. Wear no jewelry, and avoid clothing with cuffs or pockets that could trap and hold a cryogenic liquid close to the skin.

Put objects into a cryogenic liquid slowly, and pour liquids into containers slowly in order to minimize the inevitable boiling and splashing.

For the same reason, dry ice should be added to liquid slowly and in small amounts, to avoid foaming and boil over. Handle dry ice with dry leather or insulated gloves, and never lower your head into a dry ice chest, as the oxygen content may be inadequate and suffocation can result.

Dewar flasks and cold traps should be taped to prevent flying glass in case of breakage. Avoid pouring cold liquid over the edge of a Dewar flask, as it may break and implode.

h. Compressed Gases

Gases are supplied in cylinders under great pressures, some as much as several thousand pounds per square inch. If the valve is broken off at the cylinder neck, the cylinder becomes a potentially deadly rocket, propelled with great momentum and high speed. Gas cylinders have been documented to cause extensive property damage, injury, and death. For this reason, all gas cylinders, full or empty, must always be strapped or chained to a sturdy support to prevent the cylinder from falling and breaking off the valve. All cylinders of compressed gas should be treated as high-energy sources and therefore regarded as potential explosives.

In addition, released gas can rapidly displace the breathing air in a room, causing suffocation. Many gases are toxic or corrosive and can cause injury if inhaled or contacted in even small amounts. Many gases are reactive with other materials or gases.
Oxygen, in greater than normal concentrations, greatly increases the risk of fire and explosion.

Compressed gas cylinders have certain safety features, including special valves, fittings, and caps. For example, many gases have special valves that prevent the inadvertent mixing of incompatible gases. The best protection, though, lies in following the guidelines developed over years of experience with the hazards of compressed gas.

1. Use: Begin with thorough knowledge of the substances and equipment involved. Always know the identity of the gas in a cylinder; if for some reason a cylinder is unlabeled, return it to the vendor; do not guess. Know the properties and potential of the gas to be used, and the procedures for using it. Be careful not to exceed the design pressure of the apparatus. Always wear safety goggles when handling or using compressed gases.

Carefully inspect fittings, regulators, and apparatus for damage before using. Do not use damaged equipment. Use only regulators, gauges, and connections with matching threads and which are designed to be used with the gas and cylinders involved. Never lubricate, modify, force, or tamper with a cylinder valve.

Only those tools approved by the cylinder vendor should be used on cylinder connections. Do not modify or alter cylinders or their attachments. Use cylinders and manifold systems only with their appropriate pressure regulators.

Use cylinders only in well ventilated areas. Corrosive gases should be used only in locations with access to safety showers and eyewash stations. Corrosive, toxic, and flammable gases should be used only in fume hoods designed for use with the particular gas or group of gases. Use flammable gases only after proper bonding and grounding connections have been made.

Do not expose cylinders to temperatures higher than about 50 °C (122°F). Some rupture devices on cylinders will release at about 65 °C (149°F). Some small cylinders, including those not fitted with rupture devices, may explode if exposed to high temperatures.

Open cylinder valves slowly. Rapid release of a compressed gas will cause an unsecured gas line to whip dangerously and also may build up a static charge, which could ignite a combustible gas. Never direct high-pressure gases at a person, or use compressed gas or compressed air to blow away dust or dirt; resultant-flying particles can be dangerous. Close cylinder and bench valves when the cylinder is not in use; the pressure regulator is not sufficiently strong to assure safe closure.

Do not extinguish a flame involving a highly combustible gas until the source of the gas has been shut off. Otherwise, it can re-ignite, causing an explosion.
Always use a trap to prevent back siphonage of liquid chemicals, and a check valve to prevent back flow of gases into the cylinder. When gas is passed from a cylinder into a vessel containing a liquid, contamination of the cylinder gas with other chemicals is a real possibility. Such contamination makes the gas unsuitable for future use and may result in explosion with resultant injury, damage, or even death. Use of a safety trap to contain liquid and a check valve to prevent back flow of gas will eliminate this possibility. These are installed immediately after the pressure regulator, and before the vessel containing the liquid. The safety trap should have a volume of about one and one half times the total liquid volume in the system.

Never bleed a cylinder completely empty. Always leave a residual pressure (about 25 psig) to keep contaminants out. Promptly remove the regulators from empty cylinders, being sure to bleed the gas from the regulator first. Replace the protective caps at once. Mark the cylinder "EMPTY" in removable printing. Never refill a cylinder.

2. Used Cylinders: Handle used cylinders, as you would full cylinders. Keep them strapped or chained at all times. Store the used cylinders separately from full cylinders so there is no chance of confusing them. Mark all used cylinders "MT" or "EMPTY" in removable writing (such as chalk), or tear the attached tag to indicate empty.

3. Leaking Cylinders: Cylinders that are leaking or otherwise damaged are an immediate danger. If they can be transported safely, they should be taken to an open place separate from all other cylinders to await vendor pickup. Be very careful, however, in moving any cylinder that is leaking. Avoid inhaling gases while carrying or loading such a cylinder, and try to avoid spreading gases in corridors and stairwells.

4. Transportation: Do not move a cylinder unless the cap is in place. Generally, cylinders must be transported on a hand truck to which they can be strapped or chained. Cylinders may be rolled on edge only for very short distances. Use an elevator, if possible, to move cylinders to upper or lower floors. If stairs must be used, move cylinders on a hand truck, which is equipped for stairs. When handling cylinders, always consider them to be full. Do not allow them to strike each other, or to be dropped, cut, scraped, or otherwise damaged.

5. Storage: Keep only those cylinders currently in use in the laboratory. Cylinders, in use or in storage, must be secured to a sturdy object, such as a wall, bench, or stand, using a strong strap or chain.

Store full and used (empty) cylinders only in isolated areas that are ventilated and protected from direct sunlight, rain, snow, damp ground, heat, fire, and electrical
contact. Temperatures in storage should be maintained between -20°F and 120°F unless the manufacturer indicates otherwise. Storage can be indoors or outdoors under shelter. Never store or use cylinders in corridors, stairwells, or in high traffic areas.

Cylinders of the same gas should be stored together. Oxidizers should be separated from flammable and combustibles by 20 feet of space, or by a one-hour rated firewall and five feet of space. In addition, store used (empty) and full cylinders separately and clearly indicate whether they are full or empty.

Keep caps on all cylinders except when connected for use, and keep cylinders upright, whether in use or storage. Consult the University Health/Safety Manual for additional information on storage of gas cylinders.

6. Handling Chemicals

Following are guidelines and principles for safety in the direct manipulation of chemicals -- holding, pouring, mixing, transporting, storing, and so on. The list of situations covered is far from exhaustive; emphasis is instead on the most common ways in which chemicals are handled in the laboratory. Safety precautions for use of laboratory equipment can be found in Safety Systems, Section 3, and General Laboratory Equipment Setup, Section 5.

1. Personal Contact: The primary safety goal in handling chemicals is to prevent the chemicals from entering your body. It cannot be said too often that protective gear must be worn at all times, and precautions for avoiding personal contact with the chemicals must always be in mind.

1. Avoid direct contact of any chemical to the hands, face, and clothing. Be aware of what you touch be careful not to touch gloves to your face, for example. After any skin contact, and always before you leave the laboratory, wash face, hands, and arms. Leave all equipment in the laboratory.
2. Never taste chemicals or sniff from chemical containers.
3. Never eat, drink, smoke, or apply cosmetics in the laboratory.
4. Dispense and handle hazardous materials only in areas where there is adequate ventilation. If you believe that significant ingestion, inhalation, injection, or skin contact has occurred, call the emergency number on your campus and follow the Emergency Procedures given earlier in this Guide.

b. Handling Containers

- Clearly label all chemical containers. The Laboratory Standard requires that labels on incoming chemical containers not be removed or defaced. Do not use any substance from an unlabeled or improperly labeled container. Printed labels that have been partly obliterated or scratched over, or crudely labeled by hand, should
be relabeled properly. Unlabeled chemical containers are a violation of the NJ Right-to-Know Act and should be disposed of promptly and properly.

- Carefully read the label before removing a chemical from its container. Read it again as you promptly recap the container and return it to its proper place. Names of distinctly different substances are sometimes nearly alike; mistakes are easy to make and can be disastrous.

- When picking up a bottle, first check the label for discoloration, and if it is clean, grasp it by the label. Spilled chemical will show up on the label better than on the glass; holding the container by the label will protect you from prior spills, and protect the label from present ones. After use, wipe the bottle clean.

- If a stopper or lid is stuck, use extreme caution in opening the bottle. Friction caused by removing tops may cause explosions with some substances (such as hydroperoxides formed from ethers or picric acid contaminated with heavy metals).

- Support beakers by holding them around the side with one hand. If the beaker is 500 ml or larger, support it from the bottom with the other hand; also, consider using a heavy-duty beaker slowly on the clean surface of the bench. If the beaker is hot, use beaker forceps or tongs, and place the beaker on a heat-resistant pad.

- Grasp flasks by the center neck, never by a side arm. If the flask is round bottomed, it should rest on a proper sized cork ring when it is not clamped as part of a reaction or distillation assembly. Large flasks (greater than 1 liter) must be supported at the base during use.

- Never look down the opening of a vessel, in case of unforeseen volatility or reaction.

c. Pouring

- Do not pour toward yourself when adding liquids or powders. Stoppers too small to stand upside down on the bench should be held at the base and outward between two fingers of the pouring hand.

- Use a funnel if the opening being poured into is small. If a solid material will not pour out, be careful when inserting anything into the bottle to assist removal. Students should seek advice from instructors before proceeding.

- Always add a reagent slowly; do not "dump" it in. Observe what takes place when the first small amount is added and wait a few moments before adding more.
• When combining solutions, always pour the more concentrated solution into the less concentrated solution or water. Stir to avoid violent reactions and splattering. The more concentrated solution is usually heavier and any heat evolved will be better distributed. This procedure is particularly applicable in preparing dilute acid solutions. Be sure to wear goggles and use the hood when diluting solutions.

• Make sure the stopcock is closed and has been freshly lubricated before pouring a liquid into an addition or separatory funnel. Use a stirring rod to direct the flow of the liquid being poured. Keep a beaker under the funnel in the event the stopcock opens unexpectedly.

• Wear an apron and gloves, in addition to goggles, whenever pouring bromine, hydrofluoric acid, or other very corrosive chemicals, to avoid painful chemical burns.

d. Pipetting

• NEVER pipette by mouth. Use an aspirator bulb, or another mechanical Pipetting device. Constantly watch the tip of the pipette and do not allow it to draw air.

e. Storage

• Keep as few chemicals as possible on the bench top. All chemicals not immediately needed should be properly stored.

• Do not store incompatible materials together or in close proximity. Use safety cans with flame arrestors for quantities of flammable solvent larger than 4 liters, and be sure to leave a space at the top of a closed container for expansion of liquid and vapors. If chemical purity requirements preclude metal containers, glass containers may be used.

• Containers no larger than one pint (500 ml) should be used to store NFPA Class IA liquids, including, but not limited to: acetaldehyde, diethyl ether, ethyl chloride, methyl formate, low boiling petroleum ether, pentane and propylene oxide.

• Store large containers of reagents on low shelves, preferably in a tray adequate to contain spills or leakage.

• Dispense corrosive liquids in small containers, no larger than 500 ml, preferably in chemically resistant-coated containers.

• Never take more than is immediately needed.

1. Refrigerators: Ordinary household refrigerators constitute a hazard when used for storage of flammable or unstable chemicals. These units produce conditions, which can lead to explosion. Domestic (household-type) refrigerators may not be
used for flammable chemical storage unless suitably modified to eliminate all possible contact between vapors and electric spark or arcing. Explosion proof refrigerators are preferred. When searching for an item in a refrigerator used for chemical storage, be careful not to inhale vapors that may have built up in the cabinet. All chemicals, including those stored in refrigerators, should be sealed and labeled with the name of the material, the date it was placed in storage, and the name of the person storing it there. Refrigerators should be cleaned on a regular schedule, and old chemicals should be properly discarded. Food must NEVER be stored in any refrigerator used to store chemicals.

2. Storage of Flammable Chemicals: Keep flammables in use in the laboratory in safety cans specifically designed for that purpose at all times. In the event that such cans are not available, glass bottles may be used with the proper precaution. The containers used by the manufacturer must meet certain standards for shipping. These same containers are not always suitable for routine use. The shipping container must be sealable and of suitable shape and strength for transport. This transport is usually within another container - carton, crate, etc. Do not use screw caps to close bottles containing volatiles (such as diethyl ether, low-boiling petroleum ether, methylene chloride, and pentane) as pressure build up can cause failure in a bottle which is not new and which may have internal strains, which come from normal use. In such situations, use corks or neoprene stoppers. Use a one-holed cork fitted with a drying tube if moisture must be excluded. To relieve pressure build up, use a cork fitted with a check valve. Keep all flammables away from direct sunlight and sources of heat.

Storage of Flammable Liquids

Flammable storage limits fro Laboratories are given in the following table.

<table>
<thead>
<tr>
<th>Class</th>
<th>Total Quantity Outside of Safety Cabinet/Safety Cans</th>
<th>Total Quantity Including Safety Cabinets/Safety Cans</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Research Labs</td>
<td>Instructional or Teaching Labs Research Labs</td>
</tr>
<tr>
<td>I</td>
<td>20 gal</td>
<td>40 gal</td>
</tr>
<tr>
<td>I, II, III Tot.</td>
<td>40 gal</td>
<td>80 gal</td>
</tr>
</tbody>
</table>

NOTE 1: Class I Liquids with flash point <100°F
        Class II Liquids with flash point >100°F and <140°F
        Class IIIA Liquids with flash point >140°F and <200°F
        Class IIIB Liquids with flash point >200°F

NOTE 2: Based on labs >200 ft². For labs <200 ft², use half the quantities given above. Larger quantities may be allowed with H&ES approval.
The maximum container size is given in the table below.

<table>
<thead>
<tr>
<th>Container Type</th>
<th>Flammable Liquids</th>
<th>Combustible Liquids</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IA</td>
<td>IB</td>
</tr>
<tr>
<td>Glass</td>
<td>1 pt</td>
<td>1 qt</td>
</tr>
<tr>
<td>Metal (other than DOT Drums or approved plastic)</td>
<td>1 gal</td>
<td>5 gal</td>
</tr>
<tr>
<td>Safety Cans</td>
<td>2 gal</td>
<td>5 gal</td>
</tr>
<tr>
<td>Metal Drums</td>
<td>n/a</td>
<td>5 gal</td>
</tr>
</tbody>
</table>

In instructional laboratory work areas, no container for Class I or Class II liquids shall exceed a capacity of 1 gallon, except that safety cans maybe of 2-gallon capacity.

Exceptions: Glass containers as large as 1 gal. (3.785 L) may be used if needed and if the required purity would be adversely affected by storage in a metal or an approved plastic container, or if the liquid would cause excessive corrosion or degradation of a metal or approved plastic container. Drums of not more than 60 gallons (227 L) capacity are permitted in a separate area inside the building if the inside area meets the requirements of NFPA 30, Flammable and Combustible Liquids Code.

Storage Cabinets

Only (1) storage cabinet may be located in a laboratory. Cabinets shall be labeled in conspicuous lettering, "FLAMMABLE--KEEP FIRE AWAY".

Flammable storage cabinets are designed to protect the contents from external fires. For this reason, the door(s) must be kept closed except when removing or replacing the cabinet's contents. These cabinets do not necessarily protect people from solvent vapors during normal use of the cabinet. There are vent kits available for flammable storage cabinets, however these cabinets are fire tested with the vent holes closed.

The NFPA Flammable & Combustible Liquids Code Handbook recommends against venting these cabinets as this practice may defeat the designed purpose. Where particularly noxious or toxic chemicals are being used, cabinets may be vented, with prior H&ES approval.

The interior of the cabinet is capable of withstanding the effects of vapors from solvents, but not of other materials such as corrosives. As these materials are incompatible with most flammables, only flammable storage cabinets are designed with a lip to contain a two-inch depth of a spilled liquid.
3. Storage of Acids

Acid storage cabinets are designed to withstand corrosion, contain spills, keep like materials together, and protect the contents from physical damage. If ordinary cabinets used for acid storage show signs of deterioration, consider relocating the acids to a specially designed cabinet. As acids are incompatible with alkalis, flammables, and other classes of chemicals, only acids may be stored in these cabinets.

Dichromate cleaning solution is an unsuspected source of pressure builds up causing explosions in the laboratory. Although storage of this common cleaning solution in the glass-shipping container is a common laboratory practice, it has led to several serious incidents. Occasionally, the dichromate solution will contain sufficient amount of organic material from previous glass cleanings to evolve a large enough quantity of carbon dioxide to explosively rupture a screw topped glass bottle. To prevent a possible explosion, and subsequent potential injury, a stopper is recommended. See the recommendation given above for storage of flammables.

f. Chemical Inventories

The NJ Right-to-Know law requires that all laboratories that have not received research and development exemptions prepare, maintain, and update a list of all chemicals present in the laboratory. The list should include, for each container, the chemical name(s) of the contents, the CAS Number (Chemical Abstracts Service Number), the quantity and the container type. This list is also useful for acquiring the MSDSs and HSFSs needed and to carry out work both safely and in compliance with the PEOSHA standards. For example, identification of a substance as a Particularly Hazardous Substance and a carcinogen and taking the appropriate precaution in its use, would not be possible without compiling this list. For more information, see Section G, "Provisions for Employee Protection when working with Particularly Hazardous Substances." In the case of shared spaces, information on chemicals present should be provided by a user to another user, upon request.

g. Transportation

Bottles of one gallon or more should be transported in bottle slings or bottle carriers that could completely contain the substance in the event of breakage. This is particularly important in transporting corrosive, toxic, or flammable liquids. If you need to move several such containers at once within a building, use bottle carriers and a properly designed cart. All containers should be tightly capped during transport.

Smaller bottles can be carried by their handles, or by grasping the label and placing the little finger under the base of the bottle. Never try to balance a bottle by holding it solely from underneath. Approach all doors with caution.

