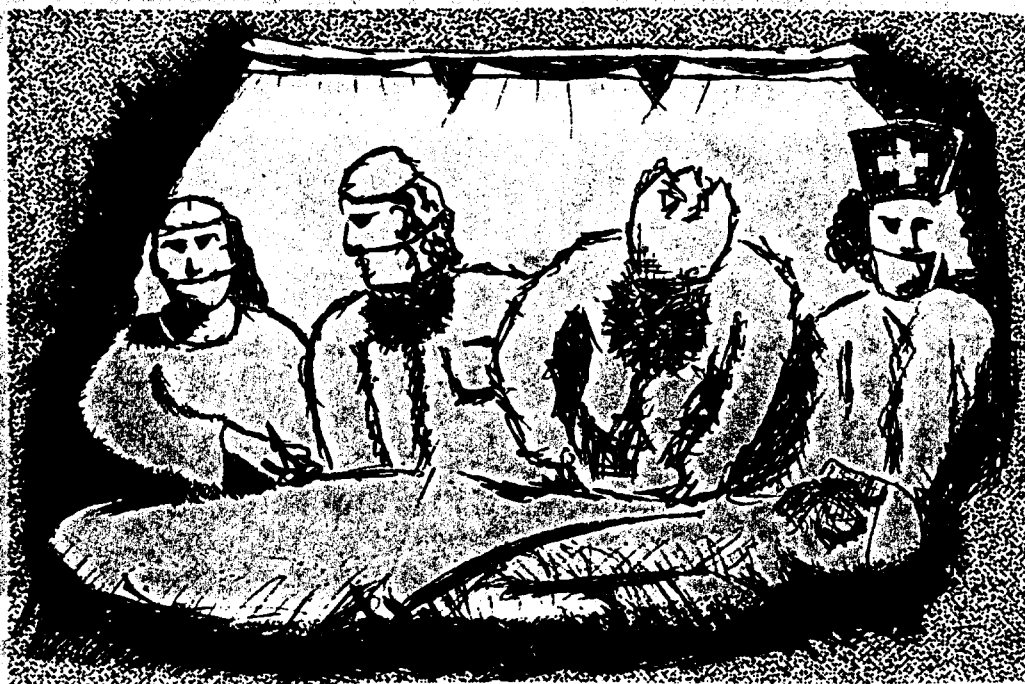


PROTECTING THE HEALERS:

A Guide to the Proper Management of
Toxic and Hazardous Materials in Health Care
Facilities



Donald Huisingh

Susan Josephson Miller

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Prepared for the North Carolina Board of Science and Technology

by

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We gratefully acknowledge the contributions of each author who has contributed his/her valuable time and wisdom to this hospital safety manual. Without your inputs, the compendium would not be in existence at this moment. With your help, we have been able to assemble this version. We also wish to thank Larry Martin for the illustration on our cover.

We extend our sincere appreciation to all who answered our questionnaire. Your inputs set the tone and pace for the types of issues addressed herein.

We thank the members of the planning committee for their advice in helping to identify topics to be addressed in this compendium. Thanks also to those who reviewed chapters and the entire document.

We gratefully appreciate financial support provided by the North Carolina Legislature through the North Carolina Board of Science and Technology.

And finally, we wish to extend our unending appreciation to Jo and Matt and to our friends (Sven, Karen, Jeff) for their love and support. We depended on their understanding and support throughout the project.

Don Huisingh

Susan Miller

PREFACE

While serving as the Toxic Substances Project leader in the office of the North Carolina Governor in 1981 and 1982, I was invited to address several hospitals' safety and risk management conferences. The conferees wanted to learn about ways they could be more effective in reducing the risks to health care providers due to exposure to toxic substances and hazardous wastes used or produced in these facilities. They said there is an urgent need for a compendium that provides clear and concise information about the health risks associated with exposure to the substances commonly utilized in health care facilities. Further, their needs were for procedures and protocols they could use for their safety programs.

These requests came so frequently and so persistently that in the winter of 1984, I decided to submit a proposal to the North Carolina Board of Science and Technology for a small amount of money to help underwrite the cost of developing such a compendium. Fortunately the grant proposal was funded and the work undertaken. Susan Josephson Miller was a co-worker on the project since its inception.

A steering committee of eighteen medical professionals hospital safety directors, state department of health officials and other concerned professionals met several times during the early planning stages of the project. Their inputs were extremely valuable in helping us develop and disseminate our questionnaire to more than 1000 health care facilities and nursing homes (see Appendix I at the end of this book). When the results of the completed questionnaire were summarized, once again, the advice of the group provided direction and perspective.

With the basic chapter topics and compendium outline developed, we set out to enlist the writing talents of health and safety professionals throughout the region and nation who work regularly in these environments. They and we have developed chapters pertaining to many of the most important toxic substances and hazardous waste management risks associated with health care and rest home facilities. Some chapters are very thorough and detailed in addressing a particular area. These chapters contain detailed identification of the risks and of the safety precautions that should be taken to minimize those risks. Other chapters are brief and serve to introduce the reader to the problem area and point him/her in the appropriate direction for making their facility a safer place for workers, patients and visitors. Thanks to all contributors, this document has come into being.

We appreciate the help provided by all contributors, reviewers and advisors. We hope that, in its present form, it will serve many valuable functions in helping health care providers reduce the risks of exposure to toxic and hazardous

substances. We hope that this book will also provide a starting point for the development of a more complete and thorough second version in the near future. In that spirit, all suggestions and recommendations for corrections and additions are solicited. Please address them to:

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TABLE OF CONTENTS

	<u>Page</u>
PREFACE	ii
TABLE OF CONTENTS	iv
 SECTION I: An Introduction	
Chapter 1: Protecting our Healers	1
by Don Huisinigh Susan J. Miller	
Chapter 2: Chemical Hazards	4
by Lawrence Gibbs [An overview of potential chemical hazards in health care facilities and a general discussion of the concept of 'risks' and 'hazards.']	
 SECTION II: Employer's Role in Risk Reduction	13
Chapter 3: A Systems Approach to Safety	14
by Wayne Thommann [The benefits and design of a comprehensive system's approach to safety in health care facilities are discussed.]	
Chapter 4: Identifying the Need for Training	30
by Ann G. Mahony [An outline of steps to be followed by health care safety administrators responsible for developing, implementing and evaluating safety training programs.]	
Chapter 5: Stress Reduction and Wellness Promotion	33
by Virginia Livingston [An analysis of the affects of stress on hospital employees, how the stress can be overcome and how to promote 'wellness' for all employees.]	
 SECTION III: Employer/Employee Relationships	55
Chapter 6: Worker's Compensation	56
by Ned Vaughan-Lloyd [In this chapter, North Carolina Worker's Compensation laws are reviewed, highlighting both employer and employee rights.]	

Chapter 7: Worker's Right to Know 64

by Molly J. Coye

[A look at various "Right to Know" legislative approaches being used throughout the country along with a discussion of what "right-to-know" means for health care providers.]

SECTION IV: Hazards Faced by Health Care Providers 72

Chapter 8: Anesthesia Gases 73

by Ed Norfleet, et al.

[A comprehensive examination of the affects of waste anesthesia vapors and what can be done to minimize their affects.]

Chapter 9: Antineoplastic Compounds 112

by Susan J. Miller, et al.

[A review of the literature on the potential affects of antineoplastic compounds on the employees who utilize them and a composite of precautions and procedures used by fifteen institutions.]

