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ABSTRACT

SAFETY GUIDELINES FOR OCCUPATIONAL HAZARDS TO THE REPRODUCTIVE SYSTEM

by
Laverne Raquel Ogieste

Most workers are unaware of the hazards to the reproductive system that surround them in the workplace, and therefore, few if any precautions are taken to avoid unnecessary exposures. In this research, safety guidelines were developed in order to eliminate such dangers from occurring or reoccurring.

These guidelines were developed by reviewing case studies of occupational hazards to the reproductive system, including federal laws and regulations related to safety within the workplace. The following forms were also developed in order to formulate suitable safety guidelines for occupational hazards to the reproductive system. They are: an occupational reproductive survey, a reproductive screening questionnaire, and a personal chemical or source of exposure monitoring form.

The safety guidelines developed for occupational hazards, would reduce the levels of exposure to the reproductive system. With these guidelines in place, workers would become more aware of the hazards around them. These established guidelines would promote the use of protective devices in the workplace if engineering controls are not feasible, thus reducing existing occupational hazards to the reproductive system.

SAFETY GUIDELINES FOR OCCUPATIONAL HAZARDS TO THE REPRODUCTIVE SYSTEM

by
Laverne Raquel Ogieste

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This thesis is dedicated to
my wonderful family and friends,
including those who reside on the beautiful island of Tobago, West Indies.

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ACRONYMS AND ABBREVIATIONS

ACGIH - American Conference of Governmental Industrial Hygienist.

CAS - Chemical Abstract Service number.

CDC - Center for Disease Control.

CFR - Code of Federal Regulations.

CNS - Central Nervous System.

DOH - Department of Health.

et al. - and others.

et seq. - and following.

e.g. - for example.

HSFS - Hazardous Substance Fact Sheet.

JSA - Job Safety Analysis.

MSDS - Material Safety Data Sheet.

NIOSH - National Institute for Occupational Safety and Health.

OSHA - Occupational Safety and Health Administration.

OSHC - Occupational Safety and Health Cases.

PEL - Permissible Exposure Limit values. Levels of exposure recommended by the ACGIH.

PPE - Personal Protective Equipment (gloves, goggles, apron, respiratory equipment).

TLV - Threshold Limit Values. Levels of exposure recommended by the ACGIH.

TWA - Time Weighted Average.

CHAPTER 1

INTRODUCTION

1.1 Problem Description

Occupational hazards to the reproductive system should be of great concern to all workers; especially those who work around hazardous chemicals. However, on a more practical level, most workers are not aware of the fact that their jobs or working environments contain many hazardous substances including some that can affect their reproductive system. Furthermore, only a small percentage of workers who are aware of occupational reproductive hazards, may know how to protect themselves.

The average person today hopes to find an ideal job, earn a comfortable income, and raise a family. For some people, however, these goals may never become reality. The truth is that too many workers forget about themselves and the hazards of the job, because their incomes have made them too complacent. Only years later, do they learn of unfortunate reproductive disabilities which occurred within the workplace, and of hazards which could have been avoided, if precautions were taken from their first day on the job.

Keep in mind, that the causes of most occupational hazards affecting the reproductive system are still not fully known. This is why it is very important that employers establish feasible safety guidelines for potential occupational reproductive hazards to avoid unnecessary and costly mishaps from occurring or reoccurring in the workplace. Listed below are some examples of causes of reproductive hazards that are currently known:

- Poor diet
- Drug abuse
- X-ray exposure
- Cigarette smoking
- Alcohol consumption
- Lack of prenatal care and other maternal factors

These potential hazards all can contribute to a poor reproductive outcome. While the contribution of workplace exposure to reproductive harm is not clear, the number of workers exposed to known or presumed reproductive toxicants is indisputably large. This fact has prompted the National Institute of Occupational Safety and Health (NIOSH), to rank work related reproductive impairment as the sixth of ten leading work-related entities requiring action.[2] Therefore it is very important that workers become aware of the hidden dangers within their work environment, especially those that pose dangers or hazards to the reproductive system. These hidden dangers can present the most deadly results over time.

1.2 Problem Statement

There is very little information on occupational reproductive hazards available today. There are also no established standards or regulations related to occupational hazards to the reproductive system set by the Occupational Safety and Health Administration (OSHA). But workers do not have to be oblivious to this important concern due of the lack of information. There are many workers who are ignorant of the fact that their jobs

or working environment can cause hazards to their reproductive system. There are also some workers who choose to ignore such hazards because management emphasizes the idea of quantity, quality and productivity as the primary goals or the mission of the job, ignoring their personal safety and security. Therefore, all efforts are directed towards the job that they are doing, and not on their personal safety, especially as it relates to reproductive exposure.

It is evident, that there is a need for regulated occupational reproductive hazard standards within the workplace. These standards can be used to educate, train and protect workers from potential reproductive exposures within the work environment. Workers must realize that their safety and well being should always be valued as a top priority at the jobs which they perform on a daily basis.

1.3 Research Objective

The objective of this research is to develop feasible safety guidelines to prevent or minimize occupational hazards to the reproductive system of both male and female workers. These guidelines can serve as a helpful tool in increasing workers' awareness of occupational hazards to the reproductive system. These guidelines can also heighten the awareness level of exposures to the reproductive system, and promote the use of appropriate protective devices in the workplace.

1.4 Organization of Thesis

The body of this thesis consist of five chapters. The research begins by giving the reader background information on occupational reproductive exposures serving as an elucidating reference source. In order to fully understand the need for safety guidelines for occupational hazards to the reproductive system, a discussion of the reproductive system serves as an informative and educational reference source. Toxicology and industrial hygiene are vital in the understanding of occupational exposures in relation to dosage and duration, and the construction of effective control measures used in eliminating occupational reproductive hazards. In order to understand the standards and governmental approaches to the subject of occupational reproductive exposure, a discussion of the applicable laws is included. This involves not only safety regulations and safety in the workplace, but also actions currently being taken on this subject.

Occupational reproductive exposure cases provide information on a few case studies of occupational exposures which have already occurred as a result of having no occupational reproductive safety guidelines for the workplace. The research focuses on three specific areas familiar to most people. The research includes: chemical exposure, specifically gasoline, lead exposure, and radiation exposure. The discussion of the risks associated with these occupational exposures delineates important reproductive risk exposure calculations or measurements which can be used in assessing occupational reproductive risk in the workplace. Finally, the development of the safety guidelines for occupational hazards to the reproductive system was obtained through the use of an occupational reproductive hazard survey, a reproductive screening questionnaire, and a personal daily exposure monitoring form.

CHAPTER 2

LITERATURE REVIEW

2.1 Background Information

Occupational hazards to the reproductive system have been a problem overlooked for too long. There are no established standards or regulations related to occupational hazards to the reproductive system set by OSHA. However, there are a few guidelines which suggest ways to prevent reproductive exposures, but none have been regulated or mandated. Some background information pertaining to excerpts of case studies on occupational reproductive exposures will show the need for safety guidelines for potential occupational exposures or hazards. Many general safety guidelines have been developed over the years, but none specifically for occupational exposures to the reproductive system. In order to fully understand the need for regulated guidelines for occupational reproductive hazards, we first need to understand the human reproductive system to evaluate various industrial hazard control methods.

2.2 The Law: Safety Regulations and Safety in the Workplace

The American Heritage Dictionary defines the word safety as "freedom from danger, risk or injury." Some companies with the best safety and health programs often look not only at injuries and illnesses, but also at near misses. However, it is hard to design a program to keep people from getting hurt if you don't know what's hurting them.[18] OSHA formulates regulations and standards for substances that show a large number of workers being exposed. However, the establishment of standards to prevent occupational

reproductive exposures before they occur should be given top priority. Companies may not be aware that a large number of workers are exposed to reproductive hazards within the workplace, if information related to reproductive exposures or hazards is limited, or not investigated. Employers also must realize that they need to identify things that cause people to get hurt or sick, then work to eliminate them. Safety training alone does not ensure a safe work environment. Once safety performance feedback is involved, workplace safety can be improved significantly.[17] In Chapter Five, the development of a personal daily chemical or source of exposure monitoring form is used as feedback in the documentation of potential workplace related hazards and exposures.

The integration of industrial hygiene control methods within the workplace should include the use of medical surveillance teams, especially for monitoring the adverse effects of chemical agents of concern that cannot be eliminated. This can be an effective approach to the control of reproductive hazards in the workplace. This technique can be enhanced by including risk communication to initiate the control of reproductive hazards in the workplace.[2] Subsection 2.4 discusses industrial control methods, and Chapter Four discusses risk communication as an effective approach to monitoring and controlling occupational reproductive hazards.

There are numerous laws and regulations pertaining to safety in the workplace. Worker safety on various industrial machine, and occupations in industry can be found in specified CFRs. However, there are no laws or regulations related specifically to occupational safety for reproductive hazards in the workplace. There are only guidelines that chemical industries follow pertaining to the prevention of chemical exposure to the reproductive system through the use of MSDSs and HSFSs. There are also reproductive

screening questionnaires (see the Reproductive Screening Questionnaire in Chapter Five) that industrial hygienists can use to obtain information on reproductive exposures that may exist in the work environment.

OSHA, which was created in 1970, has as its mission - "to assure working men and women a safe and healthful workplace." Under the 29th Code of Federal Regulations Subtitle B - Regulations Relating to Labor, a number of workers are covered; for example, employees who work with lead, cadmium, radiation, et al. However, most chemical manufacturers do not specify the reproductive hazards associated with certain chemicals, and very few chemical manufacturing companies indicate reproductive dangers or precautions in the MSDSs and HSFSs given to chemical consumers. This is why the development of regulations and standards that apply established procedures relating to occupational reproductive hazards or exposures for all manufactured chemicals should be mandatory. Not only must established procedures be set by the government, but some provision must be made for mandatory education and training on the safe usage of all potentially dangerous chemicals.

2.3 The Reproductive System: A Synopsis

The word reproduce is defined as the ability to produce a counterpart, image, or copy of, the ability to produce offspring, or re-create. The word system is defined as the human body as a functional unit, a network as for communication.[14] Therefore, the reproductive system, is the human body as a functional unit with the ability to produce an offspring. There are two main reproductive systems of concern in this research; they are the male reproductive system, and the female reproductive system. We will first look at the male reproductive organs and functions (see Figure 1). The male reproductive system consists of eight organs, they are:

1. The Testes
2. The Duct System
3. The Seminal Vesicles
4. The Prostate Gland
5. Mucus Producing Glands
6. The Urethra
7. The Penis
8. The Spermatozoa

The testes produces sperms and sex hormones. The seminal vesicles, prostate gland, and bulbourethral glands produce lubricating and alkalining secretions to aid the transport of the sperm.[15]

Table 2.1: The Human Male Reproductive Organs and Functions

ORGANS	FUNCTIONS
Testes	The gonads in the male
Gonads	Gamete-producing gland; a testis; a sex gland
Seminal vesicles	In mammals, glandular sacs which secrete a component of the seminal fluids, In some invertebrates, structures that store sperm.
Prostate glands	The largest accessory sex gland of male mammals; it surrounds the urethra at the point where the vasa deferentia join it, and it secretes a large portion of the seminal fluid.
Mucus producing glands	A viscous secretion that serves to lubricate body parts and to trap particles of dirt or other contaminants.
Urethra	The tube which conducts urine from the bladder to the outside of the body.
Penis	The male sexual organ of copulation (sexual union) in reptiles and mammals.
Spermatozoa	Mature sperm cells.