If you do drop and break a container, you have the responsibility of calling the emergency number to report the spill and to request assistance in cleanup.
7. Chemical Hazards

This section contains descriptions of the general categories of chemical hazard, and the principles of safety associated with each. This section purposefully does not contain advice for handling specific chemicals. Safe work in a chemical laboratory requires very detailed knowledge of the nature, potential, and compatibility's of each substance used; cursory or selective description in this Guide would be misleading and, as a result, unsafe. Anyone planning an experiment or procedure should acquire and review a Material Safety Data Sheet (MSDS) or Hazardous Substance Fact Sheet (HSFS) for each substance, and also for all likely products and byproducts.

The following categories provide a structure for thinking about -- and planning protection against -- common chemical hazards. In actual practice, such hazards do not group themselves in neat categories, but usually occur in combination and/or sequence. The categories and concepts are provided as an aid to awareness, and as encouragement for consistent safe planning and practice.

a. Flammability: Flammability is one of the most common chemical hazards. The exact degree of hazard, however, depends on the specific substance and the conditions you expect to use it in. To handle a flammable substance safely, you must know its flammability characteristics: flash point, upper and lower limits of flammability, and ignition requirements. This information appears on each MSDS or HSFS.

1. Flash Point: For a liquid, the flash point is the lowest temperature at which the liquid gives off enough vapor to form an ignitable mixture with air and produce a flame when a source of ignition is present. Many common laboratory solvents and chemicals have flash points that are lower than room temperature.

2. Ignition Temperature: The ignition (or auto ignition) temperature of a substance -- solid, liquid, or gas -- is the minimum temperature required to initiate self-sustained combustion. Some ignition temperatures can be quite low (for example, carbon disulfide at 90°C (194°F).

3. Auto ignition: Auto ignition or spontaneous combustion occurs when a substance reaches its ignition temperature without the application of external heat. This characteristic is particularly important to keep in mind in the storage and disposal of chemicals.

4. Limits of Flammability: Each flammable gas and liquid (as a vapor) has a limited range of flammable concentration in mixtures with air. The lower flammable limit (or lower explosive limit) is the minimum concentration below which a flame is not propagated when an ignition source is present -- such a mixture would be too lean to burn. The upper flammable limit (or upper
explosive limit) is the maximum concentration of vapor in air above, which a flame is not propagated — such a mixture is too rich. The flammable range (or explosive range) lies in between the two limits.

Listed measurements of all these characteristics — flash points, ignition temperatures, limits of flammability — are derived through tests conducted under uniform and standard conditions that may be very different from actual practice. For example, concentrations of vapor in air in a laboratory are rarely uniform, and point concentrations can be quite high. It is good practice to set maximum allowable concentrations at 20 percent of the listed lower limit of flammability within closed systems. (It is important to note that, generally, this 20 percent limitation is still well above the maximum concentration considered to be safe for health considerations.)

5. Precautions with Flammable Liquids: Flammable liquids do not burn; their vapors do. For a fire to occur, there must be 1) a concentration of vapor between the lower and upper flammable limits, 2) an oxidizing atmosphere, usually air, and 3) a source of ignition. As it is unlikely that air can be excluded, and unrealistic (given the constant possibility of a spill) to assume that the vapor concentration can be controlled, the primary safety principle for dealing with flammable liquids is strict control of ignition sources.

Ignition sources include electrical equipment, open flames, static electricity, and, in some cases, hot surfaces. Others working in the laboratory should be informed of the presence of flammable substances so that ignition sources can be eliminated. Obviously, it is very important to know which of those sources is capable of igniting a substance you are using.

Remember most flammable vapors are heavier than air, and will spread out horizontally for considerable distances until an ignition source is contacted.

If possible, flammable liquids should be handled only in areas free of ignition sources. Heating should be limited to water and oil baths, heating mantles, and heating tapes.

Static-generated sparks can be sudden ignition sources. When transferring flammable liquids in metal equipment, take care that metal lines and vessels are bonded together and grounded to a common ground.

Ventilation is very important. A fume hood should be used when flammable liquids are allowed to stand in open containers or are handled in any way.

6. Precautions with Flammable Gases: Leakage of compressed or liquefied gases can quickly produce a flammable or explosive atmosphere in the laboratory. This is obviously true where the gases themselves are flammable and under
high pressure, but may also be true in the use of non-pressurized liquefied gases. For example, even relatively safe liquefied gases such as liquid air or liquid nitrogen, if kept in open vessels for too long, will generate concentrations of liquid oxygen, which can contribute to an explosion. Proper care with compressed gas cylinders and cryogenic setups is essential (see General Laboratory Equipment Setup, Section 5).

b. Explosiveness

Ignition of flammable vapors or gases can occur with such speed that an explosion results. There are other substances that are explosive in themselves -- in response to heat, mechanical shock, or contact with a catalyst. With some substances, very tiny amounts of impurity are sufficient to begin a reaction that quickly becomes explosive.

1. Precautions: Acquire a Material Data Safety Sheet (MSDS) or Hazardous Substance Fact Sheet (HSFS) for each chemical you are using. It is crucial that you know its potential including its compatibilities with other substances.

   Be alert to any unusual change in the appearance of a reaction mixture. Rapid unexpected temperature rise or fuming are signals for emergency measures such as removing the heat source, quickly applying a cooling bath, or leaving the room.

   Explosive compounds should be protected from the conditions to which they are sensitive (mechanical shock, heat, light, etc.). Check your MSDS/HSFS to see what those conditions are. Such substances should be brought to the laboratory only as required, and only in the smallest quantities absolutely necessary. Reactions involving or producing explosives should be designed on as small a scale as possible, and should be done behind a suitable barricade.

   Special care should be taken that equipment is maintained (for example, that oil is routinely changed in vacuum pumps) and that heating methods used do not cause, or increase the potential for ignition.

   Other laboratory workers must be notified when an explosive hazard is present, through direct announcement and conspicuous warning signs. Highly exothermic or potentially explosive reactions must never be left unattended.

2. Personal Protection: In addition to protection otherwise required in the laboratory, wear face shields, and heavy gloves at all times when handling known explosive substances. Laboratory coats of a flame-resistant material or treatment may help reduce minor injuries from flying glass or flash. When serious explosive hazard is anticipated, shields and barricades will be necessary, along with devices for manipulating equipment at a safer distance long-handled
tongs, stopcock turners, mechanical arms, etc.). Some experiments at NJIT have required specially designed rooms be constructed for the safety of the researchers. Contact H&ES if you plan to run an experiment with a significant explosion potential.

c. Toxicity

Toxicity is the potential of a substance to cause injury by direct chemical action with the body tissues. Whether the effect is acute or chronic, the only way to avoid such injury is to prevent or greatly minimize contact between toxic chemicals and body tissues.

1. Measurement: Dose, or amount of chemical, you are exposed to determines the body's response. In the workplace, there are certain guidelines or regulations, which limit your exposure to hazardous substances. These guidelines, which are set by various regulatory or professional organizations, are referred to as "workplace exposure limits".

A workplace exposure limit is the airborne concentration of a material below which most persons can be exposed for long periods of time without adverse effect. These limits are based on an 8-hour time-weighted-average (TWA) over a working lifetime. Permissible Exposure Limits (PEL) are those set by PEOSHA. Workplace exposure limits may be expressed as Threshold Limit Values (TLV) or Workplace Environmental Exposure Limits (WEEL).

Time-Weighted Average (TWA) is the average concentration of a substance integrated over a period of time (e.g. a normal 8-hour workday).

A Short-Term Exposure Limit (STEL) is the maximum concentration limit for a continuous 15-minute exposure period, provided that the daily TWA is not exceeded. Because workplace exposure limits are generally expressed as average concentrations, excursions above these values are permitted. The exposure levels during such excursions must be below the STEL. However, there are certain levels, which must never be exceeded even instantaneously. These are known as the ceiling levels for a TLV, or TLV-C.

All these measurements, though often based on data from animal research, refer to the exposure and resistance of a healthy adult. These levels do not necessarily apply to pregnant women, their unborn fetuses, or adults who are ill or under special stress. In such situations the individual and his/her supervisor or instructor must carefully consider all pertinent information. H&ES can be consulted in such matters.

2. Acute Toxicity: Acute toxic effects are usually produced by a single large dose; generally well above the TLV, received in a short period of time. The
effects are immediate, and may be partially or totally reversible. Acute toxic effects include:

- **Simple asphyxiation**: the body does not receive enough oxygen (for example, when gaseous nitrogen has displaced the air in a room).
- **Chemical asphyxiation**: the body is prevented from using oxygen (for example, when carbon monoxide instead of oxygen is absorbed in the blood).
- **Anesthetic**: causes dizziness, drowsiness, headaches, and coma (for example, by the vapors of many organic solvents).
- **Neurotoxin**: the brain's control of the nervous system is slowed down or changed (for example, by concentrations of lead and mercury).
- **Corrosive**: body tissue is directly damaged by reaction with chemicals (for example, by strong acids or bases -- see separate subtopic below).
- **Allergic**: repeated exposure to a chemical produces sensitizing, until there is an allergic reaction at the contact site (usually skin).

3. Chronic Toxicity: Chronic toxicity refers to adverse or injurious effects that can result from prolonged exposure to a substance, sometimes at dose levels just above the TLV. Damage may not appear for many years -- perhaps generations -- and is often irreversible. As a result, this class of hazard is both very difficult and very important to guard against. The body can filter and process levels of toxicity that might seem surprisingly high, but over extended periods of time, even with the dose very low, the filtering process may fail, and damage may occur. Types of chronic toxic effects include:

- **Carcinogenicity**: produces cancer (for example, asbestos and vinyl chloride are known to produce cancer in humans).
- **Mutagenicity**: alters cell genes; subsequent generations show genetic damage.
- **Teratogenicity**: harms developing fetus.
- **Reproductive toxicity**: interferes with the reproductive system in men or women.
- **Specific organ toxicity**: damages specific organs (for example, carbon tetrachloride can cause liver damage).

1. Precautions: The precautions to take against contact with toxic substances are repeated many times throughout this Guide. With chemicals of low acute toxicity, it may be tempting to be less rigorous; yet it is precisely those chemicals, which most require continual caution -- an unvarying habit of safety.

You must protect your body against all forms of chemical contact: absorption, inhalation, ingestion, and injection. Never eat, drink or smoke in the laboratory; wear the appropriate protective gear, and always remove it before you leave the laboratory. Make sure you carefully wash your hands before leaving the laboratory.

Remember that the chemicals you bring home on your clothes will have a more powerful effect on growing children and elderly people than on most adults.
In order to know what level of personal protection will be adequate, keep up to date on recent tests for substances you are using. MSDSs are updated regularly, and you should consult the most recent data each time you begin a new procedure. The best precaution is to treat all chemicals as toxic.

d. Corrosives

Corrosiveness is a form of acute toxicity sufficiently common and hazardous to merit separate discussion. Corrosive chemicals include strong acids, strong bases, oxidizing agents, and dehydrating agents. When they come in contact with skin, eyes, or, through inhalation, the surface tissues of the respiratory tract, they react with the tissues they touch and cause local injury.

1. Liquid Corrosives: A liquid corrosive will act on the skin rapidly or slowly depending on concentration and length of contact. These chemicals react directly with the skin: dissolving or abstracting from it some essential components; denaturing the proteins of the skin; or disrupting the skin cells. Mineral acids, organic acids, and bases are among the typical liquid corrosives.

When handling liquid corrosives, contact with them must be scrupulously avoided. Wear goggles, rubber or suitable synthetic gloves, and a face shield. A rubber or synthetic apron and rubber boots may also be necessary. Since many liquid corrosives also release irritating vapors, procedures using these materials should be performed in a fume hood.

2. Solid Corrosives: Solid corrosives interact with the skin or other surfaces when dissolved by the moisture there. Damage then occurs both from the corrosive action and from the heat of solution. Because they are solid, these chemicals are relatively easy to remove; but because they may not react immediately and may not be painful at first (as with the caustic alkalis), they may cause much damage before being detected.

Solid corrosives are most commonly dangerous in a finely divided state. Dust control and good exhaust ventilation are essential, as well as goggles, gloves, and other protective clothing. In case of chemical contact, much care must be taken during the emergency shower irrigation to remove all particles of solid matter that might be lodged in the skin or clothes.

3. Gaseous Corrosives: Gaseous corrosives pose the most serious health hazard of all corrosives because of possible damage to the lungs, including spasm, edema, pneumonia, and even death. Different corrosive gases affect different parts of the lung (for example, ammonia affects the upper respiratory tract, while phosgene affects the lung, causing pulmonary edema), but all are to be avoided.
It is thus crucial that corrosive gases not be inhaled. Careful design and the use of fume hoods are essential. Skin and eyes must also be protected, as gases contact all exposed parts of the body.

e. Impurities and Combinations

MSDSs contain information on pure chemicals, known mixtures, and proprietary materials; unfortunately, there are no such sheets for other materials found in the laboratory, including solutions, mixtures of unknown or uncertain composition, and byproducts of reactions, all common in the laboratory. Impurities, synergistic effects, formation of unexpected products and byproducts, insufficiently clean equipment, and the combination of vapors from your experiment with that of your neighbor's can all produce sudden and unanticipated hazards.

There is no absolute protection against all contingencies, but it helps to wear protective gear, to clean equipment scrupulously, to be aware of experiments in progress in nearby areas, and to be completely familiar with emergency procedures.

8. Cleanup And Waste Disposal

a. Cleanup

Cleaning up should be a continual process, performed during as well as after an experimental procedure. Cleaning should include yourself and your clothing, laboratory surfaces, equipment, and containers. Wash hands frequently while working in the laboratory; when you leave, remove protective gear and inspect clothing.

Care with gear and clothing will prevent taking chemicals home with you; care with equipment and containers will help avoid future contamination and surprise mixtures. Such care requires planning as well as good housekeeping. Cleanup and disposal methods should be part of your written procedures.

When washing glassware, work with a few items at a time, and allow them to drain where they will not fall over. If anything falls, let it fall rather than risk severe cuts by grabbing it as it breaks. If glass has broken into a sink containing water, drain the water and then use gloves when picking out broken pieces.

Clean vessels or equipment with appropriate materials (water, soap, acid, etc.). Do not proceed unless you are sure which materials to use; check Material Data Safety Sheets (MSDSs), Hazardous Substance Fact Sheets (HSFSs), or other references for advice on proper cleaning materials to use with the specific substance to be cleaned up. Follow directions carefully. If you have any questions, call H&ES.
b. Waste Disposal

The university has programs for the management of waste generated in University laboratories. Details of the programs are given in the following Appendices:

Appendix 5  Policy for the Disposal of Laboratory Glass
Appendix 6  Policy for the Disposal of Chemicals
Appendix 7  Policy for the Disposal of Regulated Medical Waste
B. CRITERIA TO DETERMINE AND IMPLEMENT CONTROL MEASURES

1. Determination

Whenever possible, MSDSs or HSFSs for chemicals used in the laboratory will be reviewed prior to the use of a chemical. These data, along with information on the conditions under which the chemical is to be used, will generally be used to determine the degree of protection required. In certain circumstances, H&ES will conduct exposure monitoring to determine adequacy of controls and to determine if additional control measures are necessary. The following criteria will be used to determine and implement control measures:

a. **Occupational exposure limits**: usually an OSHA Action Level (AL) or Permissible Exposure Limit (PEL), an ACGIH Threshold Limit Valve (TLV), or other equivalent standard -- Generally, substances with lower exposure limits require higher levels of protection.

b. **Vapor pressure**: Generally, substances with higher vapor pressures require higher levels of protection.

c. **Exposure potential**: This will be determined by reviewing experimental procedures. Exposure potential is generally increased with increased temperature or pressure, when working with open rather than closed systems, during transfer of materials, during the use of hazardous substances with live animals, etc. Exposure can occur via inhalation, skin contact (with liquid, solid or vapor) or through accidental ingestion. Generally, greater exposure potential requires higher levels of protection.

d. **Exposure monitoring results**: H&ES can use results of personal or area exposure monitoring to make judgments on appropriate control strategies.

2. Implementation

Once the required degree of control is determined, control measures will be selected from one of the following categories:

a. **Engineering Controls**: Engineering controls reduce an exposure at its source. Engineering controls are the method of choice for reducing exposures and will be used whenever possible/practicable. Examples of some engineering controls include:
   1. Substitution of hazardous materials or operations with those which are less hazardous
   2. Use of Laboratory fume hoods
   3. Use of glove boxes or other enclosures
4. Use of local exhaust ventilation (e.g. "elephant trunks", slotted exhaust hoods, and canopy hoods).

b. Administrative Controls: Administrative controls are work practices, which are designed to control exposures. Administrative controls will be used in conjunction with engineering controls or when engineering controls are impractical or infeasible. Examples of administrative controls include:
1. Limiting time of exposure to maintain levels below acceptable exposure limits
2. Utilizing good housekeeping procedures to reduce exposures.

c. Personal Protective Equipment: Personal protective equipment does not reduce the source of exposure, but rather protects the individual. Personal protective equipment will be used in addition to engineering controls, while engineering controls are being installed or when engineering controls are impractical or infeasible. Some examples of personal protective equipment include:
1. Respirators -- This includes dust masks, as well as other types of respiratory protective equipment). Because all respirator users must participate in the university respiratory protection program, you must call H&ES if you think you have a need for respiratory protection.
2. Gloves, aprons, boots, and other skin protection
3. Goggles, face shields.
C. DOCUMENTATION THAT FUME HOODS AND OTHER PROTECTIVE EQUIPMENT ARE FUNCTIONING PROPERLY

1. Fume Hoods

All renovated/retrofitted or newly installed fume hoods will be equipped with a flow-indicating device. In the absence of such a device, other methods can be used to determine if a fume hood is functioning (e.g. checking the face velocity with small handheld velocity meter, or by hanging a small piece of tissue, or a "tell-tail" from the sash).

H&ES will annually survey all laboratory fume hoods to determine if they are functioning in accordance with University requirements. H&ES will post a copy of the survey results on the fume hood and will maintain a copy of the results on file. The Department Chair will also be informed in writing of the results of the survey. Any fume hoods found not to be operating in accordance with these requirements DUE TO THE USER'S ACTIONS (e.g. hood cluttered) will be referred to the user for correction. All other hood malfunctions will be reported to Campus Facilities Operations and Maintenance for repair. Under certain circumstances, fume hoods will be placed out of order by H&ES until such repairs can be made.

2. Safety Showers and Eyewashes

All safety shower and eyewash units will be inspected annually by the Physical Plant Department. Safety shower and eyewash units found not to be operating in accordance with University requirements will be repaired immediately. If repairs cannot be made immediately, they will be placed out of order until such repairs are completed.