Chapter 10: Ethylene Oxide 134

by F.A. Lawton

[A review of the potential adverse affects of exposure to ethylene oxide and a summary of the protocols for reducing the risk of these adverse affects occurring to employees using ethylene oxide.]

Chapter 11: Biohazards: Hospital Epidemiology 157

by Debra Hunt

[A review of the biohazards that present risks to health care workers and a discussion of what safety approaches can be utilized to minimize adverse affects.]

Chapter 12: Radiation and Radioisotopes 182

by Garri Parker and Daniel Sprau

[A comprehensive examination of the potential risks from radiation sources within health care facilities.]

Chapter 13: Laser Safety 215

by Geoffrey Aldridge

[An introduction to laser technology and a preliminary look at safety techniques.]

	<u>Page</u>
Chapter 14: Clinical and Research Laboratories by Rosanne Feild [A comprehensive survey of ways to perform laboratory safety audits and of methods to be used to make clinical and research laboratories safe.]	221
 SECTION V: Special Topics	
Chapter 15: Cleaning Compounds by J. David Root [A brief overview of potential dangers to employees utilizing cleaning compounds improperly and recommendations for safe use of these substances.]	260
Chapter 16: Pest Management by Eric Smith [A look at how to locate a pest management service, what questions to ask, and how to know if they are fulfilling all of their obligations.]	262
 SECTION VI: Waste Management	
Chapter 17: Hazardous Waste Management at NIH by Jonathan Richmond [A discussion of prudent procedures for the management of infectious wastes from health care facilities.]	297
Chapter 18: Sharps Management by Bob Adams [An analysis of the risk of injury due to mismanagement of sharps and recommendations for their proper management.]	298
Chapter 19: Incineration by Garris Parker [A review of the basic terminology for incineration procedures and a discussion of its applicability to the needs of health care facilities.]	306
APPENDIX: A copy of the original questionnaire	315
	330

PROTECTING OUR HEALERS

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"Health care is one of the largest and most rapidly growing sectors of the United States economy. Total health care expenditures increased from \$130 billion (8.6% of GNP) in 1975 to \$355.4 billion (10.8% of GNP) in 1983, representing an average annual increase of approximately 13%. Health care is now the second largest industry in the United States. Nursing home care is the third largest segment in the health care industry behind hospital care and physician services, with 1983 expenditures of approximately \$28.8 billion (Interstate Securities)." The entire health care industry employs five percent of the total American work force (Handbook of Labor Statistics, 1980).

While this is so, the health care providers are often exposed to a vast array of toxic and hazardous substances without proper training or safety equipment. The following quote underscores this startling reality.

Health care institutions in general and hospitals in particular have not only failed to keep pace with advancing knowledge in the field of occupational health and safety but have failed even to recognize that this was an area deserving more than passing attention.

(Denton, 1982)

In 1976 a NIOSH report (Pub. #76-115) revealed that, of the 3,686 hospitals studied, only 8 percent had an occupational health and safety program with even the basic NIOSH recommendations for such a program.

One of the primary causes of this problem in the health care facilities is the basic attitude prevalent in many hospital programs. Hospitals are places where the emphasis is upon curing people with ailments that have already occurred rather than upon the preventative measures characteristic of health and safety programs. The consumers of the hospital's "commodities," the patients, are present on the premises to receive care. This has led to the primary emphasis for safety being for the patient, not the employee. The basic structure of many hospitals is another deterrent to implementation of health and safety programs. Many hospitals are non-profit. The lost revenue due to the lost work days of sick or injured employees does not directly financially

affect the facilities because any loss is passed directly on to the consumer.

Although the risks to employees associated with exposure to toxic and hazardous materials has been all too frequently neglected, the problem is real and attention is finally being directed to these areas. The largest number of reported injuries to health care providers, as in industries as a whole, are muscle strains and sprains. However, with increasing numbers and quantities of new compounds being utilized in health care facilities, another type of injury is becoming prevalent- injuries and illnesses associated with the use of toxic and hazardous substances. Among the toxic substances that present health hazards to health care providers are anesthesia gases, ethylene oxide, antineoplastic compounds, substances used for diagnostic tests, experimental compounds, pesticides and cleaning compounds. Additionally, there are many radiation sources and types that present risks to employees and/or their patients.

It is estimated that over 50,000 hospital operating room personnel are exposed to one or more anesthesia gases on the job (NIOSH Pub. # 77-140, 1977). This does not include the thousands of dentists, dental assistants, veterinarians, their assistants and the many researchers that are also exposed. All of the possible affects of waste anesthesia gases are not known, but it is known that these gases can cause cancer, liver and kidney diseases and a decrease in the performance rate of the exposed worker. Also, studies by Cohen and Dahlgreen (Cohen, 1974 and Dahlgreen, 1979) have revealed an unusually high rate of spontaneous abortions and fetal abnormalities in the children of exposed workers as compared with unexposed workers. This includes the children of male employees.

Ethylene oxide is another compound that a large number of health care providers are exposed to each year. Ethylene oxide is used to sterilize items that would be damaged by heat or moisture sterilizing processes. According to a 1977 NIOSH study (Pub. # 77-200) short term exposure to ethylene oxide can cause nausea, vomiting, dermatitis, eye and respiratory track infections and has also been known to cause anemia. In one case, an accidental exposure to high concentrations caused chromosomal aberrations. The May 1981 NIOSH Current Intelligence Bulletin linked ethylene oxide exposure to stomach cancer, leukemia and assorted circulatory failures.

Antineoplastic compounds, those chemicals used to treat neoplasms (cancer), are another danger faced by certain employees in hospitals. Although no conclusive proof has been found linking these drugs to cancer in the employees who prepare, administer and dispose of them, increased mutagenic potential has been found in the urine of exposed workers leading to the conclu-

sion that utilization of safe handling techniques for these drugs is of extreme importance.

Another major source of problems for workers in the health care industry is job stress. A study conducted by NIOSH, of 130 occupations in the United States to determine the incidence of job stress revealed that 7 of the top 27 occupations listed as the most stressful were directly related to health care professions. This list included health care technologists, licensed practical nurses (LPN's), clinical lab technicians, nurses aides, health aides, registered nurses (RN's) and dental assistants. When the list was expanded to include other occupations not solely restricted to health care facilities, such as dishwashers, research workers, chemists and social workers, eight more health care occupations were listed in the 27 with very high incidence of job stress. An additional problem with job stress at health care facilities is that there is "more opportunity for one of the most debilitating side affects of stress, drug abuse" (Denton, 1982). Stress management and wellness promotion programs already in operation at some health care facilities show promise for reducing this class of problems.

Many of the hazards to health care professionals, such as the risk from antineoplastic compounds and waste anesthesia gases, are unique because of the workers environment. However, many of the hazards from compounds, such as cleaning compounds and pesticides, could, if improperly used, affect a large portion of a hospital's population. Additionally, the hazardous waste produced during daily operations of health care facilities pose risks and provide opportunities for minimization of those risks. All health care providers working conditions should be as risk free as possible. Safety consciousness should be present in all health care providers' minds and used in their work consistently.

Unfortunately, until recently, health care providers' working conditions were not given the consistent or thorough safety considerations that some of their counterparts in industry have been receiving. This is particularly surprising and shocking in light of the nature of these professions. Far too many health care providers have focused almost exclusively upon helping to cure a disease or diseases and less upon prevention of the disease. The old adage, "An Ounce of Prevention is Worth a Pound of Cure," is relevant in all areas of human endeavors, but especially in the health care field! How will our health care providers provide health giving care unless they are healthy themselves???