Source: A. J. Vander, et. al., Human Physiology: *The Mechanisms of Body Function*, 6th Edition, McGraw-Hill: New York, 1994

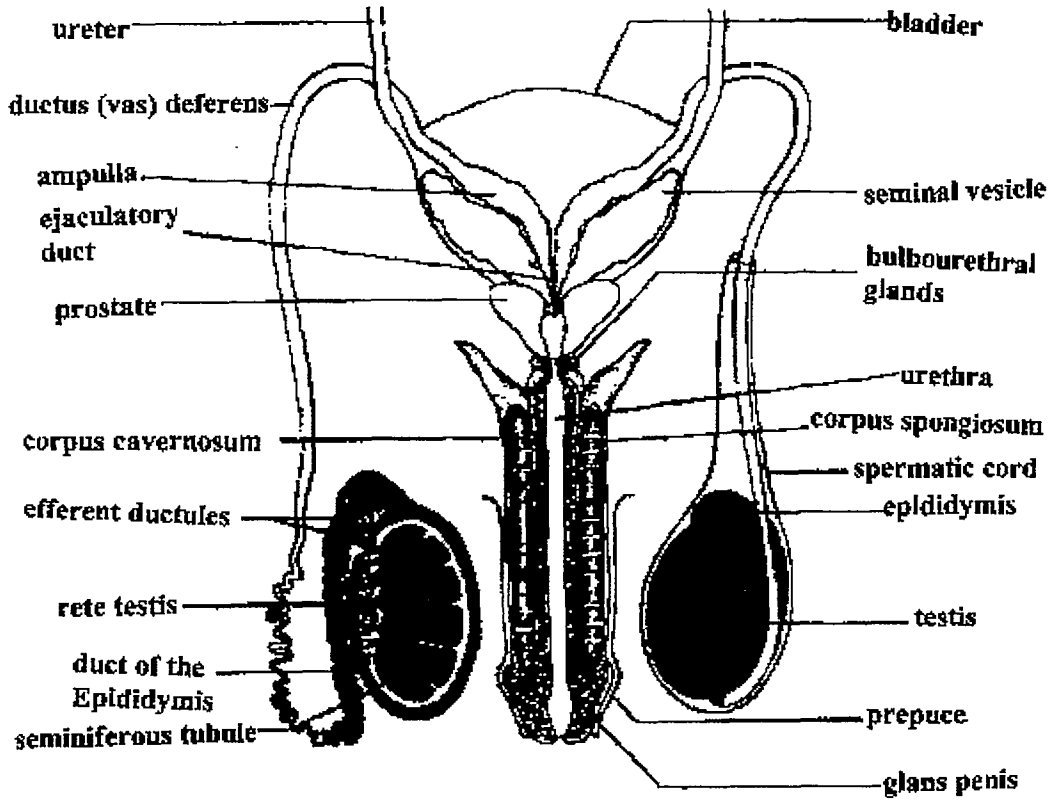

Figure 1: A Cross Sectional View of the Human Male Reproductive System.[8]

The female reproductive system consists of seven major organs (see Figure 2):

1. The Ovaries or Female Gonads
2. The Oviducts
3. The Uterus
4. The Vagina
5. The Greater Vestibular Glands
6. The Vulva
7. The Perineum

Table 2.2: The Human Female Reproductive Organs and Functions

ORGANS	FUNCTIONS
Ovaries or Female Gonads	Responsible for producing eggs and sex organs
Oviducts	Tube that carries ova from the ovary to the uterus, body exterior.
Uterus	The womb, the hollow, muscular organ of the female reproductive tract in which the fetus undergoes development.
Vagina	The elastic, muscular tube extending from the cervix to its orifice, that receives the penis during sexual intercourse, and serves as a death canal.
Greater vesicles glands	In mammals, glandular sacs which secrete a component of the seminal fluids.
Vulva	The liplike external genital structures in the female
Perineum	The area between the vaginal opening and the anus.

Source: A. J. Vander et al , Human Physiology: *The Mechanisms of Body Function*, 6th Edition, McGraw-Hill: New York, 1994.

The ovaries produce ova and hormones, the oviducts provide a place for fertilization, the vagina receives the spermatozoa, and is part of the birth canal.[15] For pregnant women, it is important to note that infections normally occur within the second trimester of pregnancy and the fetus is normally affected through the placenta.

In some females, abnormal menstrual cycles, are clear indications of problems within the reproductive system. The menstrual cycle of a female occurs every twenty

eight days. During this time, the reproductive organs can become targeted organs prone to attack by certain types of chemicals or other occupational sources of exposure.

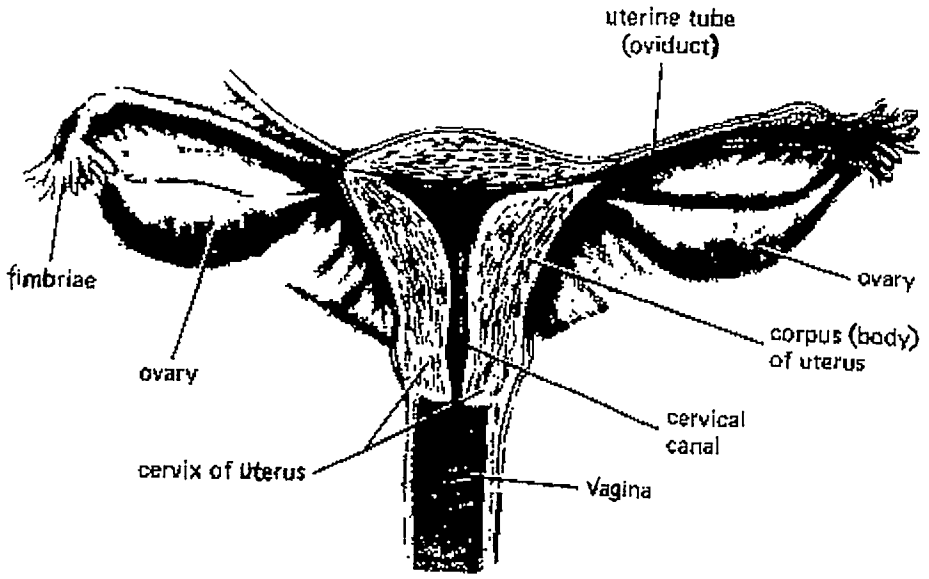

Figure 2: A Cross Sectional View of the Human Female Reproductive System.[8]

The reproductive system is one of the most vital systems in the body. It plays an indispensable role in continuing the existence of mankind, and therefore, its level of importance is critical. Diseases, deformities and genetic information are created or transmitted as a result of the environmental factors affecting the human body. Factors such as chemical exposures within the workplace, and the physical tasks performed on the job are two factors that directly affect the reproductive system. The chapters which follow will address these factors, and preventive measures that should be taken in order to avoid potential occupational reproductive exposures in the workplace. Together both male and female reproductive organs are necessary in the development of another human

being and the need to protect each person's vital organs, should be every individual's priority in life.

2.4 Toxicology and Industrial Hygiene

Toxicology is the study of how chemicals enter the body and affect various systems and organs within the body. Industrial hygiene addresses effective control methods that can be used in reducing occupational hazards or exposures. By looking at both toxicology and effective industrial hygiene preventative measures, potentially hazardous occupational exposures to the reproductive system can be prevented and eliminated.

Any substance can be harmful if it is not handled properly.[23] The following are toxicological terms frequently used in assessing occupational exposures, they are :

- *Toxicity* - the ability of a substance to cause injury or harm to the body.
- *Hazard* - the likelihood that a substance will cause injury or harm within a set of given conditions.
- *Dose* - the amount of a substance taken into the body at one time.
- *Toxic Effect* - for the body to experience a toxic effect several factors must be considered:
  - ⇒ The dose
  - ⇒ The substance itself
  - ⇒ Time (length) of exposure
  - ⇒ Personal susceptibility

There are four basic routes of exposure, they are: (1) inhalation; (2) ingestion; (3) injection; and (4) absorption.

Back in the late 1950s and early 1960s, English mothers were given the chemical thalidomide for morning sickness during their pregnancy. As a result of taking this drug, some of the babies born to these mothers had no toes, fingers or limbs. This was not an isolated incident. Examples of some of the more common chemicals and factors that target the reproductive system of both males and females are shown in the table below:

Table 2.3: Ten Common Chemicals that Target the Reproductive System.

CHEMICALS	PHYSICAL STATE	OSHA P.E.L. mg/m^3
Benzene	Liquid	30
Carbon Disulfide	Liquid	-
Cocaine	Solid	-
Ethyl Alcohol	Liquid	1900
Formaldehyde	Liquid	-
Hydrogen Peroxide	Liquid	1.4
Lead	Solid	0.05
Nicotine	Liquid	0.5 -
Toluene	Liquid	750
Zinc Oxide (metal fume)	Solid	5

Source: B. Plog et al, *Fundamentals of Industrial Hygiene*, 3rd Edition, Library of Congress Cataloging in Publication Data National Safety Council, 1988.

Based on estimates from Doll and Peto, an estimated 50,000 people die from illnesses caused by workplace chemical exposures.[26] The usage of or exposure to certain chemicals can result in the effects of multiple exposures. The four effects of multiple exposure are listed below:

1. SYNERGISM 1+1 > 2
2. ANTAGONISTIC 1+1 < 1
3. ADDITIVE 1+1 = 2

4. POTENTIATION - A chemical does not represent a significant toxic hazard except, in the presence of a second chemical which may or may not be toxic.

Exposure to various chemicals, toxic substances or any source of occupational exposures can result in serious health effects. There are two types of health effects to investigate:

- ACUTE EFFECTS
- CHRONIC EFFECTS

An Acute Effect - occurs immediately, the result of a large dose over a short period of time. Below are five acute health effects:

1. Irritant - a substance that will aggravate or inflame tissues, mucous membranes - eyes, nose, and throat upon contact; e.g. ammonia
2. Corrosive - a substance that will cause burns by destroying tissues at the point of contact; e.g. acids and bases
3. Asphyxiate - a substance that will reduce the amount of oxygen in the air or limit the blood from carrying adequate amounts of oxygen to the vital organs of the body. e.g. carbon di/monoxide, nitrogen propane, methane, freon 22, and trichlorofloromethane.
4. Anesthetic - a substance that will cause dizziness, drowsiness and headaches; e.g. 1,1,1 trichloroethane, paint thinners and ether which was used years ago as an anesthetic in surgery.
5. Allergic/Sensitizer - individuals might develop allergic responses to certain types chemicals that others may not. The reaction varies from person to person. People who work with organic solvents such as paint thinners or part cleaning chemicals may develop contact dermatitis (scaly, dry rash on skin) when exposed to the substance.[23]

A Chronic Effect occurs more slowly, where small doses are observed over long periods of time (for example working with a hazardous substance 40 hours per week for 50 weeks per year over 20 years). Four chronic health effects are listed below:

1. Carcinogen - causes cancer: e.g. benzene, coal, tar, asbestos
2. Mutagen - causes changes in genetic material (DNA), produces mutagen in offspring. e.g. radiation, LSD - a drug used in the early 1960's and benzene, an additive in gasoline.
3. Tetratogen - a substance that will not hurt the mother, but will cross the placenta and hurt the unborn child. e.g. a drug called thalidomide used in the early 60's for morning sickness on pregnant women. The effect was devastating, the babies were born with no limbs, blind, deaf or still borne.
4. Systemic or Target Organ - a substance that enters one place but affects specific organs in the body, e.g. drinking alcohol which enters the body through ingestion but affects the brain and liver. Mercury enters through absorption or inhalation and also affects the brain or liver.