All inspected units will be tagged with the date of inspection and the initials of the person completing the inspection.

3. Biological Safety Cabinets

All biological safety cabinets at NJIT are certified annually or whenever they are relocated. Certification is performed by an outside vendor under contract.

To certify new or relocated cabinets, a request must be made through H&ES. H&ES notifies the certification contractor of the location of the unit and schedules the certification.

The cost of the initial certification of new or relocated units is the responsibility of the principal investigator.
D. EMPLOYEE INFORMATION AND TRAINING

The intent of the Information and Training Program is to inform workers of the physical agents and hazardous chemicals in their laboratory, and the nature of the risks associated with handling these materials. Before working with any of these hazardous materials, lab workers will be informed of the conditions under which the materials may be harmful or may cause injury. They will be trained in the proper control methods (engineering, personal protective equipment, etc.) and appropriate procedures necessary to control occupational exposure to hazards in the laboratory. This training is designed to satisfy the requirements of the Public Employees OSHA Occupational Exposure to Hazardous Chemicals in the Laboratories Rule (the Laboratory Standard) and the NJ Worker and Community Right-To-Know (NJ RTK) Act.

The information and training will be provided to University laboratory employees in **two separate training sessions.** First, a general orientation session will be provided, scheduled, and documented by H&ES. The session covers the topics outlined below, under "General Orientation (Classroom Training)". Second, a "hands-on" training session specific to the employee's work area must be scheduled by the employee's Department and given by their lab supervisor or Chemical Hygiene Officer. This session must cover the items listed below, under "Laboratory Training (Hands On/Specific to Work Area)". H&ES will provide blank attendance forms to document this "hands-on" training session. However, a copy of the completed Department attendance form must be sent to H&ES for compliance documentation.

**1. General Orientation (Lecture) - to be provided by H&ES**

a. **Regulatory Review** - the contents of the Laboratory Standard and the NJ RTK Act will be reviewed, and a copy will be made available in the CHP.

b. **CHP** - The contents of the Chemical Hygiene Plan will be reviewed.

c. **Physical and Health Hazards** - the physical and health hazards of chemical exposure will be reviewed, including, but not limited to: biohazards, carcinogens, compressed gases, corrosives, cryogenic materials, embryotoxins, explosives, flammables, mutagens, oxidizers, poisons, radioactive materials, reactive materials, sensitizers, and teratogens.

d. **Methods of Determining Exposure** - the following methods of determining exposure will be reviewed:
   1. Exposure monitoring
   2. Evaluation of work practices
   3. Use of senses: sight with emphasis on sense of smell and focusing on the odor threshold of materials with poor warning properties.

e. **Permissible Exposure Limits (PELs)** - PELs and other occupational exposure limits will be reviewed. Also, a copy of OSHA Air Contaminants Standards, 29 CFR 1910.1000 is included in the CHP in Appendix 8. If a material is considered hazardous but has no PEL, H&ES will help establish controls for working with the material safely.
Central Files - Employees will be informed that the University maintains, for hazardous materials in the workplace, Material Safety Data Sheets (MSDSs) and Hazardous Substance Fact Sheets (HSFSs) in the university Health and Environmental Safety (H&ES) Department and Public Safety Dept. Employees will be informed of the location and availability of these hazard information resources. Additional reference materials, available in individual departments, on the hazards, safe handling, and storage of hazardous materials will also be discussed.

Chemical Exposure Prevention - the following exposure prevention mechanisms will be reviewed:

1. Engineering Controls: Substitution - Substitute less hazardous materials for more hazardous material, whenever possible. Isolation/Enclosure - Enclose the lab experiment or procedure; (e.g. utilize glove box). Ventilation - Remove airborne toxic materials from workers breathing zone through use of local exhaust ventilation (e.g. fume hoods).
2. Administrative Controls - minimize exposure through good housekeeping procedures, by minimizing exposure time, through good work practices.
3. Personal Protective Equipment - use of personal protective equipment will be discussed, including: eye and face protection, skin protection (e.g. gloves, aprons, lab coats), and respiratory protection.

2. Laboratory Training ("Hands-On"/Specific to work area) to be provided by laboratory supervisor or principal investigator, as required or needed.

a. CHP Availability - The location and availability of the Chemical Hygiene Plan (CHP) for individual labs will be reviewed.

b. SOPs - Standard Operating Procedures developed for that specific lab will be reviewed, if required.

c. Emergency Procedures - Emergency procedures and equipment for the lab (e.g. Location and use of eyewash, safety showers, fire extinguishers, exit routes, etc.) will be reviewed.

d. Safety Equipment - Safety equipment used in the lab (e.g. fume hoods, face shields, gloves, etc.) will be reviewed.

e. Designated Areas - Designated areas and any special procedures for handling extremely hazardous substances will be reviewed.

f. Signs and Symptoms of exposure: Signs and symptoms associated with exposure to materials in the laboratory will be reviewed. In addition, the methods and observations that can be used to detect the presence or release of hazardous materials in the laboratory will again be covered in the hands-on training.
E. LABORATORY OPERATIONS, WHICH REQUIRE PRIOR APPROVAL

In general, prior approval must be obtained when a laboratory procedure presents a significant risk of injury, illness, or exposure to hazardous substances. The risk is considered significant when there are very large quantities of particularly hazardous substances involved or the experimental procedures exacerbate the potential for a hazardous condition. Obviously, these conditions must be applied on a case-by-case basis.

Prior Review and Approval by a Principal Investigator
For routine operations, other than those detailed under "Prior Review and Approval by a Unit Safety Committee," the principal investigator, or someone designated by the principal investigator, may review and approve operations by completing the "Safety Review and Approval Checklist," copy attached. Only principal investigators or their designees who have attended University-sponsored Laboratory Standard Training may review and approve these laboratory operations.

Prior Review and Approval by a Unit Safety Committee
The following would require prior approval by the Unit Safety Committee before proceeding with a particular experiment or activity:

- When it is likely that occupational exposure limits could be exceeded or that other harm is likely
- When there is a failure of any of the equipment used in the process that did or could have resulted in injury, illness, or exposure of a laboratory worker to a hazardous material, the Unit Safety Committee must grant approval before the procedure may be undertaken again.
- When any laboratory workers become ill or suspect that they or others have been exposed due to any experimental procedure.
- Principal investigators who wish to obtain prior approval from the Unit Safety Committee must provide to the committee the information on the "Request for Prior Approval" form, copy attached. If animals are to be used in this research activity, you must obtain approval from the university Institutional Review Board for the Use and Care of Animals.
SAFETY REVIEW AND APPROVAL CHECKLIST

Name of Operation: ________________________________

Location: _______________________________________

Principal Investigator: ____________________________

Department: ____________________________________

Date ___/___/___

List all individuals who have been trained in this procedure:
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________

General

Provide a brief description of the activity, which will be carried out. Activities can include, but are not limited to: a particular reaction, a reaction system, use of a particular chemical, use of additional or new components to a new or old system, initiation of a new research project, or the addition of a new chemical to an old procedure. If available, a copy of the written procedure may be attached to satisfy this requirement.
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________

Question Answer Yes or No

1. Have you identified and addressed all hazards associated with materials, equipment, and procedures?

   Summarize the hazards which may be encountered including: toxicity, flammability, pressure, vacuum, temperature extremes, noise, explosivity, etc.

2. Are there written procedures for what you are doing?

3. Are current copies of the most recent MSDSs for the materials available?

   The information of the MSDS should be reviewed with all individuals who will be involved in this procedure. The MSDS must be readily available.

4. Have all individuals been trained and do they understand the written procedures?
5. Has the potential for emergency situations been addressed (e.g. runaway reactions, loss of temperature control, etc.)

6. Are shut offs for bottled gases or other critical valves/shut offs located where they can readily and safely be reached and closed?

7. Are specific emergency shutdown instructions posted and visible?  
   *Post-emergency shutdown procedures for all overnight and unattended operations. Ensure that there is a current Caution Sign posted on the laboratory door.*

8. Is the appropriate protective equipment available and being used (e.g. gloves, goggles, face shields, lab coats, etc.)

9. Are all individuals familiar with what to do in the event of accidental contact (e.g. inhalation, ingestion, skin contact)?

10. Are all individuals familiar with what to do in the event of a spill or other emergency?  
    *This information may be found on an MSDS. Additional information may be obtained by the H&ES department.*

11. Are you using the least hazardous materials and minimum practical quantities for the needs?

12. Is the appropriate safety equipment available and in working order (e.g. fume hoods, glove boxes, etc.)?

If any question above is answered with a "NO", please explain, below. Also, add any additional comments below.
Request for Prior Approval by the Unit Safety Committee

Date of Request ____________________
Principal Investigator ____________________________________________
Department Chair ________________________________________________
Department ______________________________________________________
Building - Room _________________________________________________
Phone __________________________________________________________

CHEMICAL TO BE USED

Name _______________________________ CAS No. __________
Synonyms _______________________________________________________
Location of Use _________________________________________________
Use Condition _________________________________________________
Location of Storage _____________________________________________
Period/Frequency of Use _________________________________________
Quantity to be procured __________________________________________

PERSONNEL PROPOSED FOR THIS PROJECT

_________________________________________________________________
_________________________________________________________________

EXPERIMENTAL PROCEDURES

Briefly describe the procedures that will involve the use of this material.

_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
_________________________________________________________________

_________________________________________________________________
CONTROL PROCEDURES
Describe controls that will be employed to protect the individuals participating in this research.

DECONTAMINATION AND DISPOSAL
Decontamination Procedures (surfaces, materials, instruments, equipment, etc.):

Disposal Procedures (wastes and unused stock):

EMERGENCY PROCEDURES
In the event of overt personnel exposure (inhalation, ingestion, inoculation):

In the event of environmental contamination (spill):

MONITORING PROCEDURES (if required by the USC)
Medical and/or personnel monitoring procedures for evidence of personnel exposure
Monitoring procedures to detect environmental contamination
F. MEDICAL CONSULTATIONS AND EXAMS

1. Medical Consultation

A laboratory worker will be offered a medical consultation or examination at no cost under the following circumstances:

a. If it is likely that the worker will be or has been exposed to a substance at a level in excess of either the OSHA recommended Action Levels, or in their absence, Permissible Exposure Limit (PEL) or the Threshold Limit Value (TLV) recommended by the ACGIH. H&ES should be consulted for assistance in assessing the exposure or potential for exposure.

b. If a laboratory worker develops signs or symptoms associated with exposure to a chemical being used.

c. In the event of an exposure to chemicals through a spill, explosion, or other accident.

2. Procedure

a. All medical consultations are provided at no cost through the H&ES. The attending University physician will decide if the person needs to be referred to an area hospital or other such medical facility for further treatment. Off-campus facilities should contact H&ES for assistance in arranging for medical surveillance.

b. In case of exposure to a chemical spill, accident, explosion, etc., or onset of symptoms associated with a chemical being used, the supervisor of the laboratory shall refer the employee to H&ES. If H&ES is closed or not easily accessible, he/she should be sent to the Emergency Room of the nearest hospital.

c. H&ES shall collect as much information as possible about the person, chemical(s) involved, MSDSs and HSFSs, symptoms, exposure monitoring results, and other relevant data, and present this information to the physician, if needed.

d. The physician in charge will inform the employee about the medical examination results, related conditions, tests required, and any follow-up required.

e. H&ES will be advised of the results of relevant tests conducted by the attending University physician.

3. Medical Records

a. The University shall keep written records of all such medical examinations. These records must be maintained for the length of employment plus thirty years.

b. Such records must contain, and not limited to, physicians' opinions, recommendations, results of any tests performed and any follow-ups.

c. Upon written request, such records shall be made available for review by the employee or an authorized representative.

d. All such records shall be maintained and made available for review in accordance with the PEOSHA standard 29 CFR 1910.20.
G. PROVISIONS FOR EMPLOYEE PROTECTION WHEN WORKING WITH PARTICULARLY HAZARDOUS SUBSTANCES: (CARCINOGENS, REPRODUCTIVE TOXINS, SUBSTANCES THAT HAVE A HIGH DEGREE OF ACUTE TOXICITY, AND CHEMICALS OF UNKNOWN TOXICITY)

Consideration will be given to adopt the procedures described in this section as appropriate, when performing laboratory work with any select carcinogen, reproductive toxin, substance that has a high degree of acute toxicity, or a chemical whose toxic properties are unknown.

1. The following definitions apply:
   a. Select carcinogen: Any substance defined as such in 29 CFR 1910.1450 and any other substance described as such in the applicable MSDS.
   b. Reproductive toxin: Any substance described as such in the applicable MSDS.
   c. Substances with a high degree of acute toxicity: Any substance for which the LD50 data described in the applicable MSDS cause the substance to be classified as a "highly toxic chemical" as defined in ANSI Z129.1.
   d. Chemical whose toxic properties are unknown: A chemical for which there is no known statistically significant study conducted in accordance with established scientific principles that establish its toxicity.
   e. For the purposes of this CHP, chemicals in the above four categories will be referred to as "particularly hazardous."
   f. Designated area: A hood, glove box, portion of a laboratory, or an entire laboratory room designated as the only area where work with quantities of particularly hazardous chemicals shall be conducted.

2. Establish a "designated area" in the laboratory for use of the particularly hazardous substance. Designated areas shall be posted and their boundaries clearly marked. Only those persons trained to work with particularly hazardous chemicals will work with those chemicals in a designated area. All such persons will:
   a. Use the smallest amount of chemical that is consistent with the requirements of the work to be done.
   b. Use high-efficiency particulate air (HEPA) filters or high-efficiency scrubber systems to protect vacuum lines and pumps.
   c. Store particularly hazardous chemicals or remove them from storage.
   d. Decontaminate a designated area when work is completed.
   e. Prepare wastes from work with particularly hazardous chemicals for waste disposal in accordance with specific disposal procedures consistent with the Resource Conservation and Recovery Act (RCRA). (For further information on specific disposal requirements, contact H&ES)

3. Store all particularly hazardous chemicals in locked and enclosed spaces with slight negative pressure compared to the rest of the building.

4. Because the decontamination of jewelry may be difficult or impossible, avoid wearing jewelry when working in designated areas.
5. Wear long-sleeved disposable clothing and gloves known to resist permeation by the chemicals used when working in designated areas. (For further guidance on selection of protective clothing, contact H&ES.)
6. Conduct a "dry run" of procedures involving particularly hazardous substances.
Appendix 1

OCCUPATIONAL EXPOSURE TO HAZARDOUS CHEMICALS IN LABORATORIES 29 CFR 1910.1450

Occupational Exposure to Hazardous Chemicals in Laboratories Rule
(Laboratory Standard)

Regulatory Overview

In February 1993, New Jersey's Public Employees OSHA adopted 29 CFR 1910.1450, Federal OSHA's "Occupational Exposure to Hazardous Chemicals in Laboratories Rule", (also known as the Laboratory Standard). An overview of the Laboratory Standard, as well as a full copy of the regulation is given in Appendix 1. The purpose of this Guide is to provide a model for the development and implementation of a Chemical Hygiene Plan (CHP) for each university laboratory, as required by the Laboratory Standard.

At NJIT, the Laboratory Standard applies to all employees and students engaged in the "laboratory use" of hazardous chemicals. It applies to research and teaching laboratories, which are carrying out small-scale operations (those which can be handled safely and easily by one person) using multiple chemicals and procedures, where the procedures are neither a part of, nor simulate, a production process.

Generally, the Laboratory Standard requires:

1. **EXPOSURE LIMITS**: For OSHA - regulated substances, adherence to Action Levels, or, in their absence, Permissible Exposure Limits (PELs) for laboratory employees.

2. **EXPOSURE DETERMINATION**: Initial monitoring and, when necessary, periodic monitoring of employee exposures to OSHA - regulated substances when there is a reason to believe that an Action Level, or in its absence, a PEL, has been exceeded. Employees must be notified within 15 days of the results of the monitoring.

3. **CHEMICAL HYGIENE PLAN**: A Chemical Hygiene Plan must be developed. When implemented, the plan must be capable of protecting employees from health hazards associated with chemicals in the laboratory and must keep exposures below occupational exposure limits.

4. **EMPLOYEE INFORMATION AND TRAINING**: Employees must be provided with information and training regarding the requirements of the Laboratory Standard and the Chemical Hygiene Plan, and the hazards of chemicals present in the work area. This training must be provided when an employee is initially assigned to a laboratory area, or when new hazards are introduced.

5. **MEDICAL CONSULTATIONS/EXAMINATION**: Laboratory employees shall be provided with medical examinations under the following conditions:
   - When an employee develops signs or symptoms of exposure to a hazardous chemical in the laboratory.
   - When monitoring reveals exposure in excess of an Action Level or PEL.
• When an event, such as a spill or explosion takes place, where there is a likelihood of exposure. These examinations shall be provided at no cost to the employee.

6. HAZARD DETERMINATION: Labels on incoming chemical containers must not be removed or defaced.

7. Material Safety Data Sheets (MSDSs), which are received, must be maintained and must be readily accessible to employees. For substances created in the laboratory, a hazard determination must be made.

8. RESPIRATORY PROTECTION: When respirators are required, they must be maintained and used in accordance with 29 CFR 1910.134.

9. RECORDKEEPING: Results of exposure monitoring as well as medical consultations and exams must be kept in accordance with 29 CFR 1910.20.
APPENDIX 2

PROCEDURES FOR HANDLING CHEMICAL SPILLS
RESPONSE ACTIONS TO SPILLS/DISCHARGES

In the event of a spill or discharge of a chemical, one must evaluate whether: 1) the chemical poses a hazard to personnel within the area or the environment, and 2) the chemical can be easily and safely cleaned up. The attached charts detail response actions for spills or discharges which occur indoors (Spill Chart I) and those, which occur outdoors (Spill Chart II). The following instructions are to be used in conjunction with the appropriate chart. If the spilled material poses a hazard to the personnel in the area or the environment, immediately notify all to evacuate the area and/or building (evacuation procedures are described in Section IV of the university Contingency Plan); this can be done verbally or by sounding the fire alarms that are located throughout the building. After evacuation, University Police must be notified as soon as possible. If the chemical does not pose a threat to the personnel in the area but cannot be easily cleaned up, immediately place paper towels or other absorbents to stop or block the flow (only for liquid), notify the people in the immediate area, then notify university police. When calling, be sure that you have all the pertinent information to give to the police.