POTENTIAL CHEMICAL HAZARDS TO BIOMEDICAL SERVICES PERSONNEL

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ABSTRACT

Chemicals are basic and necessary ingredients in all research and clinical institutions. Proper understanding of the basic properties of chemical substances is essential to the safe and healthful handling, use, storage and disposal of chemical materials from such facilities. Biomedical services personnel in these institutions often have position responsibilities which may incur risk due to chemicals at some point in time between the acquisition and ultimate disposal of those substances.

Responsibilities of biomedical services personnel may include positions ranging from stockroom handlers, maintenance employees, housekeeping staff and animal care handlers to laboratory personnel and office and clerical staff located adjacent to laboratory facilities. An understanding of the types of risks due to chemicals for each of the different positions is essential to providing the proper protection and minimizing the risk to the employee.

This paper focuses upon three main areas of interest to biomedical services personnel: typical illustrations of situations in these institutions which create high risk conditions; what factors are necessary to assess the potential risk; and, what can be done to minimize the risk due to the chemicals.

INTRODUCTION

Chemical!! The very word creates anxiety and stress in many people in our workplaces, in our modern American society. The daily public media reports carry warnings and advice about the presence of chemicals in our food, air and water, and the harm they are doing to us. Reports of newly found chemical waste sites, pesticide contamination of drinking water, and the media "discovery" of the "carcinogen of the month" are received continually by the public. As a result, the very mention of the word "chemical" conjures up visions of damage, debility, disease and death in minds of many people.

Biomedical services personnel have a wide range of responsibilities that utilize toxic substances. Ventilation personnel may have to work on perchloric acid fume hoods or in the air

stream of ventilation systems which carry chemical fume hood exhaust. Plumbers often have to replace aged pipes which had a variety of chemicals running through them and which have traps that may contain some dense, non-water soluble chemicals such as mercury, or reactive chemicals such as sodium or lead azides. The housekeeping staff must handle the many different types of sharps, many of which are contaminated with minute amounts of toxic chemicals. The use of detergents can be a source of dermatitis and can cause open wounds. Glass-cleaners often use very corrosive cleaning chemicals. Some, such as the chromic acid/sulfuric acid cleaning solutions commonly used in biomedical research and cleaning facilities, can cause chemical burns which are significantly more serious than burns due to flames. There are others, such as the grounds maintenance personnel, who are exposed to pesticides and other chemicals, and the refuse haulers who, in addition to handling a variety of substances may, after compacting a dumpster of refuse into their truck, be surprised to realize the refuse in the truck is on fire, most likely from the compression of an "empty", sealed, volatile chemical container! These are just a few of the typical situations where biomedical services personnel may have occasion to come into contact with, or experience the results of or exposure to chemical substances.

There are, of course, other service areas such as the clinical laboratory and the operating rooms where chemical exposure may also occur. However, these areas tend to have limited and specific substances to contend with such as ethylene oxide, laboratory chemicals and anesthetic gases. Although the risks are more well defined, the comments which follow are just as pertinent to them as to the workers in the other areas.

CHEMICAL HAZARDS IN BIOMEDICAL FACILITIES

Any discussion of chemical hazards to biomedical services personnel has to begin with a delineation of the differences between the two basic types of risks associated with chemicals. I have labeled these risks as "chemical safety risks" and "chemical health risks."

Chemical Safety Risks

The properties of the chemicals distinguish one type of risk from the other. The properties of chemicals which constitute safety risks are grouped to include substances which are flammable, corrosive, irritant, reactant and those that readily give off oxygen, the oxidizers.

Flammable chemicals will burn when they come in contact with a spark or flame, or any other sufficient energy source such as extreme pressure. All of the petroleum distillates such as kerosene, naphtha and various hydrocarbon solvents are flammable and should be stored and used in such a manner that keeps them away from heat and flames.

Corrosive chemicals do damage by destroying tissue they contact. They can destroy skin, but are especially destructive to eyes, mucous membranes of the mouth and throat and the linings of the lungs, esophagus and stomach. Common corrosives are sodium hydroxide (caustic soda, lye), potassium hydroxide (caustic potash), hydrochloric acid (muriatic acid), and sulfuric acid (oil of vitriol or battery acid). Corrosive chemicals can cause injury or death as a result of chemical burns and tissue damage.

Some chemicals are irritants. They do not destroy tissues as do the corrosives, but they produce varying degrees and combinations of redness, swelling, blistering, burning or itching sensations. Dilute solutions of corrosives, many cleaning solvents and polishes, liquids with a high or low pH (acidity or alkalinity), turpentine, oil and spices such as nutmeg, cinnamon, pepper, mustard and clove are examples of irritants. As a general rule, chemicals do not cause death or permanent injury as a result of their irritant properties. However, their affects can be very discomforting, both physically and cosmetically.

Other substances may be reactive chemicals which require careful direct handling, or oxidizers which require special storage precautions.

Chemical Health Risks

Finally, many chemicals can harm us by virtue of their toxicity. The toxicity of a chemical refers to its ability to damage an organ system, such as the liver or the kidneys, or to disrupt a biochemical process, such as the blood forming mechanism, or to disturb an enzyme system at some site in the body removed from the site of contact. This property known as "toxicity," I have placed under the heading of chemical health risks. This area, I believe, consumes the most time on the part of chemical health and safety professionals and is a major cause of alarm, anxiety and fear to the professional involved.

These, then, are some of the chemical risks to which biomedical service personnel may be exposed. In my opinion, the probability of occurrence of the chemical safety risks is significantly higher than for the chemical health risks, and the results can be just as devastating for the personnel involved.

Evaluation of Toxicity

I would like to address some of the factors used in the evaluation of toxicity of chemicals and the associated health risks, and offer what I believe can be done to overcome some of the anxiety and fear associated with the use and handling of chemicals in general.

Risk or hazard can be defined as the probability of an exposure, and the consequences of the exposure. The probability of an exposure, or in the case of chemical safety risks an occurrence, is dependent upon a number of factors which include the physical and chemical properties of the substance combined with the conditions of the use of the chemical. For example, hydrogen cyanide gas is an extremely toxic substance. However, if it is contained in a gas cylinder which is properly sealed, the probability of exposure during handling is very small and the subsequent risk is minimal. Similarly, the consequences of the exposure can have an impact on the total risk. If, for example, the probability of exposure is high, such as occurs during the ingestion of alcoholic beverages, the subsequent risk is minimal due to the low toxicity of ethyl alcohol used in moderation.

There are a number of factors which must be considered when attempting to evaluate the health risk or hazard of a chemical. These include the total amount of exposure, the route of exposure and a number of other factors.

All affects of chemicals, beneficial, indifferent or toxic, are dependent upon a number of factors, the most important of which is known as the dose-time relationship, that is, how much chemical is involved and how often the exposure occurs. The dose-time relationship gives rise to two different types of toxicity which must be distinguished. These are acute toxicity and chronic toxicity.

The acute toxicity of a chemical refers to its ability to do systemic damage as a result of a one-time exposure to relatively large amounts of the chemical. Acute toxicity is the concern, for example, when some chemical substance is accidentally spilled and persons nearby or the response team are exposed. The exposure is sudden and often produces an emergency situation.