Health effects are associated with exposures which exceed recommended exposure limits. There are four measures which may be applied here:

- TLVs - Threshold Limit Values - recommended values
- PELs - Permissible Exposure Levels - required by law
- STELs - Short Time Exposure Levels
- TWA - Time Weighted Average

The use of HSFSs and MSDSs gives a detailed description as to the PELs or TLVs recommended for a particular substance including any personal protective

equipment which may be required, proper handling procedures, contents or ingredients and other information which pertains to the safe usage of a particular chemical. Below is some helpful and useful information pertaining to MSDSs and HSFSs. The similarities and differences between MSDSs and HSFSs are also noted:

SIMILARITIES BETWEEN MSDS AND HSFS

- Both list the hazardous ingredients by common name and CAS number.
- Both list chemical exposure data and limits: PEL, TLV, STEL.
- Both list physical properties: vapor pressure, flash point, water solubility, and both list fire and explosion hazards.
- Both list reactivity data.
- Both list health associated with the chemical: signs and symptoms, routes of entry emergency first aid procedures.
- Both list and suggest safe handling procedures and what to do when a spill occurs.
- Both list and suggest engineering controls, administrative controls and use of Personal Protective equipment.
- Both include proper techniques for handling chemical(s).[23]

DIFFERENCES BETWEEN MSDS AND HSFS

MSDS

- Must be located in the work place area for immediate accessibility by law.
- OSHA does not require or suggest any type of specific training.
- Mandated by federal law and required for all products manufactured and used.
- Written by the manufacturer

- One or many chemicals may be listed on the form if they are contained in the product
- Some of the forms are not completely filed out and the information may not be available.
- Contains eight sections
- May contain some codes for trade secret ingredients
- Not regulated for updates and correct information
- Contains emergency phone numbers and contact person names for further information.

HSFS

- Not required to be located in the work area, however, it must be accessible to employees during normal operational hours. If an employee requests information on a particular chemical, then information must be given to the person making the request within five working days or they can refuse to work with that substance, with no penalty.
- Contains many useful points of information and is very thorough in scope. It consists of twenty two sections and does not contain any trade secret information. It is updated on a yearly basis by the state DOH and has no information on emergency information.
- Employees must be trained in how to use/read the HSFS.
- Are not required by law, and are written by the DOH for one specific chemical.[23]

Classical risk management regulations and risk communication right-to-know laws mandated by OSHA insure employee awareness of hazardous chemicals to which he or she may be exposed. Employees should know how to read and use labels on chemical containers, MSDSs, and HSFSs, and in turn, be able to use or follow the appropriate protective measures and guidelines associated with the usage of all chemicals in the workplace.

The following paragraphs list evaluation techniques which can be used in properly assessing occupational exposures. Warning properties and sampling procedures for the person, and the general work area are evaluated along with some grab, integrated and equipment sampling techniques.[23] These are all suggested methods for identifying potential occupational reproductive exposures. Some other effective control methods that can be used in eliminating potential occupational reproductive exposures look at the source of the exposure, the path of the exposure, and the employee. Methods of controlling the source, the path and the employee are summarized in Table 2.4:

Table 2.4: Industrial Hygiene Control Methods

SOURCE	PATH	EMPLOYEE
• Substitution: Substituting a chemical which is known to cause reproductive hazards, with another chemical which is not a reproductive toxicant. • Process Change: For e.g. brush-painting or dipping instead of spray-painting can minimize the concentration of airborne contaminants. • Wet Method: Airborne dust can be eliminated by applying water/suitable liquids.	• Housekeeping Controls: Housekeeping implies keeping the workplace clean. • Isolation: Isolate workstations where contaminants are released. • General Ventilation: Add or remove air from the work area, to minimize the exposure or hazardous levels. • Local Exhaust: For e.g. dust collectors, which traps contaminants near their source, so that the worker is not exposed to a high and harmful concentration.	• Education/Training: Educate and train workers of the occupational reproductive toxicants within the workplace. • Rotation of Workers: Another example is that a pregnant worker can be placed in a work area that presents a less danger to the fetus. • Monitoring Procedures: For e.g. the use of radiation badges to monitor workers daily exposures. • Personal Protective Equipment (PPE): The use of lab coats, goggles, gloves, etc..

CHAPTER 3

CASE STUDIES

3.1 Cases of Occupational Exposures to the Reproductive System

Occupational Safety and Health Cases (OSHC) on lead exposures to female workers, chemical exposures, specifically gasoline, and radiation exposure will be discussed in the following subsections of this chapter. These cases serve as an insight into the importance or need for mandated safety guidelines for occupational exposure to the reproductive system. The public has long been aware that the health of individuals can be adversely affected by exposures to substances or conditions existing in certain occupations or work-places.[12] The following paragraphs briefly discuss a few cases of occupational reproduction exposures, and results within certain workplaces. There are over 60,000 chemicals to which humans are exposed, and only 1,600 have been evaluated for their feto-toxic and teratogenic potential in animal. "Chemical contamination of the environment not only presents hazards to the current population, but also to future generations through toxic effects on reproduction."[37] All of the results indicated in these case studies reflect reproductive hazards due to occupational exposures.

3.1.1 Pesticide Exposure

A study conducted on the pregnancy outcome of women exposed to pesticides through work showed detection of cholinesterase inhibitors, which are normally found in insecticides. Cholinesterase inhibitors can cause reproductive defects such as malformations and fetal death. They are also known to be a toxicant in both male and

female reproductive system. There was a total of 534 women who participated in the study and approximately 358 women were used in the analysis of reproductive outcomes. The study showed that the women who handled the pesticides at work used them on a weekly or biweekly basis, and that 90% of these women did not wear proper protective clothing while handling the chemicals on the job. The results also showed eight spontaneous abortions among the women, and a variety of reproductive complications during pregnancy such as toxemia (toxic matter in the blood) which 39 women developed, 248 low birth weights in most women at the average age of 30, and 47 pretermed births.[21]

In Finland, it is not legally permissible to obtain information from employers on maternal employees and workplace exposures in order to gain a more accurate assessments of occupational hazards. Unless occupational illness occurs, an employer is not obliged to declare the nature of chemicals being used at the workplace. In this study, there was no right of access to company records for the purpose of identifying exposures more accurately. During the first trimester of pregnancy, there was a slightly greater exposure to organic solvents among non-control mothers at work than control mothers. Organic solvents have caused congenital abnormalities in animal experiments, and some epidemiological studies have shown higher rates of such defects among children born to women exposed to organic solvents at work. Maternal exposure to organic solvents during the first trimester resulted in a 96% decrease in birth weight. Neural tube defects were the malfunctions most commonly associated with exposure to organic solvents in this study.[1] Neural tube defects relates to or involves a nerve or the nervous system.

3.1.2 Nitrous Oxide Exposure

Nitrous oxide is a gas administered by some dental offices as a pain killer or to calm patients. A new study suggests that using this gas to calm patients may impair a woman's ability to conceive. A total of 439 female dental assistants ages 18 to 39 who had become pregnant four years prior to the study were used in the research.

The research showed that women exposed to high levels of nitrous oxide were "significantly less fertile" than women exposed at lower levels, or not exposed to the gas at all. Women who were exposed to high levels of the gas for five hours or more had a 41% smaller chance to conceive each month than their peers who were not exposed to the gas. The research also showed no fertility harm for women exposed to lower levels of the gas, based on the fact that the rooms in which they worked were well ventilated.

The exact process by which nitrous oxide affects or interferes with infertility is not known. However, it is assumed that the gas blocks the brain's secretion of gonadotropins, a releasing hormone, and therefore prevents ovulation. Another assumption is that the gas disrupts the development of the fertilized egg causing early miscarriages.

Women are not the only target of infertility when exposed to nitrous oxide. Studies have also shown that the gas has produced abnormalities in sperm and reduced fertility in male rats. However, the American Dental Association advises its members to obtain equipment that minimizes exposure to the gas. At present, the recommendation is not mandatory and therefore not all dentists will heed this warning.[36]

3.1.3 Gasoline Exposure

Gasoline contains over one thousand harmful substances. Billions of gallons of gasoline vapors are released at service stations during the refueling of automobiles, at bulk plants, tanks, large transports, and during the refining processes. Gasoline contains many cancer-causing chemicals such as benzene and butadiene. Gasoline is know to cause cancer in many human tissues and organs. In particular, it causes cancer of the mammary glands and uterine sarcoma which are organs of the reproductive system. Gasoline is a derivative of crude petroleum which emerges after a number of refining and manufacturing processes.[4] The world consumed approximately 62 million barrels of crude oil in 1986 and the US alone consumed 120 billion gallons of gasoline in 1989.[13]

Gasoline vapors are the primary route of exposure for the public. There are two routes of exposure for gasoline vapors to enter the body, e.g., (1) inhaled through the nose, and (2) absorbed through the skin. Due to the potential hazards gasoline presents to humans, some states in the United States have implemented control measures in an effort to reduce human exposure to gasoline vapors. There is a substantial vapor release from gasoline and oils, to which humans are exposed at a variety of points including retail refueling stations, inside motor vehicles, and in private homes and commercial buildings. Gas attendants are an especially high risk group with regard to exposure to gasoline. When one pumps gasoline into a vehicle the vapors can be strongly smelled and this odor remains on the hands for a considerable period of time. After twenty four hours and several hand washes and a shower, a faint smell of gasoline still remains on the hands. Imagine the exposure levels of gas station attendants who may work an average of eight hours or more, many days a week, pumping gasoline into thousands vehicles over a year.

In 1982, the EPA estimated that approximately 3.6 billion gallons of gasoline were emitted as vapor or exhaust into the atmosphere in the US alone. Benzene has been identified as the cause of urethelial cancers in petroleum refining workers, printers, and shoe production workers.

Table 3.1: Changes in the TLV - TWA for Benzene Over the Past 46 Years.

YEAR	TLV-TWA (ppm)
1946	100
1947	50
1948-1956	35
1957-1962	25
1977-1987	10
1988-1989	1

Source: M. A. Mehlman, *Dangerous And Cancer-Causing Properties of Products and Chemicals in the Oil Refining and Petroleum Industry: Part IV. Health Effects of Petroleum Products - Scientific Update*, Journal of Occupational Medicine and Toxicology, vol. 1, No. 1, Jan. 1992.