1. This would include:
2. The chemical substance involved in the release, if known.
3. An estimate of the quantity.
4. The time and duration of the release, if known.
5. The location of the release, where and onto what surface.
6. Any known or anticipated acute or chronic health risks associated with the spill/discharge, if known.
7. Proper precautions to take as a result of the release, including evacuation, if known.
8. The names and telephone numbers of the person(s) to be contacted for further information.

Radioactive substances are not covered under the federal spill-reporting requirements; if radioactive substances are released to the environment, contact H&ES, who will notify the EPA Radiological Response Coordinator.
APPENDIX 5
POLICY FOR DISPOSAL OF LABORATORY GLASS

The purpose of this policy is to ensure the safe disposal of all laboratory glass, which includes preventing injuries to anyone who must handle, discarded glass. This policy applies to all laboratory glass, intact as well as broken, except for radioisotope-contaminated glass and Regulated Medical Waste (RMW) contaminated glass, which are covered under the radioactive waste and RMW disposal procedures, respectively.

A. Procedure

Place all glass, intact as well as broken, into a specially marked rigid container designed for this purpose (refer to "Specifications" section, below). A properly labeled thick-walled, rigid cardboard container may be substituted. The container must be able to withstand penetration by the sharps it contains, and must be lined with a leak-resistant liner (e.g. a polyethylene or polypropylene bag). Seal the container and clearly mark it "BROKEN GLASS" to describe its contents.

Rinse all empty hazardous chemical containers three times with small amounts of a suitable solvent or appropriate detergent solution (triple-rinsing) before discarding. The solvent may be any liquid, which is effective (e.g., water or water-detergent solutions effectively clean water-soluble substances and water-dispersible substances; mineral spirits is useful in dissolving many oily materials). Collect the rinsate for disposal as a hazardous material (Refer to the POLICY FOR THE DISPOSAL OF CHEMICALS). Then deface or remove all labels. After this step, they may be discarded as ordinary trash.

Seal filled glass-disposal containers before placing them for disposal. Ordinary, uncontaminated, discarded glass, when packed in its special container, may be disposed of with the regular trash. If a container of ordinary non-contaminated glass is so heavy or bulky that special handling is required, call Custodial Services for proper disposal. They can be reached by dialing the Service Desk Number under the appropriate Campus Maintenance Section of Facilities.

Do not put glass originating in the laboratory into a recycling container.

B. Specifications: Glass disposal containers

1. Table Model 8" x 8" x 10", with cover. Fisher Catalogue No. 12-009-7B
2. Floor Model 12" x 12" x 27", with cover. Fisher Catalogue No. 12-009-7A
APPENDIX 6

POLICY FOR THE DISPOSAL OF CHEMICALS

A. POLICY FOR DISPOSAL OF CHEMICALS

The collection of all unwanted chemicals is routinely coordinated by the university Health & Environmental Safety (H&ES). You are encouraged to recycle chemicals that are usable within your department. H&ES will also collect and offer chemicals for recycling. A recyclable chemical inventory will be distributed periodically. These procedures must be followed for disposal of unwanted chemicals. They apply to chemicals that H&ES does not authorize for disposal with the regular trash, or, in a very few instances, those which may be poured down the drain. Refer to the drain disposal policy for a list of chemicals that can be disposed of via the sanitary sewer system. The policy discussed below, however, does not apply to radioactive, biohazardous, or Regulated Medical Waste (RMW) disposal, each of which is covered by a separate policy.

1. Procedures

a. Chemicals must be collected in individual, leak proof, sealed containers. Glass containers may be safely used for virtually anything, except hydrofluoric acid, acidic fluoride salts, and very strong alkalis. The chemicals must be compatible with the container material (e.g. acids must not be placed in a steel container, alkalis must not be placed in an aluminum container).

b. Select the smallest container available that will properly hold the material, allowing sufficient headspace above the surface of the liquid to allow room for expansion. This makes for economy and efficiency. Five-gallon pails and fifty-five gallon drums are available from H&ES, as required. Do not use your own pails or drums without prior approval from H&ES; they may not meet US Department of Transportation requirements.

c. All containers must be identified and labeled with the chemical name of the substance. Trade names, acronyms, abbreviations, codes, or formulas are not acceptable.

d. All "spent" chemical waste (waste which cannot possibly be recycled as a result of either of several substances having been mixed together or a substance being contaminated) must have a HAZARDOUS WASTE LABEL affixed to its container prior to use. HAZARDOUS WASTE LABELS can be obtained by calling H&ES. These labels must not be put on bottles containing pure chemicals, as these materials may be recycled.

e. Each component of a mixture of chemicals in a container must be identified on its label, along with its corresponding concentration. The units of concentration must be on the label together with their numerical values. When the solute is either a liquid or a gas, concentrations may not be expressed simply as 'percent' but must be given as either a 'weight percent' or a 'volume percent'.

f. Substances which are unidentified (unknowns) cannot be accepted for collection by H&ES. This stems from regulations requiring waste haulers to accept only
identified materials. Responsibility for establishing the identity of an 'unknown' rests with the department wishing to dispose of it.

g. When the 'spent' chemical waste container becomes full, enter the "accumulation start date" on the Hazardous Waste Label. The New Jersey Hazardous Waste Regulations define "accumulation start date" as the date at which the container is completely full and storage of the container has begun. The New Jersey Department of Environmental Protection requires that full containers of 'spent' waste be removed to an approved Storage and Disposal Facility within 90 days after this date. The date upon which each period of accumulation for storage (as defined above) begins must be clearly marked, and the label must be easily visible for inspection.

h. Removal of unwanted chemicals will be arranged by H&ES. Complete and submit a REQUEST FOR HAZARDOUS WASTE DISPOSAL form (See copy of form attached.) An H&ES staff representative will then schedule the removal of the chemicals from your laboratory.

i. Broken or intact hypodermic needles or syringes that are contaminated by chemicals or that have been used in chemical laboratories only for 'chemical procedures', such as removal of a solution from a vial through a septum or adding liquid to a gas chromatograph must be disposed of, according to law, by the procedure described in POLICY FOR THE DISPOSAL OF REGULATED MEDICAL WASTE as over-classified medical waste.

2. Laboratory/central Waste Storage Requirements

a. **Daily inspections** (working days only) of the chemical hazardous waste containers in both the laboratory or in designated central waste storage areas must be performed, looking for leaks and for deterioration caused by corrosion and other factors.

b. Containerized hazardous waste must be segregated in storage by waste type. Containerized hazardous waste must not only be segregated in and before transportation according to general waste type, e.g. flammables, poisons, and acids, but must be so arranged that incompatible substances cannot mix. Incompatibles must be kept apart. Incompatible substances are those pairs of substances that, when mixed, either react violently or evolve flammable or poisonous gases or vapors.

Below are a few general principles that must be followed in the safe storage and shipping of chemicals:

1. Keep acids and bases apart.
2. Keep acids apart from cyanides or sulfides.
3. Acids should never be put into steel containers, e.g. cans or drums.
4. Glass bottles and jars are inert to nearly any chemical except for hydrofluoric acid and some acidic fluorides. (They are also somewhat etched by concentrated aqueous solutions of strong alkalis.)
5. Organic acid halides, organic acid anhydrides, inorganic acid anhydrides, e.g. phosphoric anhydride (phosphorous pentoxide) and anhydrous strongly acidic salts (such as aluminum chloride, ferric chloride) must all be treated as water-reactive and strong acids. They must be kept apart from both alkalis and water.

6. Oxidizing agents must be kept apart from reducing agents; they often react violently when mixed. Oxidizing agents include hydrogen peroxide, chromium trioxide, potassium permanganate, sodium chlorate, and sodium nitrate. Three particularly potent oxidizing agents are perchloric acid, nitric acid, and sodium dichromate-sulfuric acid mixtures (e.g., ChromergeR). Reducing agents include metals and nearly all organic compounds and solvents.

7. Water-reactive must be stored apart from water, aqueous solutions, and acids. Care must be taken so that the containers in which they are shipped do not break or leak.

8. Air-reactive chemicals must be packed in containers that are sealed off from the atmosphere. Quite often these containers are sealed glass ampules or bulbs. Particular care must be taken when packing and unpacking them or handling them so they are not broken. In the case of certain air-reactive gases, the container is usually a compressed gas cylinder or lecture bottle; air-reactive liquids and solids are often sent in sealed glass ampules, and solids

c. Explosive materials and shock-sensitive substances present special risks that require special packaging, shipping, and handling. Consult with H&ES before handling or shipping them for disposal.

d. Every container must be arranged so that its identification label is readily visible.

e. Hazardous waste must not be placed in an unwashed container in which an incompatible waste has previously been stored.
REQUEST FOR HAZARDOUS WASTE DISPOSAL

<table>
<thead>
<tr>
<th>A. Name of Chemical(s) (No Formulas)</th>
<th>B. Hazard Class</th>
<th>C. Quantity</th>
<th>D. Other Information</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Send to: Department of Health and Safety
REQUEST FOR HAZARDOUS WASTE DISPOSAL

Instructions for Completing

I. The Requester is the person who is responsible for the generation of the waste.

II. This request form is to be completed by the requester.

III. A. The correct chemical name or names should be written on the form and the waste labels to identify the material. Chemical formulas and trade names are not acceptable. i.e. Methylene Chloride, not CH2 Cl2.

   B. For mixtures of liquids, all constituents must be listed on the form as well as the waste label and add up to 100%. Solutions of solids or gases in liquids must be expressed in concentrations of either weight percent, molarity (moles per liter), or normality (equivalents/liter).

   C. List each hazard presented by the substance, by using the corresponding letter shown below:

      C - Corrosive   O - Oxidizer
      E.- Explosive   P - Poison
      F - Flammable   R - Reactive

   D. Fill in the unit used to record the amount of substance listed, such as gram, ml, liter, gallon, and pound.
3. Disposal of empty containers and other equipment

Empty bottles or cans that have contained hazardous substances and are to be discarded must be rinsed three times with a suitable solvent. Destroy or deface the label so as to make it illegible and destroy the cap to prevent its reuse. Place in a proper waste container (glass, metal, etc.), separate from regular room trash. They must not be placed in recycling bins. No item of laboratory glassware or any chemical container may ever be put in the ALUMINUM AND GLASS Recycling Bins.

Broken glass and other sharp or hazardous objects must be placed in their own appropriate specially marked rigid containers. Hypodermic needles and syringes (including those used to introduce samples for gas chromatographic analysis) and scalpel blades must be disposed of in a container specially designed for this purpose. Discarded glassware, broken as well as unbroken, must be put into special puncture-resistant cartons marked "Broken Glass." These special containers prevent sharp objects from poking through and protect physical plant personnel and others who must handle the trash. Waste paper baskets and plastic trash bags are to be used only for waste paper and other office trash.

It must be emphasized that no item of laboratory glassware or any chemical container may ever be put in the ALUMINUM AND GLASS Recycling Bins. The only glass permitted in those Recycling Bins are jars and bottles that have contained only edibles -- food and beverages.

B. POLICY FOR DRAIN-DISPOSABLE SUBSTANCES

Research and instruction in laboratories continually produces small amounts of aqueous wastes. In such cases, laboratory workers must decide whether to pour particular solutions down the drain or keep them for pick-up by H&ES personnel. This guide will help them make such decisions.

1. General: Generally, unwanted chemicals are collected by H&ES for disposal. This is done in accordance with Section A. "Policy for the Disposal of Chemicals." Certain materials are suitable for drain disposal. These should be carefully considered to ensure they do not cause damage to the plumbing system or cause other problems such as odors in a building. Materials, which are suitable for drain disposal, are listed in the table, which follows. Other materials are prohibited from drain disposal without prior approval from H&ES.

2. Drain disposal of dilute acids and alkalis: Acids and alkalis, which have been rendered neutral by the experimental process, may be discarded by drain disposal. Proper care must be taken to adjust the solutions to a pH of between 6 and 9. Generally, 1N hydrochloric acid can be used to neutralize alkaline materials and 1N sodium hydroxide can be used to neutralize acid materials. Remember to SLOWLY add the acid to the water or alkali, not vice versa. Drain disposal is properly done in the following manner:
   a. Protective gear (gloves, laboratory apron, and safety goggles) must be worn.
b. Before pouring the solution, turn on the tap to get a good flow of water to wash it down. Also, make sure that the sink and drain lines are washed free of any substances that will generate noxious gases when mixed with the solutions. Such substances include cyanides, sulfides, bisulfides, sulfites, bisulfites, nitrates, and nitrites.

c. Pour the solution down the drain slowly, making sure that before, during and after pouring, the tap is turned on to provide a strong flow of water that aids in washing it down the drain.
### TABLE 1 DRAIN-DISPOSABLE SUBSTANCES

**SOLUTIONS ADJUSTED TO A pH OF 6-9**

<table>
<thead>
<tr>
<th>Polyhydroxyalcohols</th>
</tr>
</thead>
<tbody>
<tr>
<td>hydrobromic acid</td>
</tr>
<tr>
<td>glycol</td>
</tr>
<tr>
<td>hydrochloric acid</td>
</tr>
<tr>
<td>(glycerine)</td>
</tr>
<tr>
<td>hydriodic acid</td>
</tr>
<tr>
<td>nitric acid</td>
</tr>
<tr>
<td>phosphoric acid</td>
</tr>
<tr>
<td>phosphorous acid</td>
</tr>
<tr>
<td>sulfuric acid</td>
</tr>
<tr>
<td>acetic acid</td>
</tr>
<tr>
<td>formic acid</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sodium Hydroxide</th>
</tr>
</thead>
<tbody>
<tr>
<td>hydrobromic acid</td>
</tr>
<tr>
<td>glycol</td>
</tr>
<tr>
<td>hydrochloric acid</td>
</tr>
<tr>
<td>(glycerine)</td>
</tr>
<tr>
<td>hydriodic acid</td>
</tr>
<tr>
<td>nitric acid</td>
</tr>
<tr>
<td>phosphoric acid</td>
</tr>
<tr>
<td>phosphorous acid</td>
</tr>
<tr>
<td>sulfuric acid</td>
</tr>
<tr>
<td>acetic acid</td>
</tr>
<tr>
<td>formic acid</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Potassium Hydroxide</th>
</tr>
</thead>
<tbody>
<tr>
<td>hydrobromic acid</td>
</tr>
<tr>
<td>glycol</td>
</tr>
<tr>
<td>hydrochloric acid</td>
</tr>
<tr>
<td>(glycerine)</td>
</tr>
<tr>
<td>hydriodic acid</td>
</tr>
<tr>
<td>nitric acid</td>
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<tr>
<td>phosphoric acid</td>
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<tr>
<td>phosphorous acid</td>
</tr>
<tr>
<td>sulfuric acid</td>
</tr>
<tr>
<td>acetic acid</td>
</tr>
<tr>
<td>formic acid</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ammonium Hydroxide</th>
</tr>
</thead>
<tbody>
<tr>
<td>hydrobromic acid</td>
</tr>
<tr>
<td>glycol</td>
</tr>
<tr>
<td>hydrochloric acid</td>
</tr>
<tr>
<td>(glycerine)</td>
</tr>
<tr>
<td>hydriodic acid</td>
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<tr>
<td>nitric acid</td>
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<tr>
<td>phosphoric acid</td>
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<tr>
<td>phosphorous acid</td>
</tr>
<tr>
<td>sulfuric acid</td>
</tr>
<tr>
<td>acetic acid</td>
</tr>
<tr>
<td>formic acid</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Potassium Carbonate</th>
</tr>
</thead>
<tbody>
<tr>
<td>hydrobromic acid</td>
</tr>
<tr>
<td>glycol</td>
</tr>
<tr>
<td>hydrochloric acid</td>
</tr>
<tr>
<td>(glycerine)</td>
</tr>
<tr>
<td>hydriodic acid</td>
</tr>
<tr>
<td>nitric acid</td>
</tr>
<tr>
<td>phosphoric acid</td>
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<tr>
<td>phosphorous acid</td>
</tr>
<tr>
<td>sulfuric acid</td>
</tr>
<tr>
<td>acetic acid</td>
</tr>
<tr>
<td>formic acid</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sodium Carbonate</th>
</tr>
</thead>
<tbody>
<tr>
<td>(soda ash)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sodium Pyrophosphate</th>
</tr>
</thead>
<tbody>
<tr>
<td>hydrobromic acid</td>
</tr>
<tr>
<td>glycol</td>
</tr>
<tr>
<td>hydrochloric acid</td>
</tr>
<tr>
<td>(glycerine)</td>
</tr>
<tr>
<td>hydriodic acid</td>
</tr>
<tr>
<td>nitric acid</td>
</tr>
<tr>
<td>phosphoric acid</td>
</tr>
<tr>
<td>phosphorous acid</td>
</tr>
<tr>
<td>sulfuric acid</td>
</tr>
<tr>
<td>acetic acid</td>
</tr>
<tr>
<td>formic acid</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trisodium Phosphate</th>
</tr>
</thead>
<tbody>
<tr>
<td>hydrobromic acid</td>
</tr>
<tr>
<td>glycol</td>
</tr>
<tr>
<td>hydrochloric acid</td>
</tr>
<tr>
<td>(glycerine)</td>
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</tr>
<tr>
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<tr>
<td>phosphoric acid</td>
</tr>
<tr>
<td>phosphorous acid</td>
</tr>
<tr>
<td>sulfuric acid</td>
</tr>
<tr>
<td>acetic acid</td>
</tr>
<tr>
<td>formic acid</td>
</tr>
</tbody>
</table>

**ALL NATURALLY-OCCURRING AMINO ACIDS**

<table>
<thead>
<tr>
<th>Alanine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cysteine</td>
</tr>
<tr>
<td>Glycine</td>
</tr>
<tr>
<td>Histidine</td>
</tr>
<tr>
<td>Leucine</td>
</tr>
<tr>
<td>Lysine</td>
</tr>
<tr>
<td>Serine</td>
</tr>
<tr>
<td>Tryptophan</td>
</tr>
<tr>
<td>Tyrosine</td>
</tr>
</tbody>
</table>

**CHEMICALS* COMMONLY USED ON THE FARM AND IN THE HOUSEHOLD (No pesticides of any kind)**

<table>
<thead>
<tr>
<th>Acetylsalicylic acid</th>
<th>Casein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bicarbonate</td>
<td>Citric acid (sour salt)</td>
</tr>
<tr>
<td>Alum</td>
<td>Citric acid (sour salt)</td>
</tr>
<tr>
<td>Bisulfate</td>
<td>Corn syrup</td>
</tr>
<tr>
<td>Ammonium alum</td>
<td>Gelatin</td>
</tr>
<tr>
<td>(ammonium aluminum sulfate)</td>
<td>Magnesium sulfate</td>
</tr>
<tr>
<td>Borax (sodium tetraborate decahydrate)</td>
<td>Potassium aluminum sulfate</td>
</tr>
<tr>
<td>Dihydrogen</td>
<td>Potassium alum</td>
</tr>
<tr>
<td>Boric acid</td>
<td>Potassium bitartrate</td>
</tr>
<tr>
<td>Hypochlorite</td>
<td>Potassium bitartrate</td>
</tr>
<tr>
<td>Calcium chloride</td>
<td>Potassium bitartrate</td>
</tr>
</tbody>
</table>

- for any chemical containing sodium, the corresponding potassium or ammonium compound may be substituted.
APPENDIX 7

POLICY FOR THE DISPOSAL OF REGULATED MEDICAL WASTE (RMW)

The following instructions are for generators of Regulated Medical Waste (RMW). These instructions are summarized from "The Policy for the Disposal of Regulated Medical Waste." All generators of RMW must attend a RMW Orientation session provided by the university Health and Environmental Safety (H&ES).