Chronic toxicity refers to the ability of a chemical to do systemic damage as a result of many repeated exposures, during a prolonged period of time, to relatively low levels of the chemical. Chronic toxicity is the concern in the evaluation of the health risks of food additives, pesticide residues in drinking water or the continual exposure to chemicals by employees during the course of their normal employment. If chronic exposure to a chemical is of sufficient magnitude to produce adverse

affects, such affects are usually not detected until the exposure has continued for some period of time.

The tremendous importance of the dose-time relationship in determining whether or not a chemical will be toxic is well illustrated by the fact that every one of us ingests many lethal doses of many chemicals, both natural and synthetic, during our lifetime. There is a lethal dose of caffeine in approximately 100 cups of strong coffee. There is a lethal dose of solanine in from 100 to 400 pounds of potatoes, of oxalic acid in 20 pounds of spinach or rhubarb. A lethal dose of ethyl alcohol in a fifth of liquor or a lethal dose of aspirin in 100 tablets. It is only when we overwhelm the natural defense mechanisms of our bodies by taking too much at one time, or too much too often, that we get into trouble.

The degree of toxicity is dependent not only on the dose-time relationship, but also on the substance's route of exposure. The route of exposure is the pathway by which a chemical enters the body. There are three principle routes of exposure; one is penetration through the skin, the second is absorption through the lungs and the third is by passage across the walls of the gastrointestinal tract. These routes of exposure are labeled dermal, inhalation and oral, respectively. In the case of the biomedical services personnel, there is one other possible route, and that is intramuscularly by accidental injection with a syringe or broken glass.

Probably the most common way of contacting chemicals is by the dermal route. Fortunately, intact skin is a very effective barrier against many chemicals. If a chemical cannot penetrate the skin, it cannot exert a toxic affect by the dermal route. If a chemical cannot penetrate the skin, its dermal toxicity depends upon the degree of absorption that takes place. Chemicals are absorbed much more readily through damaged or abraded skin than through intact skin. Once a chemical penetrates the skin, it enters the blood stream and can be carried to all parts of the body, and thus to the system where it exerts damage.

Inhalation is a second common route of exposure to chemicals. Unfortunately, unlike the skin, the surface of the lungs is a poor barrier against the entry of chemicals into the body. We have a great deal more lung surface area than skin surface area. This lung surface is a thin membrane which allows ready passage of not only oxygen, but also many other chemicals from the alveolar space to the blood, in which the chemical is then carried throughout the body, including the system where it can cause damage such as the liver, kidneys or central nervous system.

If a chemical cannot become airborne, it cannot enter the lungs and cannot be toxic by the inhalation route. Chemicals can become airborne in two ways, either as tiny particles composed of many molecules of atoms (dusts, mists or fumes) or as individual molecules or atoms (gases or vapors). Dust particles become respirable only when they are below a certain very small size. The largest of the respirable particles deposit on the surfaces of the nasopharynx or throat and do not enter the lungs. Smaller particles are breathed into the lungs and impinge on the lung surfaces. Vapors and gases, which are present in the air as individual molecules, are also breathed in and out with the respiratory movements. The number that impinge on the walls of the respiratory tract and the lung surfaces is dependent upon the concentration of the compound in the air. Chemicals that are absorbed through the surfaces of the lungs enter the blood stream and are distributed to other parts of the body by the general circulation.

The third way chemicals enter the body is by ingestion. This is by far the least common route of exposure and often occurs through intentional means. However, the use of improper procedures in a laboratory such as mouth pipetting or drinking from laboratory containers can lead to the accidental ingestion of toxic substances.

In actual practice it is difficult to have an exposure to a chemical that is solely by the dermal, inhalation or oral route. Dermal exposure can also become ingestion exposure when hands are not washed after handling or working with chemicals and before eating or smoking. Thus, when route of exposure is specified, what is really meant is exposure primarily, rather than solely, by that route.

There are two basic reasons why toxicity varies with route of exposure. One relates to the quantity of chemical that gains entry into the body and the other to the pathway that the chemical follows in the course through the body.

A number of other factors can have an impact on the toxicity of a chemical due to exposure. These include species differentiation where the extrapolation of results from animal experiments to man is not always easily made; age, sex, nutrition, current state of health and individual susceptibility are variable factors to consider. Wide ranges of individual susceptibility to chemicals occur in all species. For this reason acute lethal doses, the measure of acute toxicity of a substance, are expressed as averages or means rather than as absolute values. It is believed that this difference regarding susceptibilities to the toxic affects of chemicals is due to differences in their genetic makeup.

The professional must put the potential risks of working with or using chemicals in perspective. Chemicals can exhibit a number of affects, both beneficial and detrimental. Everything we do in daily life carries risk. One has to start leaving the concept of "safety," and drive home the concept of risk and what is considered an acceptable risk. The major point of this discussion centers on the concept of what factors contribute to the total risk, what can be done to minimize the risk, and how do we determine what is "safe" or "acceptable" risk?

In the biomedical services, I believe there are two major concepts which can help to minimize the risk to personnel. The first is to make people aware. If people are aware of what the risks are and how the risks are incurred, then they can make more knowledgeable and appropriate decisions as to how they face their job responsibilities. Methods of awareness development should focus heavily on educational programs for all employees. Personnel should be given some generic chemical awareness training and at the same time be made aware of who the technical resources are that can be called upon to obtain the necessary information. Often these resources are available at the individual health care institutions but the employees just aren't aware of where they are or who they are.

The question uppermost in the minds of individuals relates to whether or not exposure to some chemical or chemicals will be harmful to their health or that of their loved ones. Often, these are the very questions that toxicologists and occupational health specialists cannot answer with a definite "yes" or "no." Science has no way of knowing the exact biochemical makeup of any individual person or exactly what threshold for the most subtle affect of which the chemical is capable. An answer based on judgement can be given, but science does not as yet have the methodology to respond to these concerns with direct evidence. Toxicologists and health specialists can make judgements about the possibilities and probabilities of harm resulting from exposure to chemicals. These judgements are based upon scientific data obtained from toxicity testing, knowledge of the behavior of the chemical in animal systems, and application of the appropriate margins of safety.

It is most natural for people to demand assurance that the exposures they experience are absolutely safe; it is very difficult for them to grasp the fact that this is an assurance that no one is capable of giving.

The area of chemicals and chemical hazards is creating significant anxiety and stress in our working populations. It is up to employers and the professionals who work in the occupational health and safety fields to help put the risk due to chemicals in perspective for these populations. To accomplish

this one must be able to listen carefully to the concerns and respond effectively. One must also provide appropriate information about ways to reduce the risks associated with the use of these substances. Further, health care facilities should be engineered and equipped to be as risk-free as possible.

SECTION II: Employer's Role in Risk Reduction

In this section, the three papers deal with what employers can do to reduce employee work risks. The first paper details how an overall view of the facility and of the employees can bring about a safer work environment for every one. The second paper is an outline for health care safety administrators responsible for developing, implementing and evaluating safety training programs. Finally, a paper dealing with job stress, a big problem in health care facilities, is presented. The paper offers suggestions on how, not only to overcome stress but also, to promote "wellness."

By blending the knowledge obtained from these papers with the specific details in following sections, we believe risks to health care providers can be greatly reduced.