In 1990, the American Conference of Government Industrial Hygiene (ACGIH) recommended that the TLV-TWA for benzene be reduced to 0.1 ppm.[4] Gasoline contains a number of toxic components which present health effects, these are;

1. Benzene which causes strong carcinogenicity and genetic effects and moderate teratogenicity and chronic effects.
2. Toluene had a strong carcinogenicity, tetratogenicity, chronic effects and moderate genetic effects.
3. Xylene has strong carcinogenicity effects and moderate teratogenicity and chronic effects.[13]

Another chemical found in gasoline that affects the reproductive system is 1,3-Butadiene (BD). It is a component of motor vehicle exhaust and has been shown to

increase the incidence of carcinomas of the mammary gland, uterine sarcomas, zymbal gland carcinomas and testicular cancers detected in animals. An inhalation mouse study with BD at Battelle Pacific Northwest Laboratories used mice of both sexes, aged 60 weeks for males and 61 weeks for females. Results showed effects within the following organs: mammary glands and ovaries of females, as well as the preputial gland and the zymbal gland. Human epidemiological studies show significant increases in prostate and urothelial cancers resulting from exposure to gasoline vapors. Stages of controls are being implemented in the United States in order to reduce exposure of the population to gasoline vapors. Figure 3 below shows gasoline vapor controls currently used in gas stations across the United States. Gasoline vapors are trapped in the hose and redeposited into the gasoline tank.

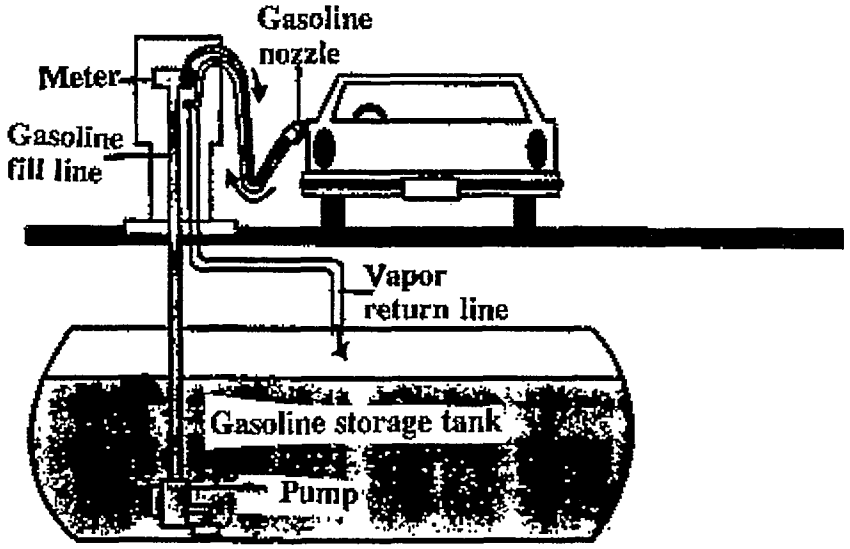

Figure 3: Stage II Controls

3.1.4 Lead Exposure

Two familiar areas where lead can be found are in our drinking water, and in paints. Lead has been utilized for over 5,000 years. United States industry consumes about 1.3 million tons of lead annually. Occupational exposures to lead may be critical for workers in lead smelting, refining, and certain manufacturing industries. In the workplace, the major route for lead exposure is by inhalation and ingestion of both lead bearing dust and fumes. Ingestion occurs from falling paint chips or rubbing hands along paint chipped walls. Skin absorption occurs at self service gas station in the form of tetraethyl lead which used to be added to gasoline. Airborne dusts settle onto food, water, and workers' clothing which is then transferred to the automobile and the house via various paths of exposure to their families.

OSHA PEL lead values are 50 $\mu g/m^3$ averaged over a eight hour period. For exposures for more than eight hours, TWA is a maximum PEL of 400/hours worked per day. NIOSH values are < 0.10 mg/m^3 averaged over a ten hour work shift. ACGIH values indicate 0.15 mg/m^3 averaged over an eight hour work day.[9]

OSHC has shown that employer's fetal protection policy often excludes females of childbearing capacity from jobs involving exposure to lead. This policy does not fall under Title VII's exemption for sex discrimination of bona fide occupational qualification because potentially reproductive female employees still retain their ability to perform other jobs in for example, a battery manufacturing plant. Employers who wish to withstand Tittle VII sex discrimination suits for fetal protection policy which bars fertile women from jobs with 30 g/m^3 airborne lead exposure should take the following steps. Employers must establish bona fide occupational qualifications by showing there is a

factual basis for believing that all or substantially all excluded women would be unable to perform the duties of the jobs involved safely and efficiently. Animal studies conducted by the employees' union failed to establish any confirmation that male employee exposure to lead presents the same dangers to the sperm or fetus as that resulting from female exposure to lead.[22]

Keep in mind that there are various compounds of lead, for example, lead sulfide, lead cyanide, lead sulfate, and lead phosphate. OSHA's allowable blood level in children should be 30μg/100g. The blood levels in the fetus and new born should not exceed 30 μg/100g. By carefully reviewing HSFSs and MSDSs, permissible occupational exposure limits for most chemicals are indicated along with any possible reproductive health effects.

Sex discrimination in the case of occupational reproductive hazards should not be an issue. Both the male and female reproductive system are vital for the formation of life. Therefore, both systems should be treated as being equally important. The table below shows some sources of lead exposure to both males and females.

Table 3.2: Sources of Secondary and Tertiary Lead Exposure on Humans

PRIMARY EXPOSURE SOURCE	SECONDARY EXPOSURE SOURCE	TERTIARY EXPOSURE SOURCE
Air	Dust & soil Water	Food Runoff water Air
Paint	Dust & soil	Runoff water Air
Water from lead pipes		
Food		

Source: P. N. Cheremisinoff, et. al, *Lead: A Guidebook To Hazard Detection, Remediation, And Control*, Prentice-Hall: New Jersey, 1993.

As discussed in Section 2.5 (toxicology and industrial), acute exposure occurs immediately, or as the result of a large dose over a relatively short period of time. The term chronic refers to longer term exposure. Reproductive hazards can generally be categorized as long-term. Over a relatively long period of time, exposure to the chemical or source results are usually not seen until after several years have passed. Acute and chronic health exposure problems associated with lead are shown in Table 3.3.

The group at greatest risk from exposure to lead are fetuses, infants, and children under the age of seven. Pregnant women and women of child-bearing age are also categorized as belonging to the high risk group, since fetuses are definitely at risk from high levels of lead in the blood.[9] A study of sperm characteristics in sixty-eight males occupationally exposed to lead while working in a battery factory eight hours a day, five days a week, showed that lead can alter spermatogenesis, decreasing fertility in exposed men.[38] Exposure to lead in human males have also shown teratogenesis and mutagenesis effects. A study reported that the number of cells with the chromosomal structure had been increased as a result of blood lead levels of 19.29 ± 6.62 μg / 100 ml.[39]

The term latency or latent period is the time that elapses between exposure and the first manifestation of damage. Therefore, the point in time the mother is exposed to the lead during her pregnancy to the point in time where the baby is delivered is the latent period. This is the period when internal damages may occur. The same holds true for children, infants, and women of child bearing age. From when they are exposed to when the damage is detected is a very crucial time period. Therefore precautions should be taken ahead of time. The exposure duration can result in serious health effects termed as acute or chronic health effects as shown in Table 3.3.

Table 3.3: Acute and Chronic Health Exposure Problems Associated with Lead

ACUTE(Short-term)	CHRONIC(Long-term)
Irritability	Nerves of hands and feet
Fatigue	Brain
Depression	Kidneys
Headaches	Reproductive System
Loss of appetite	
Hard to concentrate	
Sleep problems	
Pains in muscular joints	
Stomach cramps (colic)	
Reproductive problems	

Source: P. N. Cheremisinoff, et al., *Lead: A Guidebook To Hazard Detection, Remediation, And Control*, Eaglewood Cliffs, Prentice-Hall: New Jersey, 1993.

The CDC has established a maximum blood level concentration of 25 μg of lead per deciliter of blood in children. However, health effects can be shown at values as low as 10-15 μg/dl. High levels of lead have been shown to cause brain and CNS damage, hearing disabilities, mental retardation, coma and death. The results of acute or chronic exposures, may cause other serious health effects. Possible reproductive health effects of lead exposure in men and women are shown in Table 3.4. The best approach to lead protection is through engineering controls and good work practices as described in 29 CFR 1910.1025 - General Industry Lead Standards.

Table 3.4: Reproductive Health Effects of Lead in Men and Women.

MEN	WOMEN
Decreased sex drive	Decreased fertility
Problems having an erection	Miscarriages
Decreased fertility	Premature births
Birth defects and miscarriages in partners	Still births
	Learning and behavioral problems in offspring

Source: P. N. Cheremisinoff, et al., *Lead: A Guidebook To Hazard Detection, Remediation, And Control*, Eaglewood Cliffs, Prentice-Hall: New Jersey, 1993.

3.1.5 Radiation Exposure

One recently conducted study featured an overview of occupational hazards among veterinarians. It showed results of physical hazards such as radiation, chemicals and drugs. The radiological procedures performed by veterinarians use equipment that gives off radiation. These devices also emit photons of the primary x-ray beam which are scattered by the electrons in the body of the patient and therefore represent a safety hazard for individuals who remain in exposure rooms during the x-ray procedures. It is also important to note that the human embryo is very sensitive to radiation, which can cause mutation and genetic defects to the unborn fetus. The chemical hazards which exist in veterinary laboratories are known to manifest teratogenic and carcinogenic effects in humans. Examples of some of these chemicals used in the laboratory are: chromium salts, nickel salts, phenol, and tannic acid.[23]

Radiation is a form of energy. There are two types of radiation; (1) ionizing radiation and (2) non-ionizing radiation. Non-ionizing radiation can be in the form of

infra-red, visible, ultra-violet, x-rays (note the veterinarian case study), microwaves or lasers. Ionizing radiation may take three related forms; alpha (the least dangerous form of radiation), beta (x-rays) and gamma (the worst and strongest form of radiation).