A. Definition of RMW

The NJ Regulated Medical Waste Act of 1989 defines RMW as solid waste generated from one of the processes listed below, which ALSO fits the description of any of the seven classes of waste listed below.

RMW is any solid waste generated:
• in the diagnosis, treatment or immunization of humans or animals,
• in research pertaining to the above, OR
• in the production or testing of biological AND which also fits into any of the seven classes listed below:
  ❖ Class 1: Cultures and Stocks
  ❖ Class 2: Pathological Wastes
  ❖ Class 3: Human Blood & Blood Products
  ❖ Class 4: Sharps
  ❖ Class 5: Animal Waste
  ❖ Class 6: Isolation Waste
  ❖ Class 7: Unused Sharps

B. Overclassified RMW

Overclassified RMW is material, which resembles RMW, which does not meet the strict definition of RMW. To avoid confusion and to prevent problems of misconception, many of these materials are collected for disposal by our RMW contractor as "overclassified RMW". Overclassified RMW can be materials that look like RMW, that are generated from activities that do not meet the process definition of RMW. Examples of these materials include:
• Syringes and blood products generated in teaching laboratories (while research laboratories are covered in the process definition, teaching laboratories are not.)
• Culture dishes generated in botanical research (because these materials are not being used in research pertaining to the diagnosis, treatment, or immunization of humans or animals.

There are also many activities, which DO meet the process definition, which generate waste that does not fit into one of the seven specific classes. An example of this material includes:
- Gloves worn during blood-drawing procedures in our health centers (because gloves, unless they are either saturated with blood, or contaminated with an infectious disease agent, are not included as one of the seven classes of RMW).

C. Segregation of RMW

During the generation period, RMW must be segregated, to the extent practicable, into the following three categories:

- Sharps (Both class 4 and Class 7)
- Fluids (Greater than 20 cc)
- Other RMW

Collect the above RMW categories in separate inner containers prior to depositing them into the outer cardboard container (i.e. needles, culture dishes, glass cover slips, scalpel blades and syringes must be collected in a sharps container; culture transfer devices, blood-soaked items and other paper or cloth related items must be collected in the clear autoclave bags).

Do not chop, bend, break or otherwise destroy hypodermic needles or syringes before discarding them into the sharps container.

D. Treatment of RMW

Classes 1, 2, 3, 4 and 5 either must be autoclaved or disinfected prior to removal by the RMW transporter (Refer to "The Policy for the Disposal of Regulated Medical Waste" to review the classes of RMW). RMW that has not been processed according to the procedures set forth in the Policy will not be removed by the outside waste transporter. (Class 7 RMW need not be treated, because it is UNUSED material.)

NOTE: Certain items cannot be safely sterilized by autoclaving. Such items include cellulose nitrate centrifuge tubes, which explode on being exposed to elevated temperatures. They are not to be autoclaved and must be sterilized by other means. Additionally, certain substances, including ammonia and primary amines react dangerously with sodium hypochlorite (bleach). Consult H&ES if you have any questions about the material to be disinfected.

RMW which has been processed in accordance with the disinfection procedures, although non-infectious, continues to be classified as RMW by legal definition and cannot be disposed of in the regular trash. This is because it has not been rendered "unrecognizable" through shielding, crushing, melting, etc.

E. Storage of RMW

Outer containers must be stored in a secure area protected from the elements, vandalism, insects, and rodents. Both the general public and other unauthorized personnel must be
denied access to this designated storage area. When storing containers make sure that their labels face outward so that they can be easily seen. Containers must also be sealed securely to prevent spillage or the leaking of vapors. Liquids (e.g. blood) must be put into containers that are packaged with a sufficient amount of surrounding absorbent material to prevent leakage.

**F. Packaging, Labeling And Marking Requirements**

**Packaging**

All RMW must be packaged by the generator before it can be removed by the medical waste hauler. The medical waste hauler will not package your waste. All needles, syringes, scalpels or any sharp objects must be packaged in the appropriate puncture-resistant containers. Unbroken as well as broken glass must never be discarded by simply being put in a biohazard bag or any other plastic bag. All other items may be packaged in appropriate medical waste containers (e.g. autoclave bags). These items must then be packaged in an outer cardboard box before removal. Replacement boxes for use in future disposals of RMW will be available from the waste hauler upon arrival for subsequent pick-ups. Only the containers and box tape supplied by either H&ES or the hauler may be used to package RMW.

**Labeling and Marking**

Generators shall mark each package of RMW according to the following labeling and marking requirements before it is transported off-site by the RMW hauler:

a. The outermost surface of each cardboard box prepared for shipment shall be labeled only with a special water-resistant identification label called "MEDICAL WASTE OUTER CONTAINER LABEL". If these labels are unavailable, the required information may be written directly on the outside of the box. Only indelible or waterproof ink or marker fluid may be used to complete this label.

b. In addition to the requirements above, the generator must also label inner containers, including sharps and fluid containers. Each inner container shall be labeled only with a special water-resistant identification label called, "MEDICAL WASTE INNER CONTAINER LABEL". If these labels are unavailable, the required information may be written directly on the inner container. Only indelible or waterproof ink or marker fluid may be used to fill out this label.

Note that all containers, both inner and outer containers, must be marked with the required information. Labels can be obtained by calling H&ES (3059).

**G. Daily Logging and the Annual Generator Summation Report**

Daily logs must be kept by all generators of RMW (this includes logging overclassified RMW). Each set of these logs must be kept in the location in which the corresponding RMW is generated. Sets of daily logs must be retained for a period of at least 3 years from the date the waste was generated. Note that RMW also includes unused as well as used sharps and unbroken glassware that has been in contact with human pathogens, or
are covered with human blood. The logs must be kept on a special Logging Form. This Form and the corresponding instructions may be obtained from H&ES at (3059).

The university Annual RMW Summation Form (a summation of the data in the preceding daily logs for a 365-day period) must be completed by the generator to cover the generation, treatment and disposal of all RMW from a given generation point during the period of June 22 of one year through June 21 of the next year. A copy of this completed form must be received by H&ES, no later that June 30, of the year in which the reporting period ends. Forms and instructions necessary for preparing this Annual Summation may be obtained from H&ES.

Generators must keep copies of all Annual Summations on-site for three years from the dates they were submitted.

H. The Tracking Form For RMW

The NJ Medical Waste Tracking Form is used to ensure proper transportation of RMW to an appropriate disposal site. The university has arranged with the RMW hauler to supply the four-copy RMW TRACKING FORM.

The Tracking Form will be filled out by the RMW transporter. The generator must check over Items 1 through 14 on the Tracking Form, for purposes of verifying its accuracy. After a thorough review of Items 1 through 14, the generator must then sign the Tracking Form in Item 15. After the RMW transporter has also signed-off in Item 16, a Copy 4 of the Tracking Form will be given to the generator.

After the RMW is received by the disposal facility a disposal facility representative will sign off in Item 22. Copy 1 will be mailed back to the generator. Both Copies 1 and 4 of the Tracking Form must be kept by the generator at the generation site for at least three years from the date the waste was accepted by the RMW transporter.

Scheduling a RMW Pick-up Call H&ES to schedule a pick-up of RMW. Allow at least 5 to 7 days for the RMW transporter to remove the waste. It is important that all requirements be completed prior to a pick-up (i.e. labeling of the outer container and the sealing and weighing of the box).
APPENDIX 8

OSHA AIR CONTAMINANTS STANDARDS (PELS) 29 CFR 1910.1000

OSHA has also adopted substance-specific standards for the following materials:

<table>
<thead>
<tr>
<th>Substance Limit*</th>
<th>Action Level*</th>
<th>8-hour TWA PEL**</th>
<th>Excursion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asbestos</td>
<td>0.1 fibers/cc</td>
<td>0.2 fibers/cc</td>
<td>1 fiber/cc @ 30 min</td>
</tr>
<tr>
<td>Vinyl chloride</td>
<td>0.5 ppm</td>
<td>1 ppm</td>
<td>5 ppm ≤15 min</td>
</tr>
<tr>
<td>Inorganic arsenic</td>
<td>5 ug/m³</td>
<td>10 ug/m³</td>
<td></td>
</tr>
<tr>
<td>Lead</td>
<td>30 ug/m³</td>
<td>50 ug/m³</td>
<td></td>
</tr>
<tr>
<td>Benzene</td>
<td>0.5 ppm</td>
<td>1 ppm</td>
<td>5 ppm ≤15 min</td>
</tr>
<tr>
<td>Coke oven emissions</td>
<td>--</td>
<td>150 ug/m³</td>
<td></td>
</tr>
<tr>
<td>Cotton dust (lint free resp cotton) from:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Yarn manufacturing and cotton washing operations</td>
<td>100 ug/m³</td>
<td>200 ug/m³</td>
<td></td>
</tr>
<tr>
<td>- Textile mill waste, house operations, or lower grade washed cotton in yarn manufacturing</td>
<td>250 ug/m³</td>
<td>500 ug/m³</td>
<td></td>
</tr>
<tr>
<td>Slashing and weaving</td>
<td>375 ug/m³</td>
<td>750 ug/m³</td>
<td></td>
</tr>
<tr>
<td>1,2-dibromo-3-chloropropane</td>
<td>1 ppb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethylene oxide</td>
<td>0.5 ppm</td>
<td>1 ppm</td>
<td>5 ppm @ 15 min.</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>0.5 ppm</td>
<td>1 ppm</td>
<td>2 ppm ≤15 min.</td>
</tr>
</tbody>
</table>

*Action Level* 8-hour Time Weighted Average (TWA) air concentration of a substance at which certain substance-specific OSHA requirements go into effect (e.g. medical monitoring, exposure monitoring, training, etc.)

**8-HOUR TWA PEL Permissible Exposure Level -- 8-hour Time Weighted Average (TWA) air concentration to which worker may not be exposed without personal protective equipment.

#Excursion limit Maximum air concentration to which worker may be exposed (for the specified time interval) without exceeding the 8-hour TWA PEL.
Re: Complaint Log

Dear

On June 27, 1995, the New Jersey Department of Health, Public Employees Occupational Safety and Health (PEOSH) Program conducted an inspection of the

The purpose of the inspection was to assess compliance with the PEOSH Occupational Exposure to Hazardous Chemicals in Laboratories Standard. As a result of this inspection, an Order To Comply (attached) was issued on July 28, 1995, citing two violations.

The Order To Comply lists the abatement date for these citations as September 28, 1995. To date, documentation from indicating that these violations have been abated has not been received by the PEOSH Program. must provide the PEOSH Program, within 10 working days of receipt of this letter, with documentation that these violations have been abated. The documentation must include a copy of Chemical Hygiene Plan, an outline of the training program provided and training rosters indicating that all laboratory employees have been trained.

If cannot provide this documentation within 10 working days, then a written request for an extension of the abatement date must be received. Extension requests must be addressed to Gary Ludwig, Acting Program Manager, at the above address. A request for an extension for the abatement date must state:

- the new abatement date requested
- reason for delay
- interim control measures instituted to protect employees

New Jersey Is An Equal Opportunity Employer
Printed on Recycled Paper
**ORDER TO COMPLY**

New Jersey Department of Labor
Division of Workplace Standards
Office of Public Employees Safety
CN.JAC
Trenton, NJ 08625

1. Issue Date: July 28, 1995
2. Insp. No.: 0426 DOH
3. Facility Code: 1AC
4. Compliance Officer I.D.: 
5. Page no.: 1 of 1
6. Insp. Date: 6/27/95
7. Insp. Site: 

The violations described in this Order to Comply are alleged to have occurred on or about the day the inspection was made unless otherwise indicated within the description given below.

**THE LAW REQUIRES** that a copy of this Order to Comply be posted in a prominent place so that it is clearly visible to affected employees at or near the location of the violation(s) cited below. This Order to Comply describes violations(s) of N.J.S.A. 34:6A-25 C.12:6-2, and N.J.A.C. 12:100-4.3. The employer is hereby ordered to take immediate steps to abate the violation(s) pursuant to N.J.S.A. 34:6A-33a, 12:6-16b, 12:6A-41, and N.J.A.C. 12:100-3.2(c) by the date(s) listed below. An intention to contest an Order to Comply must be made in writing to the Program Director within 10 working days of the receipt of this Order to Comply by the employer.

<table>
<thead>
<tr>
<th>Standard, regulation or Section of the Act Violated</th>
<th>Description</th>
<th>ABATEMENT DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 29 CFR 1910.1450(e)(1): Where hazardous chemicals were used in the workplace, the employer did not develop and carry out the provisions of a written Chemical Hygiene Plan which was capable of protecting employees from health hazards associated with hazardous chemicals and which was capable of keeping exposures below the limits specified in 29 CFR 1910.1450(e).</td>
<td>September 28, 1995</td>
<td></td>
</tr>
<tr>
<td>LOC: Department of Chemical Engineering, Chemistry and Environmental Science</td>
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<td></td>
</tr>
<tr>
<td>A Chemical Hygiene Plan was not available for review.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. 29 CFR 1910.1450(f)(1): The employer did not provide laboratory employees with information and training to ensure that they were apprised of the hazards of chemicals present in their work area.</td>
<td>September 28, 1995</td>
<td></td>
</tr>
<tr>
<td>LOC: Department of Chemical Engineering, Chemistry and Environmental Science</td>
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<td></td>
</tr>
<tr>
<td>Training records were not available for review.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Chief, Office of Public Employees Safety:

*Employers who fail to comply with this order are subject to penalties pursuant to N.J.S.A. 34:6A-44(c).*

**DISCRIMINATORY ACTS AGAINST EMPLOYEES ARE UNLAWFUL** - N.J.S.A. 34:6A-45 - No person shall discharge, or otherwise discriminate, or in any manner discriminate against any employee because such employee has filed any complaint or instituted or caused to be instituted any proceeding under or related to this section.

An employer who believes that he has been discharged, discriminated, or otherwise discriminated against by an employee in violation of this section may, within 180 days after the employee first has knowledge such violation did occur, bring an action in the Superior Court against the person alleged to have violated the provisions of this section.
ORDER TO COMPLY

1. Issue Date: July 28, 1995
2. Insp. No.: 8426 DOH
3. Facility Code: 1AC
4. Compliance Officer I.D.:
5. Page No.: 1 of 1
6. Insp. Date: 6/27/95
7. Insp. Site:

The violations(s) described in this Order to Comply are alleged to have occurred on or about the day the inspection was made unless otherwise indicated within the description given below.

It is required that a copy of this Order to Comply be posted in a prominent place so that it is clearly visible to affected employees at or near the location of the violation(s) cited below. This Order to Comply describes violation(s) of N.J.S.A. 34:6A-25 41:56A-1, and N.J.A.C. 12:100-4.3. The employer is hereby ordered to take immediate steps to abate the violation(s) pursuant to N.J.S.A. 34:6a-3a, 34:6a-41, and N.J.A.C. 12:100-3.2(a) by the date(s) listed below. An intention to contest an Order to Comply must be made in writing to the Program Director within 15 working days of the receipt of the Order to Comply by the employer.

<table>
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<tr>
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<td>September 28, 1995</td>
<td></td>
</tr>
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</table>

LOC: Department of Chemical Engineering, Chemistry and Environmental Science

If the above information regarding citation abatement or a request for an extension is not received, further enforcement action will be taken. If you have any questions or need assistance in this matter, please call me at (609) 984-1863.

Sincerely,

Research Scientist II
Public Employees Occupational Safety and Health Program

Attachment

C: Complainant
APPENDIX D
Order to Comply from 2003

New Jersey Department of Labor
Division of Public Safety and Occupational Safety & Health
Office of Public Employees Occupational Safety & Health
PO Box 386
Trenton, NJ 08625-0386
Phone: (609) 292-0767
Fax: (609) 292-3749

NOTICE OF ORDER TO COMPLY

To: Inspection Number:
Reason: Complaint
Inspection Date: May 9, 2003
Compliance Officer:
Issuance Date: June 27, 2003

Inspection Site: Building 1

Each violation described in the Order to Comply is alleged to have occurred on or about the day(s) the inspection was made unless otherwise indicated.

The enclosed Order to Comply describes violations of the Public Employees’ Occupational Safety and Health Act. The violations referred to in this Order must be abated by the dates listed unless within 15 working days (excluding weekends and State holidays) from the issuance of this Order to Comply you mail a notice of intent to contest to the Department of Labor at the address shown above. Please refer to the enclosed Public Employees’ Occupational Safety and Health Act which outlines your rights and responsibilities and which should be read in conjunction with this form. The Order will become the Final Order if no notice of intent to contest is filed as provided for in the Act or, if contested, the Order is affirmed by the Review Commission or a court.

Posting - The law requires that a copy of this Notice and the Order to Comply be posted immediately in a prominent place at or near the location of each violation cited herein, or, if it is not practicable because of the nature of the employer’s operations, where it will be readily observable by all affected employees. This Order must remain posted until each violation cited herein has been abated, or for 15 working days (excluding weekends and State holidays), whichever is longer.