SYSTEMS APPROACH TO SAFETY

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ABSTRACT

Recently, there has been an increased demand to develop efficient, responsive, comprehensive safety programs within our health care facilities. However, there is mounting evidence that our existing safety management systems are not effectively responding to these pressures. A system analysis of a hypothetical safety function is performed. It is postulated that this operation has become a "closed" system which is inefficient in reading the environmental demands, and therefore is slow to respond and change. The systems approach is utilized to provide a template for describing the synthesis of an integrated, comprehensive safety system. The key elements of developing interrelationships and communication networks with other safety function are discussed. The systems approach also is applied to the evaluation and utilization of computerized information management.

INTRODUCTION

Recently, there has been an increased demand to develop efficient, responsive, comprehensive safety programs within our health care facilities. However, there is mounting evidence that our existing safety management systems are not effectively responding to these pressures. This possibility was highlighted in the new Joint Commission on Accreditation of Hospitals (JCAH) guidelines which specifically outline a multidisciplinary approach to safety management (JCAH, 1985). This action could be interpreted as meaning the JCAH views our present programs as being deficient and is attempting to provide a template for developing a different approach to safety.

The following chapter is predicated on the assumption that our present safety management systems are, in fact, failing. The systems approach will be utilized for the analysis of this failure. The application of the systems approach to safety management is not a novel concept. In fact, many of our present safety programs were originally founded on management systems principles. However as we will see, there are numerous junctures at which a management system can lose inertia and begin to lose efficiency. After analyzing our present system, the author will again apply the systems approach to propose the design of a new more efficient system.

BASIC SYSTEMS THEORY

A system may be defined as a set of parts coordinated to accomplish a set of goals (Churchman, 1968). Systems provide mechanisms for the directed movement of energy from an input stage, through a process, to a final output. Process refers to the internal organization of the system. Many of the elements of internal organization, such as channels, interactions, components, and roles are quite familiar to most of us. However, the development of internal organization is subject to individual management style and will not be covered in this discussion (refer to Branden and Huban, for a detailed analysis of this topic).

The flow of energy within the system, which proceeds from input to output is defined as internal system operation. Some systems are limited to internal operation, there is no

exchange of information with the external environment. These systems are called closed systems and are rigidly organized and slow to change with the times. On the other hand, many systems contain a feedback loop which allows the introduction of data from the surrounding environment which in turn affects the internal systems operation. Such systems are classified as open systems and are generally more responsive to change. However, the exchange of information with the environment is not always directly constructive because feedback may be either positive or negative. Positive feedback comprises data that leads to change. On the other hand, negative feedback comprises data that leads to stability or resistance to change. (Braden and Hurban, 1976).

Systems can be classified according to their size and degree of complexity. If the focal unit is small it is called a microsystem. As a focal unit becomes more complex and incorporates several microsystems (subsystems) it is classified as a mezzosystem. The organization or facility may be viewed as a macrosystem which incorporates complex interrelationships of numerous subsystems.

PAST SAFETY MANAGEMENT - CLOSED SYSTEM APPROACH

The following analysis of the operation of our existing safety systems is based on the previously stated premise that these systems are failing to effectively respond to change. This section represents the author's evaluation of pressures that may have transformed an efficient safety function into a system that cannot effectively "read" the environmental demands. It is not the author's intent to place blame, but rather to outline a sequence of events that may have contributed to the present state of safety management.

Many of our safety operations were established as fire safety or security offices which performed efficiently within their originally defined constraints. The responsibilities of these functions were fairly well defined and internal operations were established based on these demands. Since the

scope of responsibilities did not change frequently, the safety office was frequently isolated from the facilities decision making process and located as a subunit of a large operational division. This isolation would have hindered the office's ability to receive input from top management and would have complicated the interpretation of institutional goals and needs.

This steady state operation ended during the 1970's when the health care industry suddenly became regulated on many new fronts; personnel exposures had to be controlled, hazardous waste had to be collected and disposed of, and new general safety standards had to be met. These external demands stretched the capacity of safety personnel in both their area of training and interest. It is probable that the organization turned to the safety office for direction in complying with these new constraints. At this juncture, the growth of the system could go either of two directions based on its ability to manage these new pressures. If the safety management system effectively interpreted and responded to these new demands, it would have continued to develop as an integrated part of the organization. However, if the safety personnel could not support the needs of the organization it is likely that institutional feedback would have switched from positive to negative. This change in feedback would have adversely affected the development of the safety office because a system that is exposed to or accepts only negative feedback will operate mainly to maintain status quo (Braden and Huban, 1976). At this point the system would probably establish mechanisms to block the negative feedback; thereby, becoming a closed system in which change and communication is inhibited. It is postulated that this is the present state of many safety management systems.

THE CHANGING MANAGEMENT ENVIRONMENT

Numerous environmental pressures are forcing safety professionals to re-evaluate their safety management systems. The simplistic approach of a safety officer independently enforcing existing codes and standards is no longer considered acceptable. Our health care facilities are encountering new pressures from: 1) increased regulatory activity, 2) a more educated work force, and 3) stringent fiscal constraints. We

are challenged to develop a more efficient, comprehensive safety management system that can respond to the demands of this rapidly changing environment.

The increase in regulatory activity from agencies both internal and external to the health care delivery system has been significant. Both the JCAH and the College of American Pathologists have placed new emphasis on regulating safety in the hospital and laboratory.

External agencies, such as The Occupational Safety and Health Administration and the Environmental Protection Agency, also have promulgated new standards and regulations. Compliance with the new standards may be complicated because they are intended to regulate the industrial environment and may not be directly related to health care exposures. Additionally, many of the new regulations are actually performance standards, that is, they define the regulatory goal or objective and then leave it to the facility to develop the compliance mechanisms for achieving those goals. Compliance with this proliferation of standards necessitates that a facility develop sophisticated support mechanisms (including safety professionals) both to analyze compliance options and to implement the compliance programs.

Additional pressures comes from health care employees who are demanding more support and information from safety professionals. The work force is becoming more knowledgeable and concerned about their exposures in the workplace environment. Many employees are questioning exposure to any physical, biological and chemical agents. The potential risks of exposure to many of these agents may not have been identified. In addition many of these exposure are not regulated. Consequently the safety manager is being recruited to provide scientific and management support for the development of facility specific policies regarding these exposures.

Furthermore, the safety professional must continue to perform within defined fiscal constraints. These constraints require the development of efficient mechanisms to manage the ever increasing spectrum of responsibilities. Additionally,

the manager must develop a fiscal conscience because his/her decisions concerning compliance may have a negative impact on the stability of the organization.

Our management environment has changed so completely that even "old truths" such as the definition of safety have come under attack. The dictionary defines safety as being free from danger or harm. However, William Lowrance, in his book "Of Acceptable Risk", states that safety is a judgement of the acceptability of risk. Consequently, a thing is deemed safe if its attendant risks are judged to be acceptable. He further states that this definition emphasizes the relativity and judgemental nature of the concept of safety. It also implies that two very different activities are required for determining how safe things are: measuring or assessing risk, and objective but probabilistic pursuit; and judging the acceptability of that risk (judging safety), a matter of personal and social value judgement (Lowrance, 1976).

This definition of safety, requires that the safety professional function on two distinctly different levels. First, he/she must perform as a scientist and direct the risk assessment that will determine the potential for harm from the exposure in question. Secondly, he/she must perform as a manager and participate in the policy making decisions that judge the acceptability or safety of an exposure.

DESIGNING AN OPEN SAFETY MANAGEMENT SYSTEM

Integrating our safety functions into an open system is one strategy for successfully managing in our changing environment. Whether starting with an existing system or beginning anew, the design process begins with a statement of the problem or goal. The purpose of a management system is to provide solutions to organizational problems (Young, 1966). As noted previously, there are numerous internal and external sources of these problems, therefore, we must develop mechanisms to identify and respond to these problems.