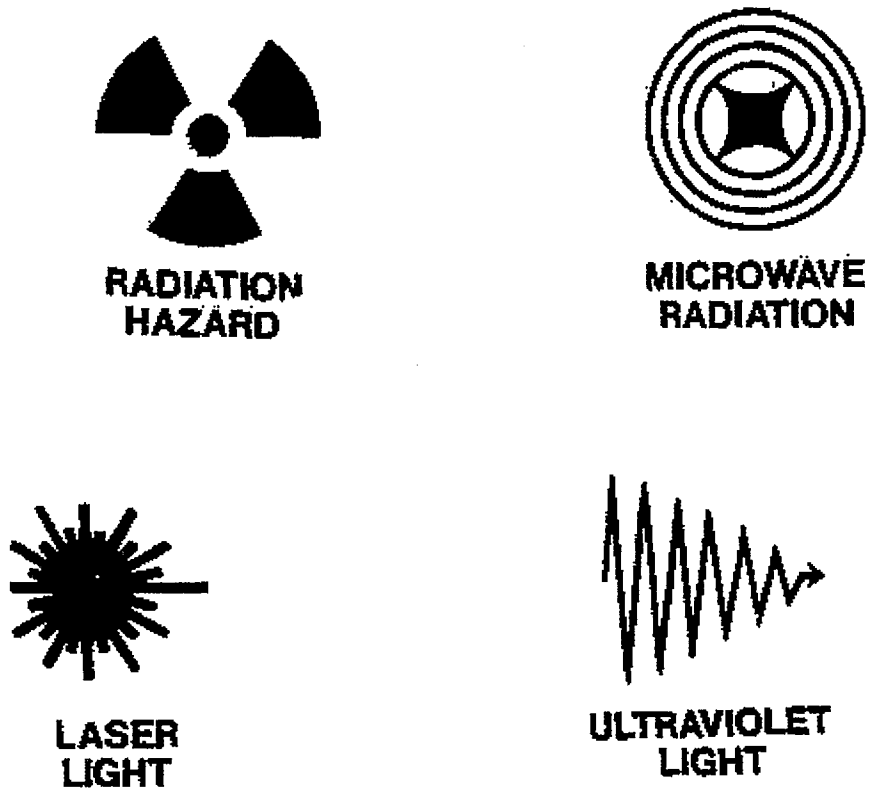

Figure 4A: Radiation Warning Symbols[10]

Figure 4B shows the general or standard symbol used for radiation warning signs, while Figure 4A shows specific radiation caution symbols used in facilities where radiation is present. The Radiation Hazard symbol indicates caution is necessary because radioactive material is being used within the area, for example, the room is designated for radioisotopes. The Microwave Radiation symbol indicates that the room or area may

contain an instrument which emits microwaves. The Ultraviolet Light symbol indicates that the area may contain a source of ultra violet light emissions. The Laser Light symbol indicates that the area or room contains a laser and entrance should not be permitted during its use. Many magnetic field or current producing devices are also sources of radiation.[23]

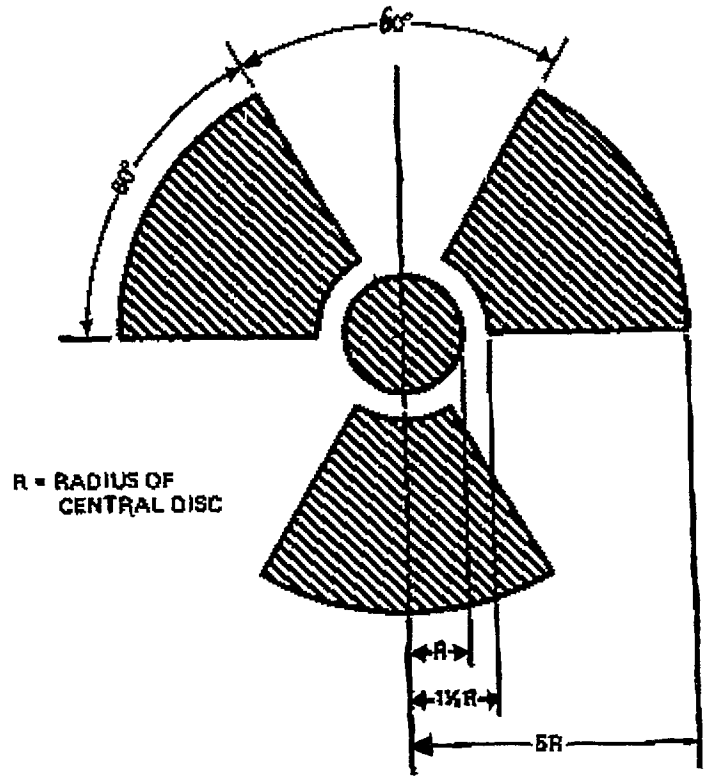

Figure 4B: Standard Radiation Warning Symbol[10]

Some radioactive substances currently used in industry that contain these types of symbols are: phosphorus[32] which emits beta radiation; barium[140] which emits beta and gamma radiation; and iodine[131] which emits beta and gamma radiation. Televisions, computer monitors, utility power lines, and other electrical appliances emit a broad range of electromagnetic radiation. Televisions and VDTs emit electromagnetic radiation at frequencies of sixty Hertz and fifteen to thirty kilohertz. The human body absorbs a

minimal amount of radiation below 200 kilohertz from weak energy field appliances. However, strong energy field appliances or devices to which the human body is exposed on a hourly and daily basis are of great concern here.

Radiation exposure in the workplace is a matter of great concern and is therefore discussed and regulated in the CFR guidelines. Specifically, see Chapter Ten under OSHA - 29 CFR 1910, parts 19 and 20 of Title 10. In 1968, Congress passed the Radiation Control Act which applies to all commercial appliances which present the potential of emitting dangerous levels of radiation. The act mandated severe limits on radiation levels; and as a result, televisions and VDTs have been shielded with lead compounds.[34] With this protective measure in place, emissions have been reduced to levels so low that they are barely detected by sensitive laboratory instruments. A study conducted by the US Public Health Service determined that each television or VDT which passes federal guidelines may degrade over time due to loose shielding or improper maintenance. The Federal Communication Commission (FCC) has also reported computer manufacturers who obtain bogus safety certifications through under-cover laboratories, which could not pass certification. The FCC has issued fines of over $220,000 to companies who marketed machines without proper radiation shielding.[35]

The use of film badges to determine daily levels of occupational exposure, training to educate workers on the dangers of radiation exposure, and protective devices to minimize occupational exposures to radiation each represent methods of control which can be instituted within any work environment that handles radiation. Close monitoring of radiation exposure among workers can be performed using a dosimeter. This may be the best approach towards the minimization of occupational radiation exposure among

workers. Types of dosimeters used in monitoring radiation are; (1) pocket dosimeters, which are direct-reading portable devices shaped like a pen with a pocket clip; These generally measure x- and gamma-radiation; (2) personal alarm dosimeter, monitors x- and gamma -radiation, with an automatic audible alarm if over exposure occurs. These devices will also provide a total read-out of exposure rates for any time period and provide digital readouts as well. [10]

It is important to note that the longer a worker is exposed to radiation, the greater the chances for radiation injury to occur. Figure 5 shows the effect of time on radiation exposure if one were within an area where the radiation level penetrating x- or gamma-radiation was 100 mr(millirems)/hr. Then in one hour, a worker would receive 100 mr. If he/she stayed within that area for two hours, it will be 200 mr, so forth. Exposure time is a major factor in determining severity of exposure.

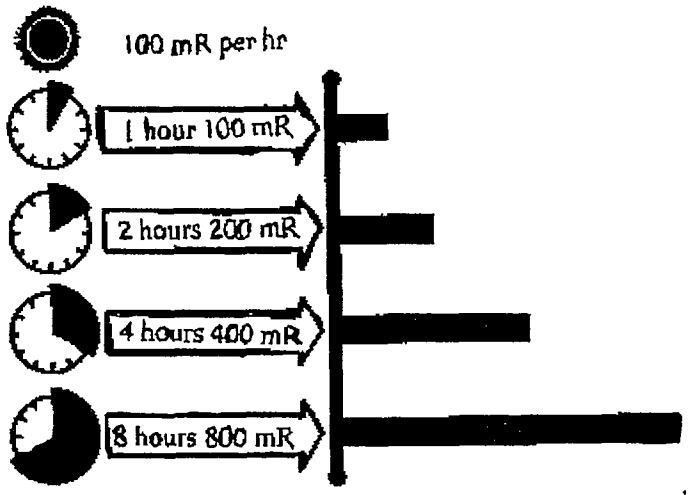

Figure 5: The Effect of Time on Radiation Exposure[10]

Distance is yet another factor in the determination of exposure and radiation injury. Figure 6 shows the effect of distance on radiation exposure. This distance of exposure follows the inverse square law which suggests that the intensity of the radiation falls off by the square of the distance from the source. Therefore, if we had a point source giving off 1000 units of penetrating external radiation at one foot for example, then we would receive only 1/4 as much or $(1/2)^2$ if we double our distance from the penetrating source of radiation. So if we triple the distance from the penetrating source of radiation, we will reduce the dose to 1/8 or $(1/2)^3$.[10] Table 3.5 enumerates several types of radiation and REMs per year recommended for facilities which use radiation. Tables 3.6 shows effects of acute exposure on the ovaries due to radiation exposure. Table 3.7 shows the effect radiation exposure on sperm count.[40]

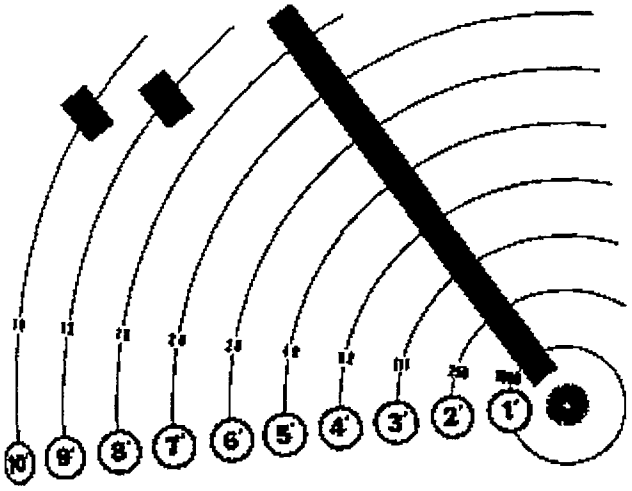

Figure 6: The Effect of Distance on Radiation Exposure[10]

Table 3.5: Types of Radiation Exposure and REMS Per Year

TYPE OF EXPOSURE	REMS PER YEAR
Total Effective Dose Equivalent (TEDE) = Deep-Dose Equivalent (for external exposures) + the Committed Effective Dose Equivalent (for internal exposures) for the whole body	5
Sum of the Deep-Dose Equivalent and the Committed Dose Equivalent to any individual organ or tissue other than the lens of the eye	50
Eye Dose Equivalent (lens of the eye)	15
Shallow Dose Equivalent to the skin or to any extremity	50
Radiation dose limit to the embryo/fetus of a declared pregnant woman during entire pregnancy	0.5

Table 3.6: Effects of Acute Exposure on Ovarian Function[40]

Ovarian Dose (Gy)	Effect(s)
0.6	No effect.
1.5	Some risk for ovulatory suppression in women > 20 years of age.
2.5 - 5.0	In women 15 - 40, 60% may suffer permanent ovulatory suppression; the remainder temporary amonorhea. Menopause may be artificially produced.
5 - 8	In women > 40 years, 60 -70% may suffer permanent ovulatory suppression; the remainder may experience temporary amonorhea. No data for women > 40 years of age.
>8	100% ovulation suppression

Table 3.7: Effects of Fractional Testicular Irradiation on Sperm Count[40]

Testicular Dose (Gy)	Effect (s)
0.1 - 0.3	Temporary oligospermia.
0.3 - 0.5	100% temporary aspermia from 4-12 months post-exposure. Full recovery by 48 months.
0.50 - 1.0	100% temporary aspermia from 3-17 months post-exposure. Full recovery beginning 8-38 months.
1.0 - 2.0	100% temporary aspermia from 2-15 months. Full recovery beginning 11-20 months
2.0 - 3.0	100% aspermia beginning at 1-2 months post-exposure.