Informal Conference - An informal conference is not required. However, if you wish to have such a conference you may request one with the Office of Public Employees Occupational Safety & Health during the 15 working day contest period by contacting the
office shown above. During such an informal conference you may present any evidence or views, which you believe, would support an adjustment to the citation(s).

If you are considering a request for an informal conference to discuss any issues related to the Order to Comply, you must keep in mind that a written letter of intent to contest must be submitted to the Office of Public Employees Occupational Safety & Health within 15 working days of issuance of this Order. The contest period is not interrupted by a request for an informal conference.

If you decide to request an informal conference, the Office of Public Employees Occupational Safety & Health will schedule the conference, which will be conducted within 30 days of receipt of the request. Employees and/or employee representatives will be noticed of their right to attend the conference. The Office of Public Employees Occupational Safety & Health will arrange for representatives of the Department of Health and Senior Services to conduct conferences requested from Orders to Comply issued pursuant to a certification from the Commissioner of Health and Senior Services that an employer violation has been determined to exist within Health and Senior Service's jurisdiction under the Act.

Be sure to bring to the conference any and all supporting documentation of existing conditions as well as any abatement steps taken thus far. If conditions warrant, we can enter into an informal settlement agreement, which amicably resolves this matter without litigation or contest.

**Right to Contest** - You have the right to contest this Order to Comply. You may contest all citation items or only individual items. You may also contest abatement dates without contesting the underlying violations. **Unless you inform the Office of Public Employees Occupational Safety & Health in writing that you intend to contest the citation(s) and/or abatement dates within 15 working days of the issuance of this Order to Comply, then this Order to Comply shall become a final order.**

**Penalties** - The Act provides that if the time for compliance with an order of the Commissioner elapses, and the employer has not made a good faith effort to comply, the Commissioner shall impose a civil administrative penalty of up to $7,000 per day for each violation of a provision of N.J.S.A. 34:6A-25 et seq., or of a standard or regulation promulgated under that act, or of an order to comply. Any employer who willfully or repeatedly violates the requirements of this section or any standard, rule, order or regulation promulgated under that act shall be assessed a civil administrative penalty of up to $70,000 for each violation. Penalties imposed under this section may be recovered with costs in a civil action commenced by the Commissioner by a summary proceeding under "the penalty enforcement law" (N.J.S.A. 2A:58-1 et seq.) in the Superior Court or a municipal court, either of which shall have jurisdiction to enforce "the penalty enforcement law" in connection with this act. If the violation is of a continuing nature, each day during which it continues after the date given for compliance in accordance with the order of the Commissioner shall constitute an additional separate and distinct offense.
If this penalty remains unpaid for more than 30 days, this order shall be recorded on the judgment docket of the Superior Court.

Penalties will be based upon factors such as gravity of the violation, the probability that an injury or illness would result from the hazard, the good faith efforts of the employer to comply, the presence of meaningful safety and health programs and the history of previous violations.

**Notification of Corrective Action** - For violations, which you do not contest, you should notify the Office of Public Employees Occupational Safety & Health promptly by letter that you have taken appropriate corrective action within the time frame set forth on this Order. Please inform the Office of Public Employees Occupational Safety & Health in writing of the abatement steps you have taken and of their dates, together with adequate supporting documentation, e.g., drawings or photographs of corrected conditions, purchase/work orders related to abatement actions, air sampling results, etc.

**Employer Discrimination Unlawful** - The law prohibits discrimination by an employer against an employee for filing a complaint or for exercising any rights under this Act. An employee who believes that he/she has been discriminated against may file a complaint, no later than 180 days after the employee first had knowledge that such discrimination occurred, with the Office of Public Employees Occupational Safety & Health at the address shown above.

**Employer Rights and Responsibilities** - The enclosed copy of the Public Employees' Occupational Safety and Health Act outlines additional employer rights and responsibilities and should be read in conjunction with this notification.

**Notice to Employees** - The law gives an employee or an employee representative the opportunity to object to any abatement date set for a violation if he/she believes the date to be unreasonable. The contest must be mailed to the Office of Public Employees Occupational Safety & Health at the address shown above and postmarked within 15 working days (excluding weekends and State holidays) of the issuance of this Order to Comply.

Assistant Director
Division of Public Safety and Occupational Safety & Health

BY: ____________________________

Assistant Chief
Office of Public Employees Occupational Safety & Health
ORDER TO COMPLY

New Jersey Department of Labor
Division of Public Safety and Occupational Safety & Health
Office of Public Employees Occupational Safety & Health
PO Box 386
Trenton, New Jersey 08625-0386

TO:

Issue Date: June 27, 2003
Insp. No: 10721DHSS
Facility Code: 1AC
Compliance Officer:
Page No.: 1 of 2
Insp. Date: May 9, 2003
Insp. Site: Building 1

The violation(s) described in this Order to Comply are alleged to have occurred on or about the day the inspection was made unless otherwise indicated within the description given below.

THE LAW REQUIRES that a copy of this Order to Comply be posted in a prominent place so that it is clearly visible to affected employees at or near each location of the violation(s) cited below. This Order to Comply describes violation(s) of N.J.S.A. 34:6A-25 et seq., and N.J.A.C. 12:100-4.3. The employer is hereby ordered to take immediate steps to abate the violation(s) pursuant to N.J.S.A. 34:6A-41 by the date(s) listed below. An intention to contest an Order to Comply must be made in writing to the Commissioner of Labor within 15 working days of the issuance of this Order to Comply by an employer, employee, or employee representative.

A CIVIL ADMINISTRATIVE PENALTY for each violation will be imposed if the employer does not make a good faith effort to comply with the Abatement Date. See N.J.S.A. 34:6A-41d.

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<td>LOC: A Chemical Hygiene Plan was not available for review. ABATEMENT DATE: December 19, 2003 PENALTY:</td>
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ORDER TO COMPLY

New Jersey Department of Labor
Division of Public Safety and Occupational Safety & Health
Office of Public Employees Occupational Safety & Health
PO Box 386
Trenton, New Jersey 08625-0386

Insp. No.: Issue Date: June 27, 2003 Page No.: 2 of 2
Inspection Site:

Standard, regulation or section of the Act Violated. Description of location.
Abatement Date and Penalty

Signed on June 27, 2003 pursuant to the authority vested by law in the New Jersey Department of Labor.

Assistant Director, Division of Public Safety and Occupational Safety & Health

BY: Assistant Chief
Office of Public Employees Occupational Safety & Health
(609) 292-0767

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c: Complainant
NOTICE OF ORDER TO COMPLY

To: [Inspection Site:]

Reason: Complaint
Inspection Date: May 9, 2003
Compliance Officer: [Inspection Number:]
Issuance Date: June 27, 2003

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Assistant Director
Division of Public Safety and Occupational Safety & Health

BY:________________________________________

Assistant Chief
Office of Public Employees Occupational Safety & Health
ORDER TO COMPLY

New Jersey Department of Labor
Division of Public Safety and Occupational Safety & Health
Office of Public Employees Occupational Safety & Health
PO Box 386
Trenton, New Jersey 08625-0386

TO:  

Issue Date: June 27, 2003
Insp. No:
Facility Code: IAC  
Compliance Officer:
Page No.: 1 of 2
Insp. Date: May 9, 2003
Insp. Site:

The violation(s) described in this Order to Comply are alleged to have occurred on or about the day the inspection was made unless otherwise indicated within the description given below.

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A Chemical Hygiene Plan was not available for review.  
ABATEMENT DATE: December 19, 2003  
PENALTY: |
ORDER TO COMPLY

New Jersey Department of Labor
Division of Public Safety and Occupational Safety & Health
Office of Public Employees Occupational Safety & Health
PO Box 386
Trenton, New Jersey 08625-0386

Insp. No.:  
Issue Date: June 27, 2003  
Page No.: 2 of 2

Inspection Site:

Standard, regulation or section of the Act Violated. Description of location.

Abatement Date and Penalty

Signed on June 27, 2003 pursuant to the authority vested by law in the New Jersey Department of Labor.

Assistant Director, Division of Public Safety and Occupational Safety & Health

BY: 

Assistant Chief
Office of Public Employees Occupational Safety & Health
(609) 292-0767

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c:
Complainant
Material Safety Data Sheet for Silane

SECTION 1. PRODUCT IDENTIFICATION

PRODUCT NAME: Silane
CHEMICAL NAME: Hydride
SYNONYMS: Silicon Tetrahydride; Monosilane; Silicane
MANUFACTURER: Air Products and Chemicals, Inc.
ADDRESS: 7201 Hamilton Boulevard
Allentown, PA 18195-1501

PRODUCT INFORMATION:
MSDS NUMBER: 1052
REVIEW DATE: October 1998
REVISION: 4
REVISION DATE: October 1998

SECTION 2. COMPOSITION / INFORMATION ON INGREDIENTS

Silane is sold as a pure product (> 99%).
CAS NUMBER: 7803-62-5
EXPOSURE LIMITS:
OSHA: None established
ACGIH: TLV = 5 ppm
NIOSH: REL = 5 ppm

SECTION 3. HAZARD IDENTIFICATION

EMERGENCY OVERVIEW

PYROPHORIC GAS! Silane is a colorless, air-reactive gas, with a choking effect. This gas usually ignites upon contact with air, releasing a dense white cloud of amorphous silicon dioxide. The primary health hazard associated with Silane is the potential for severe thermal burns from contact with flames resulting from the spontaneous ignition of this gas. Depending on the severity of the burns, such exposures can be fatal. Flame or high temperature impinging on a localized area of the cylinder of this product can cause the cylinder to burst without activating the cylinder's relief devices. If Silane is released at high pressure or high flow velocity, a delayed detonation may occur. Silane releases which have not spontaneously ignited must be considered extremely dangerous, and should not be approached. Emergency responders must have personal protective equipment and fire protection appropriate for the situation to which they are responding. Do not attempt to extinguish fire without stopping the flow of the gas.

EMERGENCY TELEPHONE NUMBERS
(800) 523-9374 Continental U.S., Canada, and Puerto Rico
(610) 481-7711 Other locations

ACUTE POTENTIAL HEALTH EFFECTS:

ROUTES OF EXPOSURE:
EYE CONTACT: Silane can be irritating to eyes. Decomposition of Silane will result in the production of amorphous silicon dioxide. Eye contact with particulates of amorphous silicon dioxide may be irritating.
INGESTION: Ingestion of Silane is not a likely route of industrial exposure.
INHALATION: Inhalation of high concentrations of this gas can result in headache, nausea, dizziness, and irritation of the upper respiratory tract. Silane can be irritating to the mucous membranes and the respiratory system. Severe Silane over-exposures via inhalation may result in pulmonary edema and adverse kidney effects that exist with inhalation of crystalline silicon dioxide. Overexposure to high concentrations may result in thermal burns due to the pyrophoric nature of the gas.
SKIN CONTACT: Silane can be irritating to the skin. Decomposition of Silane will result in the production of amorphous silicon dioxide. Skin contact with particulates of amorphous silicon dioxide may be irritating.

POTENTIAL HEALTH EFFECTS OF REPEATED EXPOSURE:

ROUTE OF ENTRY: None

TARGET ORGANS: Not applicable

SYMPTOMS: There are currently no known adverse health effects associated with chronic exposure to Silane.

MEDICAL CONDITIONS AGGRAVATED BY OVEREXPOSURE: Skin conditions and respiratory disorders may be aggravated by exposures to Silane and its decomposition products.

CARCINOGENICITY: Silane is not found on the FEDERAL OSHA Z LIST, NTP, CAL/OSHA, or IARC Carcinogenicity lists.

SECTION 4. FIRST AID MEASURES

THERMAL BURNS: In the event personnel are burned as a result of a Silane release, trained personnel should provide first aid treatment. Get medical attention immediately.

EYE CONTACT: Immediately begin decontamination with running water, open victim's eyes while under gently running water. Use sufficient force to open eyelids. Have victim "roll" eyes. Minimum flushing is for 15 minutes. Victim must seek immediate medical attention from an ophthalmologist.

INGESTION: Ingestion of Silane is not a likely route of exposure. Efforts to relieve discomfort may cause further irritation. Induce vomiting if necessary. Have victim seek medical attention immediately.

INHALATION: Remove victim(s) to fresh air, as quickly as possible. Trained personnel should administer supplemental oxygen and/or cardio-pulmonary resuscitation, if necessary. Victim must seek medical attention if irritation persists, or if there are other adverse health effects.

NOTES TO PHYSICIANS: Administer oxygen, if necessary and treat symptoms. Be observant for initial signs of pulmonary edema.

SECTION 5. FIRE FIGHTING MEASURES

FLASH POINT: Not applicable

AUTOIGNITION: Unknown

FLAMMABLE RANGE: (LEL): 1.4% (UEL): 96.0%

FIRE EXTINGUISHING MEDIA: Extinguish Silane fires by shutting off the source of the gas. Use a fine water spray or fog to reduce combustion products formed in air. Do not use halocarbon-type fire extinguishing agents. Cool fire-exposed cylinders with water spray, from the maximum distance possible.

SPECIAL FIRE-FIGHTING PROCEDURES: Evacuate all personnel from area. If possible without risk, shut off source of gas, then fight fire according to types of materials burning. Use a fine water spray or fog to reduce combustion products formed in air. Water may not be effective in actually extinguishing a fire involving Silane. Do not use halocarbon-type fire extinguishing agents. Stop the leak or discharge, if possible. Do not attempt to extinguish fire without stopping the flow of the gas. This will avoid possible accumulation and reignition of a flammable gas mixture. For small releases, if it is not possible to stop the leak, and it does not endanger personnel, let the fire burn itself out. Keep adjacent cylinders cool by spraying with large amounts of water until the fire burns itself out. Large fires should be fought from a distance with an unmanned hose holder or monitor nozzles. Incipient fire responders should wear eyeguards. Structural fire fighters must wear Self-Contained Breathing Apparatus and full protective equipment, including fire resistant clothing. If necessary, decontaminate fire-response equipment with soap and water solution.

UNUSUAL FIRE AND EXPLOSION HAZARDS: PYROPHORIC GAS! This product is a colorless, air-reactive gas. This gas usually ignites upon contact with air, releasing a dense white cloud of amorphous silicon dioxide. If Silane is released at high pressure or high flow velocity, a delayed detonation may occur. Silane releases which have not spontaneously ignited must be considered extremely dangerous, and should not be approached.

Must cylinders are designed to vent contents when exposed to elevated temperatures. Pressure in a cylinder can build-up due to heat and it may rupture if pressure relief devices should fail to function.

HAZARDOUS COMBUSTION PRODUCTS: Combustion products include oxides of silicon.
SECTION 6. ACCIDENTAL RELEASE MEASURES

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED: Evacuate immediate area. Silane is a pyrophoric gas and can ignite spontaneously upon contact with air, releasing a dense white cloud of amorphous silicon dioxide. Uncontrolled releases should be responded to by trained personnel using pre-planned procedures. Normally, a release of Silane will result in a fire. If Silane is released at high pressure or high flow velocity, a delayed detonation may occur. Silane releases which have not spontaneously ignited must be considered extremely dangerous, and should not be approached. Shut off source of leak, if possible. Isolate any leaking cylinder. If this does not stop the release (or if it is not possible to reach the valve), allow the gas to release in-place or remove it to a safe area and allow the gas to be released there.

If leak is from container, pressure relief device or its valve, contact your supplier. If leak is in user's system, close cylinder valve, safely vent pressure and purge with inert gas before attempting repairs. Protection of all personnel and the area must be maintained. All responders must be adequately protected from exposure. Monitor the surrounding area for Silane level. The level of Silane must be at acceptable levels (see Section 2, Composition / Information on Ingredients) before personnel can be allowed in the area without Self-contained breathing apparatus. Combustible vapor levels must be below 0.14%, which is 10% of the LEL of Silane, prior to entry. Attempt to close the main source valve prior to entering the area.

SECTION 7. HANDLING AND STORAGE

STORAGE: Store cylinders in a well-ventilated, secure area, protected from the weather. Cylinders should be stored up-right with valve outlet seals and valve protection caps in place. Storage should be away from heavily traveled areas and emergency exits. There should be no sources of ignition. All electrical equipment should be explosion-proof in the storage areas. Storage areas must meet National Electrical Codes for Class 1 hazardous areas. Flammable storage areas should be separated from oxygen and other oxidizers by a minimum distance of 20 ft. or by a barrier of non-combustible material at least 5 ft. high, having a fire resistance rating of at least 1/2 hour. Post "No Smoking or Open Flames" signs in the storage and use areas. Do not allow storage temperature to exceed 125 °F (52 °C). Full and empty cylinders should be segregated. Use a first-in, first-out inventory system to prevent full containers from being stored for long periods of time. Consideration should be taken to install leak detection and alarm equipment for storage areas.

HANDLING: Non-sparking tools should be used. Do not attempt to repair, adjust, or in any other way modify the cylinders containing Silane. If there is a malfunction, or another type of operational problem, contact nearest distributor immediately. Working alone with Silane should be avoided when possible. All work operations should be monitored in such a way that emergency personnel can be immediately contacted in the event of a release. The Silane dispensing area should be monitored with the use of hydride monitors to detect leaks and releases and a UV/IR monitor to detect fires. Both monitors should be interlocked (fail safe) to shut off the flow of Silane upon detection. Monitoring systems should be equipped with a source of back-up or emergency power. A remote emergency shutdown device must be present to shut off Silane at the source. The use of packed valves on systems containing silane should not be permitted. Only valves such as packless diaphragm or bellows-type should be used. An excess flow valve or excess-flow switch should be installed on all dispensing systems to shut off flow in the case of a downstream line rupture. This shut off valve should be located as close to the source as possible. Do not drag, roll, slide or drop cylinder. Use a suitable hand truck designed for cylinder movement. Never attempt to lift a cylinder by its cap. Secure cylinders at all times while in use. Use a pressure-reducing regulator and separate control valve to safely discharge product from cylinder. Use a check valve to prevent reverse flow into cylinder. Never apply flame or localized heat directly to any part of the cylinder. Once cylinder has been connected to property purged and inerted process, open cylinder valve slowly and carefully. If user experiences any difficulty operating cylinder valve, discontinue use and contact supplier. Never insert an object (e.g., wrench, screwdriver, etc.) into valve cap openings. Doing so may damage valve, causing a leak to occur. Use an adjustable strap-wrench to remove over-tight or rusted caps. All piped systems and associated equipment must be grounded. Electrical equipment should be non-sparking or explosion-proof.