The second step in designing the program is developing a model of the proposed system. (Young, 1966). In developing the model the designer utilizes systems analysis and proceeds from analysing the whole organization (to develop of perception of the "big picture") through the careful review of each subunit. The model is usually a block diagram or flow chart which outlines the relationship of safety functions to the organization, so that each subsystem can be analyzed for the form of its input, operation, and output, as related to the goals of the organization. The benefit of using the systems analysis approach is that it enables the designer to maintain a concept of the whole while analyzing the interrelationships of the parts. An evaluation then can be made as to the way all the subparts should be united into the whole during system synthesis. (Young, 1966).

Specifically, in designing an open safety management system we must evaluate operation on three levels. First, there is the internal process of our own function, which represents a microsystem. Next, we must analyse each of the group of safety functions (subsystems) which comprise the mezzosystem of the facility's safety program. Finally, we must analyze the position and interrelationships of these systems within the whole management scheme of the facility (macrosystem).

This strategy does not require that all functions be organized under a single administrative director. Rather, the inputs, processes, and outputs of each subsystem must be interrelated to the others through either formal or informal links. The interrelationships are the key to designing an efficient system. The safety manager's challenge is to assure that all subunits are properly interrelated or overall results will be deficient even though specific parts are highly sophisticated. (Young 1966).

The most important element for the maintance of the interrelationships is the development of effective communications networks. A system should have both intrasystem (internal) and intersystem (outward) communication networks. The hypothetical past safety management system may have had highly sophisticated intrasystem communication but it had a minimal intersystem communication network. This system

therefore had no mechanism for accepting input or sharing output and was classified as a closed system.

An open system communicates both internally and outwardly. The feedback loop is the avenue of intercommunication. The feedback loop provides an outlet for the services produced by the internal system function and offers a channel for input of new energy for further system use. The inputted energy may be applied to redirecting the function and output of the system (change).

The primary goal for developing a communication network is to provide a mechanism for directing change through facilitating the "reading" of the environmental pressures. The organizational environment must be monitored on at least three levels: 1) top administration, 2) other subsystems, and 3) employees. One mechanism for promoting communication between the first two groups is the multidisciplinary safety committee which was recently mandated by the JCAH (JCAH, 1985). The JCAH standard states that:

1. There is a multidisciplinary safety committee whose membership includes individuals qualified by training and/or experience to develop, implement, and maintain a comprehensive hospitalwide safety program. Individuals with expertise in all areas of concern are included on the committee or are available to participate as needed.

2. The chief executive office or designee appoints the chairman and the members of the safety committee.

3. The chief executive officer or designee appoints a safety director or officer who is qualified for the position by training and/or experience. The safety director or officer is a member of the safety committee and is responsible for carrying out the functions of the safety program.

4. The safety committee meets as frequently as required by the chairman, but not less than quarterly. The conclusions, recommendations, and actions of the safety committee must be reported at least quarterly to the administrative, medical, and nursing staffs, and others as appropriate.

5. The authority of the safety committee is approved in writing so that, through the chairman or the safety director or

officer, action can be taken when conditions exist that pose an immediate threat to life or health or pose a threat of damage to equipment or building. This authority must be approved by the governing body or chief executive officer or designee, as appropriate, and by the medical staff.

6. There is evidence of information exchange and consultation between the safety committee and the various safety programs (for example, safety programs for engineering and maintenance, housekeeping, laboratory, nursing, and dietetic services), the infection control committee, the hospitalwide quality assurance function, and other standing committees.

7. There is evidence that the conclusions, recommendations, and actions of the safety committee are evaluated by the appropriate administrative directors of the areas affected and that proper action is documented in subsequent safety committee minutes.

While establishing this committee is a significant step, the development of a communication network can not be limited to formation of this committee. We must remember that the primary recipient of safety function services are the employees and other organizational subsystems. To a degree the safety office output must be designed to satisfy the goals or needs of these groups. The output must be generated in a form that can be interpreted and used by the recipients.

Recognizing that the content and form of output is defined by our internal operation, it is appropriate to discuss guidelines for organizing the internal safety process. The National Institute for Occupational Safety and Health (NIOSH) has developed an excellent resource manual that describes the basics of establishing a comprehensive occupational safety and health (OSH) program (Godbery and Hatch, 1978). In this manual the OSH program is defined as an organized program devised to correct and prevent safety and health hazards in the workplace. Through the use of this formal program, it is possible to identify, evaluate, and control problem areas, be they unsafe acts or practices, unsafe conditions, or an unhealthful work environment. A formal OSH program is one that:

- o is recognized by the institution
- o is supported by top-level administration;

- o has as its overall program objective the concept of reducing the number and severity of work-related injuries and illnesses;
- o has a program of planned activities that will achieve program objectives; and
- o has a specific person responsible and accountable for the program.

Each safety function actually encompasses numerous programs with specific objectives. These programs must be interrelated within the safety function to form a system with a directed, yet flexible, output.

Considering output throughout the process of designing both the system and the communication network should contribute to accomplishing two important secondary goals of the safety management system. These goals are efficiency of operation and establishment of the safety function as an information resource/support center.

Correctly identifying the organizational needs (through communication) will facilitate prioritizing the objectives of internal operation and will contribute to efficiency because effort can be directed toward the most pressing issues, and not wasted on projects that do not serve the goals of the institution. This prioritized approach will promote maximum useable output (on an organizational level) from the limited resources that are generally available to the safety functions.

Establishing the safety function as an information resource or support center is critical to its continued growth and development. Remember that a system engenders support by virtue of what it accomplishes (Godbey and Hatch, 1978). The accomplishments are magnified if they contribute to the efficiency and production of other subsystems. Designing the systems output to complement or support other functions will both reduce duplication within the organization and promote the interdependence or interrelation necessary for effective systems operation.

Summary

The utilization of the systems approach should provide the framework for developing an efficient responsive safety operation. However, designing or redesigning a safety management system is not a simple undertaking. Changing or redirecting an organizational scheme requires a significant input of energy to overcome established roles and channels. The safety professional will have to provide this initial energy and then continue to input direction to the system development.

Furthermore, the safety professional will have to consult with top administration, first to ascertain their specific expectations for the system and then to garner support for the proposed change. The administrator either may not recognize that there is a problem or may place low priority on resolving it. Therefore, several meetings may be required to educate the administrator. It is advisable that the preliminary analysis and synthesis of the system be accomplished prior to these meetings and that the safety professional have a proposed solution to the problem in the form of a system model. This preliminary system design should outline the appropriate interrelationships of the proposed system.

Finally, the initial analysis of the existing safety operation may be uncomfortable to perform. It is difficult enough to perform an honest evaluation of the goals and operations of one's own safety function. However, there may be significant resistance when one begins to analyze the operation of related functions. This analysis will require special management finesse because people may question the motives of the review and may activate defense mechanisms to "protect their turf".

COMPUTERIZED DATABASE MANAGEMENT SYSTEMS

Computer applications are becoming commonplace in both personal and professional life. We are told that the personal computer (PCs) uses the "systems approach" for information management. This statement does accurately describe the PC hardware because it is a whole composed of interrelated parts.

However, many of the software packages, which are the database management components of the computer, are not based on systems principles. Many software packages are designed specifically for information processing or "fact retrieval" and support the development of independent database. These databases do not interrelate with other databases and therefore do not represent a system.