3.1.5.1 VDT Exposure: Video display terminals (VDT), commonly known as computer monitors, have generated controversial discussions on possible harmful effects to the reproductive system. Over ten million Americans use VDTs on a regular basis, and many believe that their health has been adversely affected by such use. Office-workers using VDTs believe that the terminals may cause birth defects and possible damage to the reproductive system. However, the American Medical Association has found no evidence that radiation levels are dangerous. So far legistrators in fourteen states have introduced bills that require employers to transfer pregnant women to positions that do not require the use of VDTs.[20]

OSHA has not acted on the issue of VDT radiation, but public pressure has moved this issue up to state level. VDTs emit nonionizing, or low frequency radiation at levels similar to those linked to birth defects in chick embryos. In 1985, an estimated count found over ten million Americans using VDTs and the number is expected to quadruple by the end of the century. Several states including California, Colorado, and New Mexico have passed guidelines for the use of VDTs.[27]

Despite the fact that researchers have found that VDTs cause no reproductive harm, the fact remains that researchers in Spain have concluded that abnormalities in chick embryos are a result to low-level magnetic pulses, emissions similar to that of VDTs.[20] VDTs possess the treat of leakage of non-ionizing radiation emitted as a part of a low-frequency electromagnetic field. Studies done so far have only been able to show biological effects in animals. Despite these studies and the indication of no effects on humans, most European governments have already restricted VDT use to no more than

four hours a day. But the first U.S. law governing VDT use, passed in New York in June 1988, is being challenged in court by businesses.[29]

However, past evidence emerging back in 1980 shows that pregnant women who work at display terminals face an increased risk of miscarriages.[30] A 1989 USA Today Periodical report discussed a study done by the University of Oklahoma's Office of Radiation Safety, Department of Fetal Medicine Unit. It asserted that there is no good evidence indicating that pregnant women who use VDTs are more likely to experience miscarriages or fetal damage.[31] Yet another study of 5,544 women, conducted by NIOSH in March 1991 suggested that VDTs caused no increased risk of miscarriage, despite the fact that previous research hinted that the very-low-frequency electromagnetic fields released by VDTs could increase a woman's risk of miscarriage.[32]

It should be remembered that the antiradiation-antiglare screens that fit over computer screens, block only electric emissions and not magnetic fields. Besides that fact, the devices that claim to block magnetic fields were tested to do so only at minimal levels. Most of the older monitors do not have protective devices to block electromagnetic emissions, and those that do decay rapidly with usage over time. Currently, some scientists have noted that the low frequency electromagnetic fields emitted by VDTs may be linked to brain tumors, childhood leukemia, cancer, and miscarriages. Computers manufacturers such as IBM, Apple, and Compaq are now selling low emission monitors that increase the cost of a display by no more than $100.[33]

CHAPTER 4

RISKS ASSOCIATED WITH OCCUPATIONAL EXPOSURES

4.1 The Use of Occupational Reproductive Risk Exposure Today

There are profound limitations to a risk assessment determination especially in the area of reproductive risk. Occupational reproductive exposure risk management guidelines generally fall under risk hazard communication and right-to-know laws. Reproductive hazard risk management can be easily woven into existing hazard communication and medical surveillance systems, enhancing efficiency and minimizing cost.[2] Effective risk communication requires consideration of at least four elements, they are:

1. Hazard
2. Person
3. Environment
4. Communication

In the case of this research, the hazard is the potential occupational reproductive exposures within the workplace. The person refers to the employees or workers. The environment pertains to the surroundings or general work areas in which the workers perform their daily tasks. Finally, communication includes feedback obtained from workers through periodic examinations by the occupational physician, as well as any training and education they may receive on potential occupational reproductive hazards in the workplace. Communication must be tailored to fit the needs of a specific case including detailed and documented information about a particular hazard, how that hazard is perceived, the persons comprising the occupational risk group, and the physical and

social environment of these workers. Medical surveillance complements risk communication and industrial hygiene controls, especially when the hazard of concern cannot be eliminated. Medical surveillance is the collection and interpretation of data for the purpose of detecting changes in the health status of the population.[2]

The use of other risk management techniques to compensate for this loss is a beginning of recognition, evaluation, and control of these hazards. Group data from potentially exposed workers should be compared with non-exposed workers to see if exposure significantly affects any health variables.[2] The non-exposed group of workers is usually designated as control data. Another way in which employers can monitor occupational reproductive hazards involves periodic examinations which are very important for the detection and control of occupational reproductive hazards. Periodic examinations may be the most effective means of recognizing, evaluating and controlling occupational reproductive hazards.

The use of "clean" and "dirty" change rooms and mandating use of showers at the end of the work day will eliminate the spreading of many occupational exposures to the home.[25] A "clean" room refers to an area designated for changing into clean clothing after showering. A "dirty" room refers to a designated area used to change dirty work clothing and contains a shower or wash up facilities. Another means of recognition, evaluation and control would be the incorporation of historic information. Past information on medical, occupational, and social occupational encounters will be helpful in determining present occupational exposures. Physical examination and laboratory studies also help to indicate the existence of many occupational reproductive hazards. One optional element that can be utilized in occupational reproductive risk assessment is

biological monitoring. The importance of documenting exposures during employment, cannot be over stressed particularly in industries where employees use or handle hazardous substances on a daily basis. Even accidents and spills should be recorded and employees periodically checked for exposure. Documenting past events such as accidents or spills also assist health care professionals in estimating opportunities for exposure and interpreting other surveillance endpoints. Documentation is associated with record keeping. Reproductive hazards education informs workers of potentially hazardous areas and trains them to use the appropriate PPE to deal with the hazards. Sharing information on why a reproductive component was added to existing safety and health programs and soliciting workers' feedback, serves to enhance the employer or employee relationship and encourage cooperation with the program. Once employees see management's concern and desire to inform them about potential reproductive hazards, it becomes easier for them to participate in safety programs and to cooperate fully with management.[2]

The idea of minimizing cost is a very important issue for management. By eliminating or minimizing potential reproductive hazards in the workplace and by incorporating reproductive safety guidelines, management can be proactive heightening employee awareness to potential reproductive hazards. Integrating these elements into existing worker education and occupational health programs enhances the efficiency of program implementation, minimizing costs while mitigating the risks of reproductive harm.[2]

A classical risk assessment consists of a four step process (see Figure 7):

1. Identify Hazards

2. Assess dose-response characteristics
3. Determine the degree of exposure with or without benefit protective controls
4. Characterize risk by evaluating the data obtained in the previous three steps in order to describe the nature and extent of potential risk including parameters of uncertainty.[2]

A reproductive risk management program can also follow this four-step process. It begins with identification of occupational reproductive hazards whether through research or medical surveillance. This is followed by assessing the risk or dosage of the chemical that may present a reproductive hazard, the length of time the employee is exposed, and the range and hazard associated with the chemicals or sources of exposure. The main risk characteristic of interest is that of human health. The investigator must then develop feasible steps to monitor and assess a risk management program that will alleviate the risk.

Yet another approach to safety on the job and risk communication, is a job safety analysis (JSA). JSA is an evaluation process resulting in documentation that addresses workplace exposure hazards. This process provides a step-by-step assessment of the work assignment tasks through recognition and elimination of hazards.

This simple four-step approach to risk management is also the best way to achieve reproductive hazard analysis. Identifying the potential reproductive hazards within the workplace helps to eliminate or minimize unnecessary accidents. After potential reproductive hazards are identified (e.g. chemical exposures), then the PEL or TLV recommended for eight hours of exposure is determined in order to avoid over-exposure to potentially dangerous chemicals.

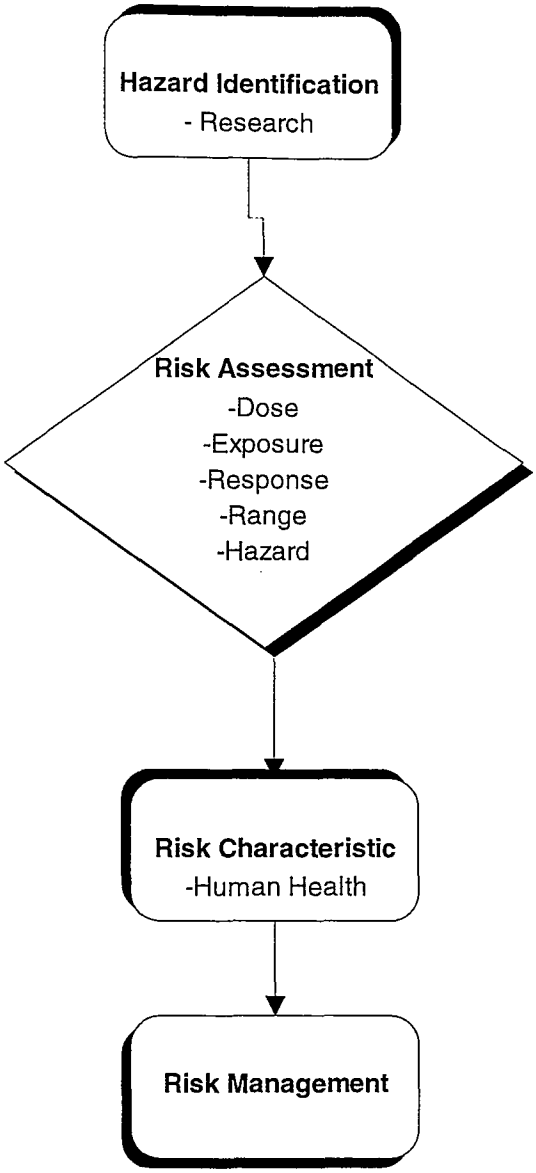

Figure 7: Four Step Approach to Risk Management[12]

4.1.1 Classification of Occupational Risks Exposures

Exposure is defined as the contact of an organism(s) with a chemical or physical agent.[11] A classical risk exposure assessment consists of (1) data collection and evaluation; (2) exposure assessment; (3) toxicity assessment; and (4) risk characterization (see Figure 8). A classical risk exposure assessment is yet another technique which can be utilized in assessing occupational reproductive exposures.