SPECIAL PRECAUTIONS: Avoid temperatures of less than -170 °F (-112 °C), due to the possibility of sucking-back air, which may form explosive mixtures within the system. Do not use Silane in conjunction with heavy-metal halides or free halogens, with which Silane will react violently. Care should be taken that all handling systems are purged free of halogens that might exist from degreasing agents, or chlorinated hydrocarbons. Evacuate and thoroughly pressure-check all systems for leaks at pressures two to three times the anticipated working pressure, preferably with...
helium. In addition, regular leak-testing should be instituted and performed. Use an alternate vacuum and inert gas purge cycles of the system to purge all air out of the system after it has been leak-tested or opened for any reason. Before disconnecting any system that has Silane in it, thoroughly purge the system of Silane with an inert gas. Any portion of a system that is dead-ended or allows "pocketing" of Silane should be treated with vacuum-purge cycles. Venting should be to an area designed for Silane disposal, preferably by burning. Concentrations, even in the low percentage range, are dangerous and should not be exposed to air. Silane can also be vented by diluting with an inert gas to prevent ignition upon discharge to the atmosphere.

Always store and handle compressed gas cylinders in accordance with Compressed Gas Association, Inc. (telephone 703-412-0900) pamphlet CGA P-1, Safe Handling of Compressed Gases in Containers. Local regulations may require specific equipment for storage and use.

SECTION 8. EXPOSURE CONTROLS / PERSONAL PROTECTION

ENGINEERING CONTROLS:
VENTILATION: Silane detectors should be installed in or near areas where this product is being used or stored. Provide adequate natural or explosion-proof ventilation to prevent accumulation of gas concentrations and adequate to ensure Silane does not reach its lower flammability limit of 1.4%. If appropriate, install automatic monitoring equipment to detect the presence of explosive air-gas mixtures and the level of oxygen.

RESPIRATORY PROTECTION: High concentration that can cause rapid suffocation are within the flammable range and must not be entered.
Emergency Use: Escape-type SCBA should be used.

EYE PROTECTION: Splash goggles or safety glasses with side shields and a faceshield. Ensure eyewash/safety shower stations are available near areas where this product is used.

SKIN PROTECTION: Work gloves are recommended when handling cylinders. Use fire-resistant gloves and clothing in emergency situations. Use double gloves for spill response.

OTHER PROTECTIVE EQUIPMENT: Use body protection appropriate for task. Static-resistant clothing is recommended. Safety shoes are recommended when handling cylinders.

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE, ODOR AND STATE: Colorless gas, with a choking effect.
MOLECULAR WEIGHT: 32.12
BOILING POINT (at 1 atm): -169.0 °F (-111.7 °C)
SPECIFIC GRAVITY (also called vapor density) (air = 1): 1.2
FREEZING/MELTING POINT: -301.0 °F (-185.0 °C)
VAPOR PRESSURE (At 70 °F (21.1 °C)): Not applicable.
GAS DENSITY (At 70 °F (21.1 °C) and 1 atm): 0.084 lb/ft³
SOLUBILITY IN WATER: Negligible

SECTION 10. STABILITY AND REACTIVITY

CHEMICAL STABILITY: Pyrophoric. Ignites spontaneously on exposure to air.
CONDITIONS TO AVOID: Cylinders should not be exposed to temperatures in excess of 125°F (52°C).
INCOMPATIBILITY (Materials to Avoid): Air, halogens, other oxidizers, and moisture.

REACTIVITY:
A) HAZARDOUS DECOMPOSITION PRODUCTS: Not applicable
B) HAZARDOUS POLYMERIZATION: Will not occur

SECTION 11. TOXICOLOGICAL INFORMATION

LC₅₀ (Inhalation): Rat LC₅₀: 9600 ppm/4 hours
LD₅₀ (Oral): No data currently available.
LD₅₀(Dermal): No data currently available.
SKIN CORROSIVITY: Silane is not corrosive to the skin. When in contact with water, Silane may form silicic acid, which is corrosive to the skin.

CARCINOGENICITY: Currently, Silane has not been found to be carcinogenic.

ADDITIONAL NOTES: Studies in mice showed that exposure to 10,000 ppm for 1 hour or exposure to ≥ 2500 ppm for 4 hours resulted in adverse kidney effects. Mice exposed to 1000 ppm, 6 hours/day, 5 days/week for 2 to 4 weeks only exhibited mild respiratory tract irritation. Silane has been shown to cause mutations in bacteria.

SECTION 12. ECOLOGICAL INFORMATION

AQUATIC TOXICITY: Currently, no aquatic toxicity data are available for Silane.

MOBILITY: Due to the pyrophoric nature of Silane in air, it will ignite before it can enter the soil.

PERSISTENCE AND BIODEGRADABILITY: Silane will not persist in the environment, as it will ignite and decompose on contact with air.

POTENTIAL TO BIOACCUMULATE: Silane will not bioaccumulate.

REMARKS: Silane is not a Class I or Class II ozone depleting chemical (40 CFR Part 82).

SECTION 13. DISPOSAL CONSIDERATIONS

UNUSED PRODUCT / EMPTY CONTAINER: Return container and unused product to supplier. Do not attempt to dispose of residual or unused quantities.

DISPOSAL INFORMATION: Residual product in the system may be burned if suitable burning unit (flair incinerator) is available on-site. This shall be done in accordance with Federal, State and local regulations. Wastes containing this material may be classified by EPA as a hazardous waste by characteristic (such as Ignitability, Corrosivity, Toxicity, Reactivity). Waste streams must be characterized by the user to meet Federal, State and local requirements.

SECTION 14. TRANSPORT INFORMATION

DOT PROPER SHIPPING NAME: Silane, Compressed

HAZARD CLASS NUMBER and DESCRIPTION: 2.1 (Flammable Gas)

UN IDENTIFICATION NUMBER: UN2203

DOT SHIPPING LABEL(S) REQUIRED: Flammable Gas

PLACARD (When required): Flammable Gas

SPECIAL SHIPPING INFORMATION: Cylinders should be transported in a secure upright position in a well-ventilated truck. Never transport in passenger compartment of a vehicle. Ensure cylinder valve is properly dosed, valve outlet cap has been reinstalled, and valve protection cap is secured before shipping cylinder.

CAUTION: Compressed gas cylinders shall not be refilled except by qualified producers of compressed gases. Shipment of a compressed gas cylinder which has not been filled by the owner or with the owner's written consent is a violation of Federal law (49 CFR 173.301). NAERG (NORTH AMERICAN EMERGENCY RESPONSE GUIDEBOOK) #: 116

SECTION 15. REGULATORY INFORMATION

U.S. FEDERAL REGULATIONS

EPA - ENVIRONMENTAL PROTECTION AGENCY:


Reportable Quantity (RQ): Not applicable

SARA TITLE III: Superfund Amendment and Reauthorization Act

SECTIONS 302/304: Emergency Planning and Notification (40 CFR Part 355)

Extremely Hazardous Substances: Silane is not listed.

Threshold Planning Quantity (TPQ): Not applicable

Reportable Quantity (RQ): Not applicable
SECTION 311/312: Hazardous Chemical Reporting (40 CFR Part 370)
IMMEDIATE HEALTH: Yes          PRESSURE: Yes
DELAYED HEALTH: No              REACTIVITY: Yes
FIRE: Yes

SECTION 313: Toxic Chemical Release Reporting (40 CFR 372)
Releases of Silane do not require reporting under Section 313.

CLEAN AIR ACT:
SECTION 112 (r): Risk Management Programs for Chemical Accidental Release
(40 CFR Part 68)
Silane is listed as a regulated substance under Section 112 (r).
Threshold Planning Quantity (TPQ): 10,000 lbs (4,553 kg)

TSCA: Toxic Substances Control Act
Silane is listed on the TSCA Inventory.

OSHA - OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION:
Silane is not listed in Appendix A as a highly hazardous chemical.
Threshold Planning Quantity (TPQ): Under this regulation, however, any process that
involves a flammable gas on-site, in one location, in quantities of 10,000 lb. (4,553 kg) or
greater is covered under this regulation unless it is used as a fuel.

STATE REGULATIONS:
CALIFORNIA:
Proposition 65: Silane is not a listed substance which the State of California requires
warning under this statute.

SECTION 16. OTHER INFORMATION

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APPENDIX F

Hazardous Substance Fact Sheet for Nitrogen

Common Name: NITROGEN
CAS Number: 7727-37-9
DOT Number: UN 1066 (Compressed)
UN 1977 (Refrigerated Liquid)

HAZARD SUMMARY
* Nitrogen is present in the air we breath. The health effects described in this Fact Sheet may occur at concentrations greater than 80%.
* Contact with liquid Nitrogen can cause frostbite.
* Exposure to very high levels of pure Nitrogen can cause you to feel dizzy and lightheaded, and replaces oxygen in the air causing loss of consciousness and death.

IDENTIFICATION
Nitrogen is a colorless gas, or liquid under pressure. It is the main component of air. It has many medical and industrial uses including the quick freezing of food.

REASON FOR CITATION
* Nitrogen is on the Hazardous Substance List because it is cited by ACGIH, DOT and NFPA.
* Definitions are provided on page 5.

HOW TO DETERMINE IF YOU ARE BEING EXPOSED
The New Jersey Right to Know Act requires most employers to label chemicals in the workplace and requires public employers to provide their employees with information and training concerning chemical hazards and controls. The federal OSHA Hazard Communication Standard, 1910.1200, requires private employers to provide similar training and information to their employees.

* Exposure to hazardous substances should be routinely evaluated. This may include collecting personal and area air samples. You can obtain copies of sampling results from your employer. You have a legal right to this information under OSHA 1910.20.
* If you think you are experiencing any work-related health problems, see a doctor trained to recognize occupational diseases. Take this Fact Sheet with you.
* Areas which do not have enough oxygen do not provide adequate warning as most simple asphyxiants are odorless.

WORKPLACE EXPOSURE LIMITS
Before entering an enclosed space where high levels of Nitrogen may be present, oxygen content should be tested to ensure that it is at least 19% by volume.

WAYS OF REDUCING EXPOSURE
* Where possible, enclose operations and use local exhaust ventilation at the site of chemical release. If local exhaust ventilation or enclosure is not used, respirators should be worn.
* Wear protective work clothing where exposure to cold equipment, vapors, or liquid can occur.
* On skin contact with liquid Nitrogen quickly immerse affected part of the body in warm water.
* Post hazard and warning information in the work area. In addition, as part of an ongoing education and training effort, communicate all information on the health and safety hazards of Nitrogen to potentially exposed workers.
NITROGEN

This Fact Sheet is a summary source of information of all potential and most severe health hazards that may result from exposure. Duration of exposure, concentration of the substance and other factors will affect your susceptibility to any of the potential effects described below.

HEALTH HAZARD INFORMATION

Acute Health Effects
The following acute (short-term) health effects may occur immediately or shortly after exposure to Nitrogen:

* Contact with liquid Nitrogen can cause frostbite.
* Exposure to very high levels of pure Nitrogen can cause you to feel dizzy and lightheaded and replaces oxygen in the air causing loss of consciousness and death.

Chronic Health Effects
The following chronic (long-term) health effects can occur at some time after exposure to Nitrogen and can last for months or years:

Cancer Hazard
* According to the information presently available to the New Jersey Department of Health and Senior Services, Nitrogen has not been tested for its ability to cause cancer in animals.

Reproductive Hazard
* According to the information presently available to the New Jersey Department of Health and Senior Services, Nitrogen has not been tested for its ability to affect reproduction.

Other Long-Term Effects
* No chronic (long-term) health effects are known at this time.

MEDICAL

Medical Testing
There is no special test for this chemical. However, if illness occurs or overexposure is suspected, medical attention is recommended.

Any evaluation should include a careful history of past and present symptoms with an exam. Medical tests that look for damage already done are not a substitute for controlling exposure.

Request copies of your medical testing. You have a legal right to this information under OSHA 1910.20.

WORKPLACE CONTROLS AND PRACTICES

Unless a less toxic chemical can be substituted for a hazardous substance, ENGINEERING CONTROLS are the most effective way of reducing exposure. The best protection is to enclose operations and/or provide local exhaust ventilation at the site of chemical release. Isolating operations can also reduce exposure. Using respirators or protective equipment is less effective than the controls mentioned above, but is sometimes necessary.

In evaluating the controls present in your workplace, consider: (1) how hazardous the substance is, (2) how much of the substance is released into the workplace and (3) whether harmful skin or eye contact could occur. Special controls should be in place for highly toxic chemicals or when significant skin, eye, or breathing exposures are possible.

In addition, the following controls are recommended:

* Before entering a confined space where high levels of Nitrogen are present, check to make sure sufficient oxygen (19%) exists.
* Requirements in the OSHA Standard: 1910.101 Compressed Gases, must be followed
* Before entering a confined space where Nitrogen may be present, check to make sure that an explosive concentration does not exist.

Good WORK PRACTICES can help to reduce hazardous exposures. The following work practices are recommended:

* Eye wash fountains should be provided in the immediate work area for emergency use.
* On skin contact with liquid Nitrogen quickly immerse affected part of the body in large amounts of warm water.

PERSONAL PROTECTIVE EQUIPMENT

WORKPLACE CONTROLS ARE BETTER THAN PERSONAL PROTECTIVE EQUIPMENT. However, for some jobs (such as outside work, confined space entry, jobs done only once in a while, or jobs done while workplace controls are being installed), personal protective equipment may be appropriate.

OSHA 1910.132 requires employers to determine the appropriate personal protective equipment for each hazard and to train employees on how and when to use protective equipment.

The following recommendations are only guidelines and may not apply to every situation.
NITROGEN

Clothing
* Where exposure to cold equipment, vapors, or liquid may occur, employees should be provided with special clothing designed to prevent the freezing of body tissues.
* All protective clothing (suits, gloves, footwear, headgear) should be clean, available each day, and put on before work.

Eye Protection
* Wear splash-proof chemical goggles and face shield when working with liquid, unless full facepiece respiratory protection is worn.
* Wear gas-proof goggles, unless full facepiece respiratory protection is worn.

Respiratory Protection
IMPROPER USE OF RESPIRATORS IS DANGEROUS. Such equipment should only be used if the employer has a written program that takes into account workplace conditions, requirements for worker training, respirator fit testing and medical exams, as described in OSHA 1910.134.
* Exposure to high levels of Nitrogen is dangerous because it can replace oxygen and lead to suffocation. Only MSHA/NIOSH approved self-contained breathing apparatus with a full facepiece operated in positive pressure mode should be used in oxygen deficient environments.

QUESTIONS AND ANSWERS
Q: If I have acute health effects, will I later get chronic health effects?
A: Not always. Most chronic (long-term) effects result from repeated exposures to a chemical.

Q: Can I get long-term effects without ever having short-term effects?
A: Yes, because long-term effects can occur from repeated exposures to a chemical at levels not high enough to make you immediately sick.

Q: What are my chances of getting sick when I have been exposed to chemicals?
A: The likelihood of becoming sick from chemicals is increased as the amount of exposure increases. This is determined by the length of time and the amount of material to which someone is exposed.

Q: When are higher exposures more likely?
A: Conditions which increase risk of exposure include physical and mechanical processes (heating, pouring, spraying, spills and evaporation from large surface areas such as open containers), and "confined space" exposures (working inside vats, reactors, boilers, small rooms, etc.).

Q: Is the risk of getting sick higher for workers than for community residents?
A: Yes. Exposures in the community, except possibly in cases of fires or spills, are usually much lower than those found in the workplace. However, people in the community may be exposed to contaminated water as well as to chemicals in the air over long periods. Because of this, and because of exposure of children or people who are already ill, community exposures may cause health problems.
The following information is available from:

New Jersey Department of Health and
Senior Services
Occupational Disease and Injury Services
Trenton, NJ 08625-0360
(609) 984-1863

Industrial Hygiene Information
Industrial hygienists are available to answer your questions regarding the control of chemical exposures using exhaust ventilation, special work practices, good housekeeping, good hygiene practices, and personal protective equipment including respirators. In addition, they can help to interpret the results of industrial hygiene survey data.

Medical Evaluation
If you think you are becoming sick because of exposure to chemicals at your workplace, you may call a Department of Health and Senior Services physician who can help you find the services you need.

Public Presentations
Presentations and educational programs on occupational health or the Right to Know Act can be organized for labor unions, trade associations and other groups.

Right to Know Information Resources
The Right to Know Infoline (609) 984-2202 can answer questions about the identity and potential health effects of chemicals, list of educational materials in occupational health, references used to prepare the Fact Sheets, preparation of the Right to Know survey, education and training programs, labeling requirements, and general information regarding the Right to Know Act. Violations of the law should be reported to (609) 984-2202.
NITROGEN

DEFINITIONS

ACGIH is the American Conference of Governmental Industrial Hygienists. It recommends upper limits (called TLVs) for exposure to workplace chemicals.

A carcinogen is a substance that causes cancer.

The CAS number is assigned by the Chemical Abstracts Service to identify a specific chemical.

A combustible substance is a solid, liquid or gas that will burn.

A corrosive substance is a gas, liquid or solid that causes irreversible damage to human tissue or containers.

DEP is the New Jersey Department of Environmental Protection.

DOT is the Department of Transportation, the federal agency that regulates the transportation of chemicals.

EPA is the Environmental Protection Agency, the federal agency responsible for regulating environmental hazards.

A fetus is an unborn human or animal.

A flammable substance is a solid, liquid, vapor or gas that will ignite easily and burn rapidly.

The flash point is the temperature at which a liquid or solid gives off vapor that can form a flammable mixture with air.

HHAG is the Human Health Assessment Group of the federal EPA.

IARC is the International Agency for Research on Cancer, a scientific group that classifies chemicals according to their cancer-causing potential.

A miscible substance is a liquid or gas that will evenly dissolve in another.

mg/m$^3$ means milligrams of a chemical in a cubic meter of air. It is a measure of concentration (weight/volume).

MSHA is the Mine Safety and Health Administration, the federal agency that regulates mining. It also evaluates and approves respirators.

A mutagen is a substance that causes mutations. A mutation is a change in the genetic material in a body cell. Mutations can lead to birth defects, miscarriages, or cancer.