Other software packages are designed with interfacing capabilities and can support the development of an information management system. Unfortunately, these databases are frequently under-utilized because the user does not employ the systems approach to assure that the databases can be interrelated. Without this interrelationship, data management becomes a collection of stand alone databases that do not comprise a system.

Many of the same principles utilized in designing a safety management system can be applied to developing a computerized information management system. For example, the output of the system must be considered from the onset, the separate components (databases) must be interrelated, and the capacity to minimize duplication of effort, through interfacing the communication network, must be developed to assure efficiency.

Application Of Database Management

The systems approach was applied to the development of an information management system for the Environmental Safety Office (ESO) at the Duke University Medical Center. The first step in the initial set-up of this system was obviously the purchase of a personal computer (an IBM-PC). Secondly, a software package with database integration capacity was selected (many inexpensive, commercial software packages such as Lotus 1,2,3, Knowledge Man, D-base, and Symphony have these capabilities). Finally, a careful systems analysis was conducted to identify goals and interrelationships for the proposed system. All of these activities were undertaken prior to collecting or entering any information.

At the start of systems analysis, the goal for developing

the computer system was defined as facilitation of collection, analysis and distribution of safety related information. The output of the system was to be analyzed data to support the decision making process. After identifying this output, we critically evaluated program deficiencies within the ESO and then determined what data needed to be collected to support improved internal operations. Next, the possible utilization of this data by other subsystems was evaluated. We determined that by slightly modifying the collection or analysis of the information, that numerous other functions could advantageously utilize the data. Based on this potentially expanded use of the data, we designed data collection/management schemes to support the individual Hospital Epidemiology, Infectious Disease, Microbiology, Employee Health, Industrial Hygiene, Hazardous Waste Management, Employee Education, Fetal Protection and Laboratory Audit subsystems, to name a few.

Separate databases have been developed for Infection Control, Hazardous Waste Management, Industrial Hygiene, Material Safety Data Sheets and Employee Education. These databases are all interrelated and can be interfaced for efficient comparison, compilation, or cross-reference of information.

This planned systems approach to computerization of the safety office has improved the efficiency of the ESO. Additionally, it has resulted in an expanded communication network and has established the ESO as a facility information resource. In other words, directed computerization has contributed to establishing the ESO as an operational, responsive open system.

Laboratory Audits

The laboratory audit program "drives" many of the other safety programs within the ESO. The audit program was designed as a special management tool that supports most of the other systems development. Therefore, it is appropriate to describe the strategy in greater detail.

The primary component of a computer-assisted environmental safety department is an effective facility audit

program. Facility audits provide a mechanism for effective communication between environmental safety specialists and facility personnel. Audits allow for the collection of current health and safety information, aiding in assuring facility compliance with applicable regulations and standards. They also provide the opportunity for distribution of current information.

The information collected during a facility audit includes the following - safety practices, containment devices and other equipment, fire fighting equipment, chemical handling and storage practices and hazardous waste management practices. An inventory of chemicals and amounts used and stored in a specific work area is an integral part of the facility audit. Special attention is given to chemical storage practices with regards to appropriate segregation of hazard classes, as well as selection of storage location. In addition, appropriate labeling of containers is evaluated. In areas where OSHA regulated carcinogens are being used, compliance with applicable standards is noted. Chemicals are finally evaluated in terms of hazardous waste management practices. Chemical wastes streams are identified, and waste disposal methods for these waste streams evaluated.

Facility audit information is applied to efficient management of a comprehensive safety program. For example, many types of equipment, including safety showers, eye washes and fume hoods require periodic recertification. Computerization of this information allows the inspector to query the data-base and identify equipment requiring recertification. Another important application occurs in an emergency response situation. Pertinent information on a specific work area can be quickly retrieved and relayed to an emergency coordinator. In a fire situation, being able to identify what chemicals are involved can assist fire fighters in choosing appropriate extinguishing material and protective clothing.

In addition to data collection, several benefits can be derived from a facility audit program. The factual data collected can help to identify program strengths and weaknesses. This enables the prioritization of goals allowing a more directed approach towards safety management. By opening the lines of communication, facility personnel can be made more

aware of safety resources available. But more importantly, an effective facility audit program can increase personnel awareness as to their responsibilities within a safety management program.

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IDENTIFYING THE NEED FOR SAFETY TRAINING

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In establishing the need to develop and conduct a safety training program several fundamental questions must be asked by representatives drawn from a variety of disciplines. Hospital settings by nature are complex, sophisticated work environments, therefore, no issue should be approached from a singular perspective by one body of people representing the same discipline or point of view.

The questions that are asked in the early stages of identifying and specifying training needs are similar to the questions a journalist asks when writing a newspaper story - who, what, when, why and how. The order in which the questions are asked and the answers may vary. However, if this critical step is omitted, the training process and, therefore, the program runs the risk of not identifying the actual training needs of the group for which it is intended.

To clarify any preconcieved notions or misconceptions about the purpose of and limits of training, it is important to define training. Training, by definition, means to make proficient by instruction and practice.

Therefore, in order for a training intervention to be successful, there must be identifiable and concrete gap in information, knowledge and simple skills as well as clearly defined training objectives designed to fill the gaps. Next, it is important to determine whether a training intervention alone will fill the defined gap(s).

Those gaps which cannot be filled by training interventions may be better and more successfully met through managerial, administrative and procedural approaches. Training is all too often identified as a panacea to solve a myriad of problems which cannot be realistically be met through training. To ensure that training objectives are realistically based and address a deficiency in information, knowledge and simple skills, several planning strategies must simultaneously be worked through.

First, gather a team or training committee which includes representatives from management, supervisory and operational levels, some of whom possess the technical skills and expertise to look at the training process from a technical perspective. Careful discussion among all group members will hopefully facilitate the sifting and sorting of training objectives from managerial and administrative objectives. This is not to imply

that managerial and administrative objectives should summarily be shelved; rather they should be resolved through the appropriate channels. The committee should also be charged with identifying the specific target audience for whom training intervention and/or managerial interventions are planned and the individuals or groups on staff or consultants, who are most able to satisfy the needs identified.

In referring back to the objectives which are best resolved through administrative and managerial means, these too need to be prioritized. This process will serve two purposes; first, to help set manageable goals; and, second, to reinforce the premise that problem solving in the workplace necessitates a variety of approaches. In doing so the pitfall of identifying training as the sole strategy, and thereby a panacea to all problems in the workplace, is avoided. It also serves to reinforce the premise that training is a good and sound strategy when information, knowledge and simple skills are lacking.

Once a consensus of this type of situation is reached on the training objectives and target audience, resource identification and development needs should be considered. Research is available on the types of strategies and the mix of resource strategies that over time have proven to work best with different types of audiences. For example, in the biomedical research institution and hospital setting, there is a wide range of job, training and educational levels. For each training program audience there will be varying degrees of differences among participants. Generally speaking, the differences are minimized because participants within an organization share similar jobs. However, within the same job classification, wide differences in background may exist. When such differences are observed or determined through a needs assessment, it may be beneficial to conduct two training sessions. Often, the learning and behavioral objectives are identical, however, the resources and training strategies introduced may differ to maximize results.

A good example is when language barriers exist. Often in the hospital setting support services personnel may have language barriers due to lack of schooling or recent immigration. Other staff members may not. Audiovisual presentations may be a sound strategy for the group with the language barrier whereas the group without the language barrier may respond more readily to a combination of didactic and written materials.