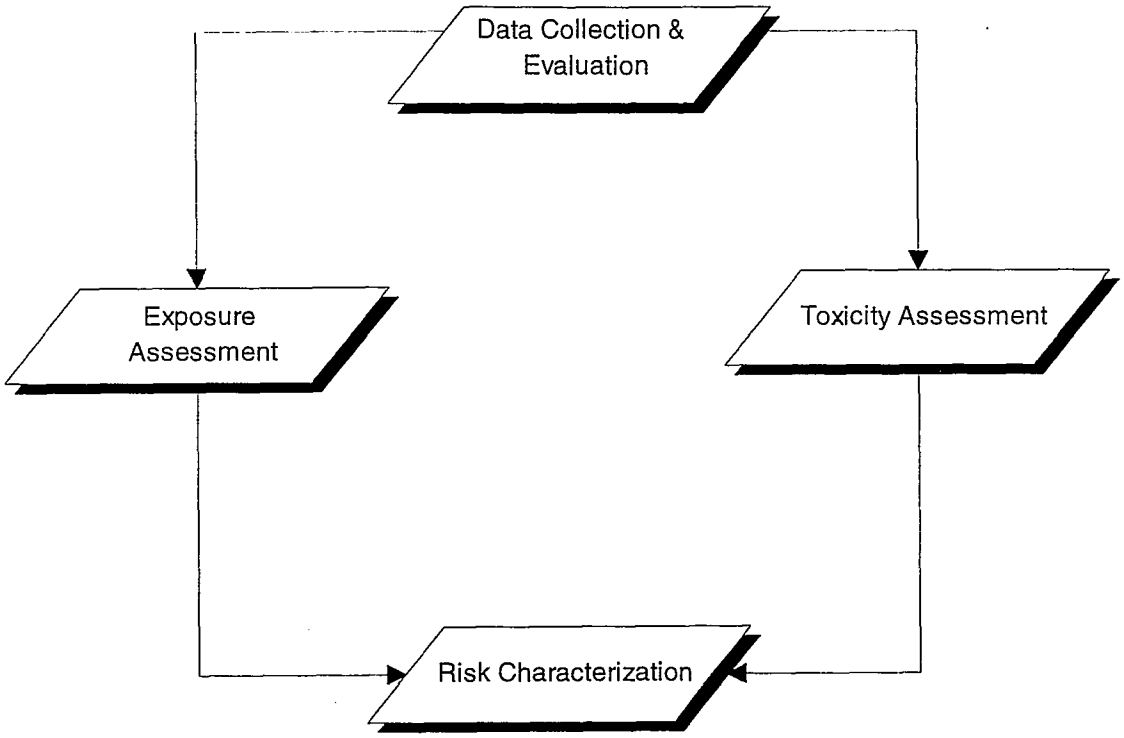

Figure 8: A Classical Risk Exposure Assessment

4.2 Occupational Reproductive Risk Exposure Measurements

Occupational reproductive risk exposure measurements can be obtained through the use of basic epidemiological tools. In this research, the epidemiological measures relevant to occupational medicine are the only measurements used. It is also important to note that the epidemiological measurements used here are determined on the basis of occupational medicine measurement studies which have already been conducted.

Occupational reproductive risks exposure measurements can be related to certain basic epidemiological measurements. The four measurements relevant to this research are Prevalence Rate (PR) which a measurement of the frequency of all cases in a defined population during specified times (see equations 4.1 and 4.2); Incidence Rate (IR), which is a measure of the frequency of new occurrences or cases in a well defined population during a specified time period (see equation 4.3); Cumulative Incident Rate (CIR), which is an occupational cohort, consisting of workers exposed to a common factor at a certain point in time.[19]

$$PR = \frac{X}{Y} \bullet K \tag{4.1}$$

$$PR = \frac{\#\text{ of workers exposed at time (t)}}{\#\text{ of workers in the facility}} \tag{4.2}$$

$$IR = \frac{X}{Y} \bullet K \tag{4.3}$$

$$CIR = \frac{\#\text{ of new cases during a time period}}{\#\text{ of those at risk at the beginning of the period}} \tag{4.4}$$

4.3 Definition of Occupational Reproductive Risk Measurements

The prevalence rate can be measured using equations 4.1 or 4.2. For example, workers in a chemical manufacturing company were screened for potential reproductive exposures. Let's suppose that there are 3000 employees in the facility and 50 cases are diagnosed as having potential reproductive exposures. Therefore the PR for potential reproductive exposures is 50/3000 = 0.0167 = 1.67%. The value (X) is the number of all the workers who have been diagnosed as having reproductive exposures. The value (Y) is the number of workers in the defined population (the facility) during the time in which the exposures occurred. The value (K) can be applied for a percentage result by multiplying the result by 100.

For the incidence rate, the value (X) refers to the number of new workers in the defined population that are diagnosed as being exposed to reproductive hazards during the specified time. The values (Y) and (K) are the same as the prevalence rates' definition. The cumulative incident rate is similar to the incident rate, except that it expresses the status of a proportion of the population.[19]

CHAPTER 5

DEVELOPMENT OF SAFETY GUIDELINES

5.1 Objective of Safety Guidelines

The objective of the safety guidelines developed for occupational hazards is to reduce the levels of exposure to the reproductive system in both male and female workers. By doing so, workers will become more aware of the hazards around them and take the necessary precautions to reduce any occupational hazards to the reproductive system that may exist.

The development of the safety guidelines for occupational hazards to the reproductive system, followed a three step approach. First, an occupational reproductive hazard survey was distributed to over one hundred respondents. A reproductive screening questionnaire was then used to create daily chemical or source of exposure forms. The development of the safety guidelines resulted from combining the information obtained from the three preliminary stages.

5.2 Occupational Reproductive Hazard Survey

The occupational reproductive hazard survey was distributed to elicit feedback and responses based on the need to develop regulated occupational reproductive safety guidelines. Over one hundred surveys were distributed with an equal number of male and females participating.

Figure 9 shows the actual survey that was distributed. The survey was used as a preliminary approach to rating the importance or the need for regulated or mandated occupational safety guidelines for reproductive hazards. The surveys were distributed to

a broad group of working people within various occupations. Occupations such as stone cutters, hospital administrators, nurses, dental assistants, mechanics, electricians, janitors and gas attendants. Some occupations posed less danger than others, as related to occupational reproductive hazards. The survey contained similar information to that of the reproductive screening questionnaire.

OCCUPATIONAL REPRODUCTIVE HAZARD
SURVEY

AGE: ☐18-24 ☐25-34 ☐35-44 ☐45+

☐ MALE ☐Single ☐Married ☐ FEMALE ☐Single ☐Married

YOUR OCCUPATION_____

PLACE EMPLOYED_____

LENGTH OF TIME EMPLOYED AT THIS PLACE: Date(s):_____

---

1. **How do you rate the need for regulated safety guidelines for occupational reproductive hazards?**

   SCALE 0-10: **0-NOT NEEDED** **10-GREATLY NEEDED**
   (Circle your choice)

   0---1----2----3----4----5----6----7----8----9----10

2. **Do you know what reproductive hazards mean?** ☐Yes ☐No
   If yes, please explain _____

3. **Are you aware that your work environment can cause potential hazards to your reproductive system?** ☐Yes ☐No

4. **Do you work with chemicals?** ☐Yes ☐No

5. **Do you have children?** ☐Yes ☐No
   If no, do you plan on having children in the near future? ☐Yes ☐No

Figure 9: Occupational Reproductive Hazard Survey

Based on the surveys distributed, 58% of the respondents claimed that they knew what reproductive hazards were. The other 42% of respondents had no idea what reproductive hazards implied. When asked about the level of awareness that their work environment could cause potential hazards to their reproductive system, approximately 50% of the sample responded "yes" while the other 50% responded "no." 33% of the sample worked with chemicals while the remaining 67% responded that they do not work with chemicals. When asked about the possibility of having children in the near future, over 66% of the sample was undecided, 17% said "definitely yes" and 17% said "definitely no." However 75% of the respondents had children, and the remaining 25% did not. Finally, an importance rating on the need for regulated safety guidelines for occupational reproductive hazard was also included in the survey. The scale ranged from zero (not needed) to ten (greatly needed). The distributed of the ratings can be seen in Figure 10.

Based on the ratings, age groups 18 to 24 and 25 to 34, showed the highest importance ratings, whereas age groups 35 to 44 and 45+ showed ratings almost as high as the two younger groups. The surveys also showed that men rated the need for regulated occupational reproductive hazard standards just as high as women. An evaluation of the surveys showed that both the male and female populations rated the needed for regulated standards for occupational reproductive hazards very highly. It is also important to note that none of the survey results collected showed a rating of less than five for the need of regulated occupational safety guidelines.

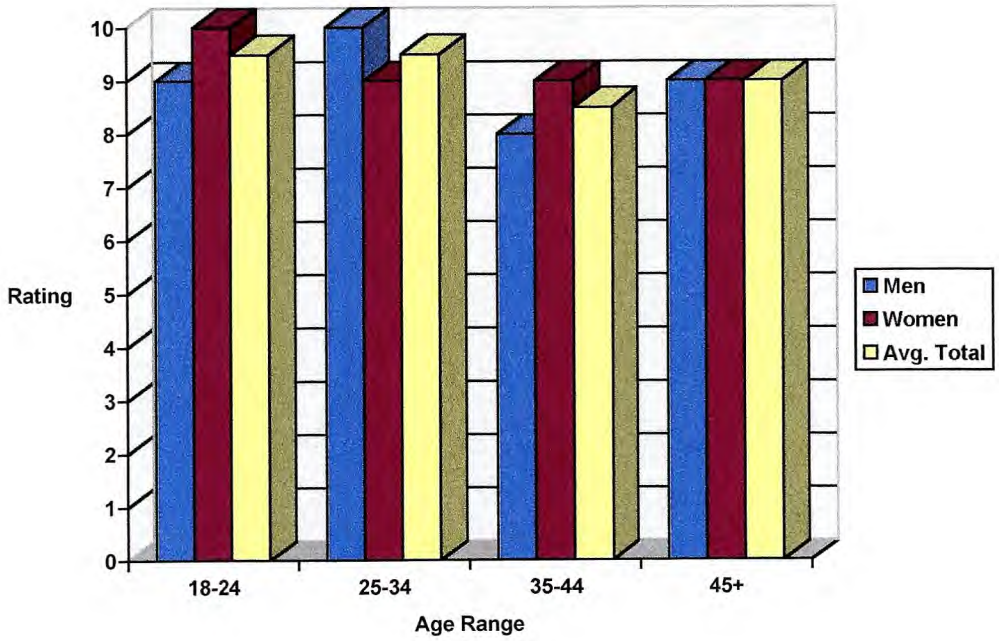

Figure 10: Importance Rating for Occupational Reproductive System Hazard Standards

5.3 Respondents to the Reproductive Screening Questionnaire

The occupational reproductive surveys and reproductive screening questionnaires used in the research were voluntarily completed by over one hundred respondents. This sample was selected on the basis of responses to the occupational reproductive hazards survey, and the willingness to participate in the research study voluntarily.

Each respondent who completed a survey also completed a screening questionnaire. Respondents to the reproductive screening questionnaire ranged from ages 18 to 45+. The main criteria used in the developing the questionnaire were as follows:

1. Male or female *currently working* within any type of work environment that may or may not contain reproductive hazards.
2. Length of time employed at present or previous place of employment.

3. Information on each respondent's occupation and past and present occupational reproductive health history (which included their partner's occupational health history as well).
4. Age and sex.
5. Marital status.
6. Specific information pertaining to men (prostate problems) and to women (abnormalities in pregnancy and menstrual cycles).

The reproductive screening questionnaire also contained a rating scale, which surprisingly showed an increase in the ratings after most respondents completed the questionnaire, compared to the ratings obtained in the first survey distributed. Figure 11 shows the actual reproductive screening questionnaire distributed in connection with this research.

The occupations of the respondents included: stone cutter, print room coordinator, administrative executive officer within a hospital, as well as a variety of private business affiliations. The average time period that these individuals were employed in their current positions was five years.

Information used the reproductive screening questionnaire was obtained from: OSHA's worker questionnaire 29 CFR 1910.1027, hazard communication, as well as 29 CFR 1918.90, information on medical surveillance, training and community right-to-know. Occupational exposure to hazardous chemicals is covered by OSHA 1910.1450 for all workplaces and public facilities.

THESE QUESTIONS APPLY ONLY TO OCCURRENCES DURING PRESENT OR PREVIOUS PLACE OF EMPLOYMENT !