NAERG is the North American Emergency Response Guidebook. It was jointly developed by Transport Canada, the United States Department of Transportation and the Secretariat of Communications and Transportation of Mexico. It is a guide for first responders to quickly identify the specific or generic hazards of material involved in a transportation incident, and to protect themselves and the general public during the initial response phase of the incident.

NCI is the National Cancer Institute, a federal agency that determines the cancer-causing potential of chemicals.

NFPA is the National Fire Protection Association. It classifies substances according to their fire and explosion hazard.

NIOSH is the National Institute for Occupational Safety and Health. It tests equipment, evaluates and approves respirators, conducts studies of workplace hazards, and proposes standards to OSHA.

NTP is the National Toxicology Program which tests chemicals and reviews evidence for cancer.

OSHA is the Occupational Safety and Health Administration, which adopts and enforces health and safety standards.

PEOSHA is the Public Employees Occupational Safety and Health Act, a state law which sets PELs for New Jersey public employees.

ppm means parts of a substance per million parts of air. It is a measure of concentration by volume in air.

A reactive substance is a solid, liquid or gas that releases energy under certain conditions.

A teratogen is a substance that causes birth defects by damaging the fetus.

TLV is the Threshold Limit Value, the workplace exposure limit recommended by ACGIH.

The vapor pressure is a measure of how readily a liquid or a solid mixes with air at its surface. A higher vapor pressure indicates a higher concentration of the substance in air and therefore increases the likelihood of breathing it in.
EMERGENCY INFORMATION

Common Name: NITROGEN
DOT Number: UN 1066 (Compressed)
        UN 1977 (Refrigerated Liquid)
NAERG Code: 121 (Compressed)
        120 (Refrigerated Liquid)
CAS Number: 7727-37-9

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CONTAINERS MAY EXPLODE IN FIRE

Hazard Rating Key: 0=minimal; 1=slight; 2=moderate; 3=serious; 4=severe

FIRE HAZARDS

* Use water to cool fire-exposed containers.
* CONTAINERS MAY EXPLODE IN FIRE.
* Extinguish fire using an agent suitable for type of surrounding fire. Nitrogen itself DOES NOT BURN.
* If employees are expected to fight fires, they must be trained and equipped as stated in OSHA 1910.156.

SPILLS AND EMERGENCIES

If liquid Nitrogen is spilled or leaked, take the following steps:

* Evacuate persons not wearing protective equipment from area of spill or leak until clean-up is complete.
* Ventilate the area of spill or leak.
* Stop the leak or move the container to a safe area and allow the liquid to evaporate.

If Nitrogen gas is leaked, take the following steps:

* Evacuate persons not wearing protective equipment from area of leak until clean-up is complete.
* Ventilate area of leak to disperse the gas.
* Stop flow of gas. If source of leak is a cylinder and the leak cannot be stopped in place, remove the leaking cylinder to a safe place in the open air, and repair leak or allow cylinder to empty.
* It may be necessary to contain and dispose of Nitrogen as a HAZARDOUS WASTE. Contact your Department of Environmental Protection (DEP) or your regional office of the federal Environmental Protection Agency (EPA) for specific recommendations.
* If employees are required to clean-up spills, they must be properly trained and equipped. OSHA 1910.120(q) may be applicable.

HANDLING AND STORAGE

* Prior to working with Nitrogen you should be trained on its proper handling and storage.
* A regulated, marked area should be established where Nitrogen is handled, used, or stored.
* Store liquid containers and cylinders in cool well-ventilated areas.
* Use only in well-ventilated areas.
* Cylinders must be secured and protected against damage.

FIRST AID

In NJ, POISON INFORMATION: 1-800-764-7661

Eye Contact
* Immediately flush with large amounts of water. Continue without stopping for 15 minutes, occasionally lifting upper and lower lids. Seek medical attention.

Skin Contact with Liquid Nitrogen
* Quickly immerse affected skin in large amounts of warm water. Do NOT rub the affected area. Seek medical attention.

Breathing
* Remove the person from exposure.
* Begin rescue breathing if breathing has stopped and CPR if heart action has stopped.
* Transfer promptly to a medical facility.

PHYSICAL DATA

Water Solubility: Slightly soluble

OTHER COMMONLY USED NAMES

Chemical Name: Nitrogen
Other Names: Nitrogen Gas

Not intended to be copied and sold for commercial purposes.
### APPENDIX G

#### General Laboratory Safety Checklist

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<td><em>FPM too low for safe operations</em></td>
<td><em>Vacuum pumps need belt guards</em></td>
<td><em>Food stored in lab refrigerator</em></td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td><em>Fan motor needs attention</em></td>
<td><em>Equipment has sharp points or edges</em></td>
<td><em>Evidence of food preparation/consumption</em></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wastes</th>
<th>Spill Kit</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Container not provided in lab</td>
<td><em>Missing</em></td>
<td></td>
</tr>
<tr>
<td>Container not properly labeled</td>
<td><em>Absorbs need replenishing</em></td>
<td></td>
</tr>
<tr>
<td>Log not maintained</td>
<td><em>Instructions missing</em></td>
<td></td>
</tr>
<tr>
<td>Excessive quantities/not being removed every 90 days</td>
<td><em>Needs unpacking</em></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mechanical Hazards</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vacuum pumps need belt guards</td>
<td></td>
</tr>
<tr>
<td>Equipment has sharp points or edges</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other Hazards</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Food stored in lab refrigerator</td>
<td></td>
</tr>
<tr>
<td>Evidence of food preparation/consumption</td>
<td></td>
</tr>
<tr>
<td>Evidence of smoking in lab</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inspector</th>
<th>Situation corrected</th>
<th>Date</th>
<th>Situation not corrected</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sent to:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Comments:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A member of the Environmental Health and Safety Department or the Laboratory Supervisor should complete the safety checklist. The lab should be re-inspected after the initial inspection to insure that the changes were made.

### General Safety

<table>
<thead>
<tr>
<th>Description</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are chemical spill kits available within the lab</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are the chemical spill kits re-stocked after use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are first aid kits available and accessible</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are the first aid kits re-stocked after use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are fire extinguishers available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are the inspections up to date</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the safety shower and eyewash unit accessible and checked regularly for proper operation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the lab equipment safely operated and maintained according to the manufactures specifications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are emergency phone numbers posted in a place that is visible</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Personal Protective Equipment (PPE)

<table>
<thead>
<tr>
<th>Description</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the appropriate glove, safety glasses, lab coats, Tyvek suits, available and worn for the intended process.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the appropriate foot wear being used (no open toed shoes)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the PPE removed when leaving the lab</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the PPE stored in the proper location</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety glasses are used do they meet the ANSI approved standards for safety glasses</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Housekeeping

<table>
<thead>
<tr>
<th>Description</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walkways clear of obstructions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety equipment clear of obstructions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work benches and work surfaces clear of clutter</td>
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<tr>
<td>Are spills cleaned up without delay</td>
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<td>Is the work area properly illuminated</td>
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<td>Are all the light fixtures working properly</td>
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</tr>
<tr>
<td>Are engineering controls examined and maintained as per the manufactures specifications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>-----</td>
<td>----</td>
</tr>
<tr>
<td>Are No Smoking signs posted within the lab area</td>
<td></td>
<td></td>
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<tr>
<td>Is the lab cleaned on a daily basis</td>
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<tr>
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<td></td>
</tr>
<tr>
<td>Lab Waste Disposal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemicals disposed of properly within the 90-day specification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are outdated and unused chemicals disposed of properly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are the proper labs on any hazardous waste containers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the broken glass separated from the regular lab waste</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical Safety</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are proper storage procedures followed for all chemicals</td>
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<tr>
<td>Are labels clear and easy to be read as per the New Jersey Right to Know Act</td>
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<tr>
<td>Are the caps and seals on the containers free of damage</td>
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<tr>
<td>Is the containers that the chemicals are stored in the proper containers for the chemicals</td>
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<tr>
<td>Has the appropriate engineering controls been put into place to handle toxic materials (fume hoods, ventilation systems, etc.)</td>
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<tr>
<td>Are procedures in place for critical shut down of the equipment if needed</td>
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<td>Can a less harmful method be used that would create the same results within the lab</td>
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<tr>
<td>Are the workers trained in the safe handling practices of hazardous chemicals</td>
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<td></td>
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<tr>
<td>Are the workers aware of the dangers that they might encounter within the lab</td>
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<td></td>
</tr>
<tr>
<td>Have the workers attended the 29 CFR 1910.1450 and the Right to Know training</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flammable and Combustible Materials</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are combustible waste kept at a minimum and disposed of properly</td>
<td></td>
<td></td>
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<tr>
<td>Are all flammable liquids stored in the proper containers or cabinets</td>
<td></td>
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<tr>
<td>Are the containers that contain flammable liquids kept tight and free of defects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do the storage rooms that contain the flammable and combustible materials contain equipment that is explosion proof</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compressed Gases</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are the compressed gas cylinders properly secured which includes when they are full or empty</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are the cylinders clearly labeled with the contents</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are the cylinders labeled to tell whether it is full or empty</td>
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<tr>
<td>Are the cylinders secured during transport</td>
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<tr>
<td>Are the cylinders stored away from a heat source</td>
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<td></td>
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<tr>
<td>Are the cylinders leak tested after installation and then again before use</td>
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<td></td>
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<tr>
<td>Are the cylinders stored in an area that they are free from damage from falling objects</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Electrical Safety**

| Is access to circuit breaker panels easily accessible | Yes No |
| Is the breaker panel closed when it is not needed |  |
| Are the electrical cords free of damage (fraying) |  |
| Are electrical cords placed so that they are not hanging off of equipment or pipes or creating a tripping hazard |  |
| Are all motors properly maintained as per the manufactures specifications |  |

**Exits and Access**

| Are all the exits visible and not obstructed | Yes No |
| Are all the exits signed and are the signs lighted |  |
| In the case of an emergency are there the appropriate amount of exits within the buildings, and is the appropriate aisle width maintained? |  |
| If there are doors that are not exits are they labeled as such (basement, storerooms, etc.) |  |

**Fire Safety**

| Are the sprinkler heads free from obstructions | Yes No |
| Are fire extinguishers located within the lab |  |
| Have the fire extinguishers been inspected (monthly) and is this noted on the inspection tag |  |
| Are the fire extinguishers mounted at the appropriate height |  |
| Are there maps of the lab posted to show the routes of exit in the case of an emergency |  |
| Has the fire alarm system been tested annually to insure that it works properly |  |
| Have the lab workers been trained on how to use the fire extinguisher if needed |  |
| Is there a master list of the location of all the fire extinguishers and the type of extinguisher |  |

**Ergonomics**

| Are workers operating in positions where the persons upper body is supporting the weight of their body on a sharp edge of the workspace | Yes No |
| Is the worker performing work that is repetitive without adequate rest |  |
| Is the worker straining to reach equipment that is too high or too low |  |
| Does the PPE fit the person (one size does not fit all) |  |
| Is the worker holding there body in a awkward position that places strain on the persons body |  |
| Is the worker lifting or carrying items that are too heavy for the individual |  |
### Record Keeping

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
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<tbody>
<tr>
<td>Is there a chemical hygiene plan</td>
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<td></td>
</tr>
<tr>
<td>Are there material safety data sheets available for all chemicals within the lab</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is there a most recent chemical inventory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is an emergency response plan in place and have the workers been trained in the plan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have all the workers within the lab gone through the appropriate training for the lab</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the training documented</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Comments and Recommendations

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
APPENDIX I

Lab Safety Checklist
Microelectronics Lab

Inspected by:  Danielle Di Gironimo (unofficial)
Date:  April 4, 2004

A member of the Environmental Health and Safety Department or the Laboratory Supervisor should complete the safety checklist. The lab should be re-inspected after the initial inspection to insure that the changes were made.

<table>
<thead>
<tr>
<th>General Safety</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are chemical spill kits available within the lab</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Are the chemical spill kits re-stocked after use</td>
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<tr>
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<td></td>
</tr>
<tr>
<td>Are fire extinguishers available</td>
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<td></td>
</tr>
<tr>
<td>Are the inspections up to date</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Is the safety shower and eyewash unit accessible and checked regularly for proper operation</td>
<td>see bottom</td>
<td></td>
</tr>
<tr>
<td>Is the lab equipment safely operated and maintained according to the manufactures specifications</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Are emergency phone numbers posted in a place that is visible</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Personal Protective Equipment (PPE)</th>
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<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the appropriate glove, safety glasses, lab coats, Tyvek suits, available and worn for the intended process.</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Is the appropriate foot wear being used (no open toed shoes)</td>
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<td></td>
</tr>
<tr>
<td>Is the PPE removed when leaving the lab</td>
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<td></td>
</tr>
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<td>Is the PPE stored in the proper location</td>
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<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Housekeeping</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walkways clear of obstructions</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Safety equipment clear of obstructions</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Work benches and work surfaces clear of clutter</td>
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<td>Are portable ladders in good condition and secured properly when not on use</td>
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<td></td>
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<tr>
<td>Are engineering controls examined and maintained as per the manufactures specifications</td>
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<td></td>
</tr>
<tr>
<td>Are No Smoking signs posted within the lab area</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Is the lab cleaned on a daily basis</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Is the floor surface kept clean and dry to prevent slip, trip, and fall hazards</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Are the pipes within the lab marked as to their contents</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

**Lab Waste Disposal**

| Chemicals disposed of properly within the 90-day specification | X |
| Are outdated and unused chemicals disposed of properly | X |
| Are the proper labels on the hazardous waste containers | X |
| Is the broken glass separated from the regular lab waste | X |

**Chemical Safety**

| Are proper storage procedures followed for all chemicals | X |
| Are labels clear and easy to be read as per the New Jersey Right to Know Act | X |
| Are the caps and seals on the containers free of damage | X |
| Are the containers that the chemicals are stored in the proper containers for the chemicals | X |
| Has the appropriate engineering controls been put into place to handle toxic materials (fume hoods, ventilation systems, etc.) | X |
| Are procedures in place for critical shut down of the equipment if needed | X |
| Can a less harmful method be used that would create the same results within the lab | X |
| Are the workers trained in the safe handling practices of hazardous chemicals | X |
| Are the workers aware of the dangers that they might encounter within the lab | X |
| Have the workers attended the 29 CFR 1910.1450 and the Right to Know training | see bottom |

**Flammable and Combustible Materials**

| Are combustible waste kept at a minimum and disposed of properly | X |
| Are all flammable liquids stored in the proper containers or cabinets | X |
| Are the containers that contain flammable liquids kept tight and free of defects | X |
| Do the storage rooms that contain the flammable and combustible materials contain equipment that is explosion proof | N/A |

**Electrical Safety**

| Is access to circuit breaker panels easily accessible | X |
| Is the breaker panel closed when it is not needed | X |
| Are the electrical cords free of damage (fraying) | X |
| Are electrical cords placed so that they are not hanging off of equipment or pipes or creating a tripping hazard | X |
| Are all motors properly maintained as per the manufactures specifications | X |
### Compressed Gases

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are the compressed gas cylinders properly secured</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Are the cylinders clearly labeled with the contents</td>
<td>X</td>
<td></td>
</tr>
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<td>Are the cylinders labeled to tell whether it is full or empty</td>
<td>X</td>
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<td>Are the cylinders stored away from a heat source</td>
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<tr>
<td>Are the cylinders leak tested after installation and then again before use</td>
<td>X</td>
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<tr>
<td>Are the cylinders stored in an area that they are free from damage from falling objects</td>
<td>X</td>
<td></td>
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</table>

### Exits and Access

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are all the exits visible and not obstructed</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Are all the exits signed and are the signs lighted</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>In the case of an emergency is there the appropriate amount of exits within the buildings, and is the appropriate aisle width maintained?</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>If there are doors that are not exits are they labeled as such (basement, storerooms, etc.)</td>
<td>X</td>
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</table>

### Fire Safety

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are the sprinkler heads free from obstructions</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Are fire extinguishers located within the lab</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Have the fire extinguishers been inspected (monthly) and is this noted on the inspection tag</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Are the fire extinguishers mounted at the appropriate height</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Are there maps of the lab posted to show the routes of exit in the case of an emergency</td>
<td>X</td>
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<tr>
<td>Has the fire alarm system been tested annually to insure that it works properly</td>
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<tr>
<td>Have the lab workers been trained on how to use the fire extinguisher if needed</td>
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<td>Is there a master list of the location of all the fire extinguishers and the type of extinguisher</td>
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### Ergonomics

<table>
<thead>
<tr>
<th>Requirement</th>
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<tr>
<td>Are workers operating in positions where the persons upper body is supporting the weight of their body on a sharp edge of the workspace</td>
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</tr>
<tr>
<td>Is there a most recent chemical inventory</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Is an emergency response plan in place and have the workers been trained in the plan</td>
<td></td>
<td>see bottom</td>
</tr>
<tr>
<td>Have all the workers within the lab gone through the appropriate training for the lab</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Is the training documented</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

Comments and Recommendations

The one of the eyewash stations was obstructed with a cylinder dolly. At the time of the unofficial inspection the tags were not visible. The walkways toward the back of the lab were tight. They did not meet the minimum 3-foot standard of how wide an aisle should be. Alternatives should be thought of in order to maintain the aisle way. The process has been checked to insure that the last hazardous chemicals are being used. Some of the workers have gone through the Chemical Hygiene Plan training and all employees have gone through the right to know training. Explosion proof equipment was not seen during the inspection. When the inspection was conducted the electrical panels were all in the open position, they should be closed and secured. The cord that powered the computer was plugged into a power strip that hung in the air. This situation should be looked at better in order for the power cord not to hang off the ground. Most cylinders were secured properly but there were a few small cylinders that were not secured and should be checked. There was a cylinder that was strapped to a table. The table was obviously a work area and there is a danger of the cylinder being struck from an object from the bench. I was not able to find out if the workers in the lab are tried to use the fire extinguishers and I was not able to ask for a fire extinguisher inventory at the time of the inspection. As per the labs own pre-qualification questionnaire workers are required to know how to respond in an emergency situation.
APPENDIX J

Layout of a Microelectronics Lab
REFERENCES


REFERENCES
(Continued)


REFERENCES
(Continued)


www.cdc.gov/niosh/homepage.html

http://hazmat.dot.gov

www.osha.gov

http://www.state.nj.us/health/eho/rtkweb/rtkhsfs.htm