AGE: ☐ 18-24 ☐ 25-34 ☐ 35-44 ☐ 45+

☐ MALE ☐Single ☐Married ☐ FEMALE ☐Single ☐Married

☐ PRESENT EMPLOYER ☐ PREVIOUS EMPLOYER

PLACE EMPLOYED:_____

YOUR OCCUPATION / JOB DESCRIPTION:_____

LENGTH OF TIME EMPLOYED AT THIS PLACE: Date(s):_____

---

1. Of what importance would you rate safety towards potential dangers to your reproductive system within your work environment.
   SCALE 0-10: 0 - NOT IMPORTANT 10 - VERY IMPORTANT (Circle your choice)
   0---1----2----3----4----5----6----7----8----9----10

2. Do you **have/*plan*** on having children? ☐Yes ☐No If you have children, how many?_____

3. Have you or your partner had problems conceiving a child? ☐Yes ☐No If yes, please specify:
   ☐Present mate ☐Previous mate ☐Self

4. What is the occupation of your partner? _____

5. Have regular visits to the physician reported any abnormal results related to the reproductive system?
   ☐Yes ☐No If yes, please specify: _____

6. Have you consulted a physician for fertility or other reproductive problems? ☐Yes ☐No
   If yes, please specify diagnosis physician made:_____

7. Have you or your partner conceive a child which resulted in any complications? ☐Yes ☐No If yes, please specify the outcome: ☐Deformed Offspring ☐Still birth ☐Miscarriage ☐Other(Abortion)

FOR WOMEN ONLY:

Did the timing of any abnormal pregnancy outcome coincide with present employment? ☐Yes ☐No
If Yes, specify date(s) of occurrence(s): _____

Have you had abnormal menstrual periods? ☐Yes ☐No Specify Type:_____
If yes, specify approximate date abnormalities began:_____

FOR MEN ONLY:

Have you ever been diagnosed by a physician as having prostate gland problems? ☐Yes ☐ No
If yes, please describe type of problem:_____
What was/is being done to evaluate the problem?_____

Thank you for answering these questions!

Figure 11: Reproductive Screening Questionnaire for Male and Female Respondents

5.4 Personal Daily Chemical or Source of Exposure Monitoring Form

Based on the need for regulated standards for occupational reproductive hazards, a personal daily monitoring form was developed. This form can be used by workers who feel a need to monitor their exposures to various chemicals or any other sources of exposure that they may encounter in the course of their daily work routines. This form can also be used as an excellent source of feedback in the monitoring of occupational reproductive exposures for occupational hygienist, nurses or physicians.

OSHA 200 logs and worker compensation reports record information similar to that of the information listed on the personal monitoring form shown on the following page. But the information recorded on the OSHA 200 logs and worker compensation forms only record injuries and illnesses after they have already occurred. Therefore, the use of a personal daily monitoring form can serve to eliminate hazards before they cause any accidents or injuries. The personal monitoring form should be seen as a primary step towards employee protection and employer detection of unnecessary hazards. The personal daily monitoring form can therefore decrease costs associated with injuries, illness and lost work days.

Figure 12 shows the personal daily chemical or source of exposure monitoring form. The form is divided into four areas, containing information such as: the name of the employee, the date, the building, area, room, or location, the chemicals or sources of exposure, the time of each exposure, the recommend TLVs or PELs, daily totals, required PPE, and a listing of the chemicals used on a daily basis, including each chemical's CAS number.

PERSONAL DAILY CHEMICAL OR SOURCE OF EXPOSURE MONITORING FORM

FOR ON-THE-JOB EXPOSURES ONLY!

NAME: _____

TITLE: _____

TODAY'S DATE: _____

BUILDING / ROOM / AREA / LOCATION: _____

_____

DAY(S) OF THE WEEK WORKED	CHEMICAL OR SOURCE OF EXPOSURE	TIME BEGIN------END		RECOMMENDED TLVs / PELs
DAILY TOTALS				

- **PPE REQUIRED:** ✍ etc._____
- **LIST CHEMICALS USED ON A DAILY BASIS:**

CHEMICAL NAME	CAS #	RECOMMENDED TLV's/PEL's

Figure 12: Personal Daily Chemical or Source of Exposure Monitoring Form

5.5 The Use of the Safety Guidelines

Companies who know that their workplaces pose potential hazards to their workers' reproductive systems, should incorporate such recommended guidelines as a preventative measure. These guidelines help to insure employee protection and prevent possible future law suits or workers compensation claims. Employees should make it a top priority to find out about potential reproductive hazards within their workplace and follow all applicable standards or guidelines to insure their own safety and well being.

Employers and companies utilizing these recommended safety guidelines can view them as a first step to increasing their awareness of occupational reproductive hazards. Incorporating them into their existing safety programs demonstrates their willingness to educate their workers on occupational reproductive hazards.

Safety guidelines for occupational hazards to the reproductive system can be used by all workers whose working environment presents known or unknown hazards to the reproductive system. These guidelines can also be used by workers who are not aware of reproductive hazards within their work environment, but who are concerned about their personal safety and well being on their jobs.

5.6 The Safety Guidelines for Occupational Exposure to the Reproductive System

Integrating reproductive hazard concerns into existing worker education programs and medical surveillance protocols encourages implementation while minimizing cost.

Figure 13 shows eight basic safety guidelines for occupational exposures to the reproductive system. Integrating these guidelines into existing safety programs, would substantially promote awareness among both employees and management.

The guidelines have value for both employers and employees. Employers should educate workers on reproductive hazards by providing trained specialists who are knowledgeable and familiar with occupational reproductive hazards. The use of MSDSs and HSFSs is often overlooked by many workers. Employees should appreciate the need for these two written sources. They often an excellent preliminary approach to understanding chemicals which may present reproductive hazards. Permissible levels of exposure (TLVs and PELs), the best type of PPE to be used when handling potentially toxic chemicals, as well as other useful information is found in the MSDSs and HSFSs. Employers must remember that both employees and the community have the right to know if their working environment contains any potential dangers that may cause harm to their reproductive system. Therefore, all appropriate protection should be provided to them.

Periodic examinations may be the most effective means for recognizing, evaluating and controlling occupational reproductive hazards. Therefore a schedule of regular visits to the occupational health nurse should be strongly enforced in the workplace. Follow-ups should be conducted for any reproductive exposures documented by performing a reproductive screening of each worker and the tasks they perform. Eliminating all potential reproductive hazards from occurring is the ideal solution, but it is seldom achieved. Other steps include reassigning pregnant workers to areas within the facility that present fewer reproductive hazards, rotation of workers to an environment which is less hazardous to the reproductive system, and applying a variety of other administrative controls. Also substitution of a less hazardous substance is advisable whenever possible. Good housekeeping never fails to be an excellent auxiliary method to

minimize the occurrence of reproductive hazards. Engineering controls offer the best approach to preventing reproductive hazards within the workplace, but sometimes they are not feasible because of economic constraints or other factors.

Figure 13: Safety Guidelines for Occupational Exposure to the Reproductive System

- Develop a occupational reproductive hazard education program.
- Designate a trained specialist within the area of occupational reproduction hazards to educated employees and management.
- Enforce mandatory reviews of *MSDSs or HSFSs* before handling or using chemicals to check which ones may pose possible health effects (reproductive health effects).
- Check and follow permissible levels of exposure if working with or around potentially hazardous chemicals and stay within the permissible limits. If possible, substitute known reproductive hazardous chemicals for less harmful substance.
- Use the Registry of Toxic Effects of Chemical Substances (RTECS) as a reference source to identify, compare and update new or current chemicals that pose reproductive hazards in the workplace.
- Provide reproductive hazard screening for all tasks performed by workers within the facility (placing workers in positions that best suit them).
- Develop mandatory workplace procedures which would incorporate regular visits to the occupational nurse or physician (periodic monitoring for potential reproductive exposures).
- Use the appropriate *Personal Protective Equipment and Engineering Controls* while performing daily tasks.
- *GOOD HOUSEKEEPING* and *PERSONAL HYGIENE* should be mandatory in all work environments!

CHAPTER 6

SUMMARY

6.1 Summary

It may seem difficult to monitor reproductive hazards separately when other environmental exposures can interfere with potential exposures which may occur in the workplace. However, closely monitoring and documenting potential occupational reproductive hazards is a major step towards eliminating costly workers compensation claims and lawsuits. Training, education and feedback are each excellent techniques which management can incorporate into existing safety programs to insure employee and management cooperation. It is also a good idea for companies who know that their facilities contain potential reproductive hazards to hire an industrial hygienist, occupational physician, or other specialists who are knowledgeable in occupational reproductive hazards to closely monitor the situation and provide monitoring and training in this area of concern.

Are reproductive hazards in the workplace considered a minor or major issue? Should standards and/or regulations be set for such hazards? Many toxic chemicals can affect human reproductive capabilities, and can cause chromosomal damage (mutations) and negative fetal effects (tetratogenesis). Signs and symptoms, including infertility, birth defects, and sterility may result from exposure to chemicals such as lead, and gasoline. Radiation exposure is another common source of reproductive hazards easily accessible to the general or working population. Cases of exposure to these sources have all demonstrated negative reproductive health effects.

Based on the surveys and questionnaires used in this research, there is a large degree of concern among workers aged 18 to 45+ within various occupations regarding potential dangers, they may be facing. Thus, regulated safety guidelines for occupational exposure to the reproductive system should be an issue of serious consideration among employers as well.

It is imperative that employers formulate safe exposure standards for their work environments that can prevent occupational reproductive hazards from occurring or reoccurring. Companies should begin to formulate programs geared towards education and training about this subject. It is not too late for companies to begin formulating specific guidelines of their own. They should not sit back and wait for government officials to impose such guidelines or regulated standards for occupational reproductive hazards in the workplace. They should set feasible standards of their own which aim to eliminate potential reproductive hazards from occurring. This step will help to protect them from unnecessary workers' compensation claims.

Currently, reproductive hazards are among the list of issues for regulatory action planned by OSHA. But the agency urges business, labor and community action to initiate their own programs to encourage worker protection. As of this writing, the White House is planning to address reproductive hazards as one of six priority safety and health issues slated for immediate action.

By utilizing the safety guidelines for occupational reproductive hazards developed in this research, employers and employees can begin the process of eliminating potential occupational reproductive hazards from occurring or reoccurring in the workplace. Because the subject of occupational reproductive hazards is relatively new, there is room

for further research in this area. Basic research aimed at eliminating environmental factors that may affect occupational reproductive hazards, needs to be conducted. Feedback is needed to evaluate the effectiveness of those guidelines which have already been established. In other words, are these safety guidelines realistic for the control, elimination, or minimization of potential occupational exposures to the reproductive system? The issue of occupational reproductive hazard is very complex. It is not easy to address a subject which has so many influential factors contributing to assessing its complexity. However, guidelines for occupational exposures to the reproductive system should address TLVs and PELs values separately, specifically for the reproductive system.

There is a strong need for further research regarding occupational reproductive hazards. This research serves as an important tool in increasing the awareness of occupational reproductive hazards, along with interpreting the results of earlier studies performed on this subject. However, for an issue as important as occupational reproductive hazards, relatively little research has been done to date. Hopefully, regulated guidelines will be established sometime in the near future, before it is too late.

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