One of the questions a training planning committee asks at the onset of discussion is who to train and when to train them. Several groupings of employees should be trained followed by a thorough discussion of the advantages and disadvantages of conducting training at different junctures.

In the hospital setting, there are well documented turnover rates in certain job classifications. In larger institutions, such as the National Institutes of Health, which employs approximately 15,000 workers ranging from basic and clinical researchers to administrative and clerical positions; new employees in certain job series are hired on a regular basis in large enough numbers to justify training programs for new employees. It is important to distinguish the intent of an orientation program from a training program. At NIH, orientation programs focus on introducing the new employee to the organization at large and some specific qualities of the group or area in which the employee will be working. However, in the Division of Safety, training programs focus primarily on the safety resources and services available to carry out specific categories of positions and the technical information and procedural skills helpful in the laboratory setting.

The advantages of conducting training programs for new employees is to introduce and reinforce proper procedures, skills and information before bad habits, misinformation and inappropriate procedures have had the opportunity to develop. New employees' attitudes and skills may also have an impact on more tenured employees as well.

When conducting training programs for the more tenured employees, if the planning process is complete, the objectives and outcomes may be easier to define and measure. The major disadvantage is, of course, that inculcated misinformation and skills are difficult to overcome.

CONCLUDING REMARKS

The need to train is based upon well-defined gaps in information knowledge and skills. The target audience, resources and training objectives must be well-defined in order to maximize the outcome and to minimize frustration. Such changes may be documented with pre and post tests, a decline in accident incidences or by observation. A comparison with established safety data may also serve as an indicator of a program's success. In short, safety training can work if carefully planned and if planned with clear goals in mind.

STRESS REDUCTION AND WELLNESS PROMOTION

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ABSTRACT

The way we define health is expanding. We share an education based on the biomolecular model of health, the logical outgrowth of the issues we were dealing with in the first part of the century. The concerns were infection and sanitation, the relationship between pathogens and people. Health assessment revolved around negatives. We measured health according to the five d's -- death, disease, discomfort, disability, and dissatisfaction. (Edlin and Golanty, 1982) The absence of disease was the criterion for defining health. The benefits obtained from focusing on communicable disease were antibiotic therapy and immunization, superb and necessary contributions to eradication of disease.

However "health as only freedom from disease is a standard of mediocrity." (Edlin and Golanty, 1982) There is more to life than not being sick. Health care providers who work in hospitals are exposed to many stressors. Rotating work shifts, work overload, mandatory overtime and short staffing all set the stage for fatigue and for vulnerability to illness. Establishing a pattern of health through cardiovascular fitness, stress management and optimal nutrition strengthens one to withstand these situations. In the following chapter, each strategy is examined in-depth. Current research is reviewed and contrasted. The bibliography provides references for those who would like to continue further study.

INTRODUCTION

Health promotion focuses on the person- the environment he enfolds around him and the patterns that he weaves into a certain kind of life. Wellness promotion is the humanistic movement which begins with people in whatever state they are in and supports the individual in developing a lifestyle that enhances his/her well being. It speaks to vitality and aliveness.

The old model for health has shifted from a fragmented, costly, illness-oriented system, to a wholistic system of prevention. The emphasis is on preventive medical care and patient responsibility. "The treatment of a disease may be entirely

impersonal, the care of the patient must be completely personal."
(Blattner, 1981)

Health education should speak to the quality of life. Halbert Dunn describes a wellness "where you are alive clear to the tips of your fingers, where you have energy to burn, when you tingle with vitality-- times when the world is a glorious place."
(Dunn, 1973)

As the model for health changes so does the emphasis. The continued preoccupation with pathogens is necessary, however it is not the whole picture. There is no space there to work on vitality, exuberance or a lust for life. Various cultural trends have converged to provoke the current paradigm shift that enables us to see old problems in a new way. It is cost-effective to prevent versus to cure diseases. It is inefficient to bring your body in for repairs when you could continually provide an environment that bathes the cells optimally and helps you stay well in the first place.

John Laird, M.D. Director of the Waters of Life Health Center in Asheville, North Carolina defines health in this way: $\text{HEALTH} = \text{VITALITY} / \text{STRESSOR LOAD}$. Health equals vitality over the stressor load. Previously, we spent all our time dealing with the bottom part of the equation. Under the new paradigm, we still spend time there-- treating disease and altering abusive habits, but we also include the strategies that promote vitality.

Vitality and stress management are essential to counter the pressure health care workers are under. The National Institute for Occupational Safety and Health (NIOSH), in a study of the relative incidence of mental health disorders in 130 occupational categories, found that when "the major occupations were rank ordered in terms of relative incidence of mental disorders, 7 of the top 27 occupations related to health care operations- health technologists, licensed practical nurses, clinical laboratory technicians, nursing aides, health aides, registered nurses and dental assistants. If the list of health care occupations were expanded to include those not involved exclusively in health care work (dishwashers, warehousemen, laborers, research workers, telephone operators, chemists, social workers, secretaries, and the like), 15 of the top 27 occupations with the highest incidence of mental health disorders would come from hospitals." (Tabor, 1982) Health care providers have need of strategies that promote vitality and protection from burn out.

Attention is given to the rhythm of one's life and its ability to produce a balance. The discipline of yoga provides an analogy. First one gently coaxes a muscle to its maximal extension. Then, after a time of rest, one counters it by stretching the opposing muscles. A balance is achieved. So too, with our

life pattern. Are the activities of one's life balanced by their opposite? Is intense mental effort, with its attention to details, followed by times of physical release and attention to the whole? Are shifts of work, inside buildings, amidst artificial lights, odors of disinfectant and infection and noises from alarming monitors, countered with time outside of buildings, in the sunshine, absorbing vitamin D, amidst nature with its soft textures and fragrances? All of these dimensions are part of wellness. We need to search out patterns that promote health and alter the patterns that provoke illness. In this chapter the strategies that help weave together the fabric of a healthy life are addressed.

ACHIEVING CARDIOVASCULAR FITNESS

People who choose to engage in a program of aerobic conditioning change the structure of their bodies, their incidence of disease and their level of productivity. In a widely quoted study of 16,936 Harvard alumni, Dr. Ralph Paffenbarger, Jr. of Stanford University, found that the more active men (those burning at least 2000 calories a week in exercise) had one-third less heart attacks than those who were less active. (Hales, 1983)

Adherence to an aerobic program will put you in the ninety-fifth percentile for cardiopulmonary endurance. And, as Kenneth Cooper, M.D. states, "endurance is the best kind of insurance." (Cooper, 1968) But for many, the motivation behind body work becomes the sense of peace and the opportunity to tap creativity. The time we make for conditioning our bodies clears out the cobwebs in our heads. It produces a relaxed concentration and reduces our mental and physical tension. So we come back refreshed and more in touch with ourselves and our feelings. A study of middle aged university professors found that regular exercise made them more self-sufficient, more persevering, less likely to experience mood swings and more imaginative (Psychology Today, 1973). Health care providers can utilize fitness as a way to counter burnout and its symptoms of insomnia, gastrointestinal disease and high blood pressure.

The conditioning effect of aerobics strengthens your body in many ways. The cardiovascular system works more effectively. Stroke volume and pumping efficiency of the heart expands delivering more blood. This decreases the workload of the heart and concomitantly lowers blood pressure and pulse rate. Fibrinolysin, the substance which breaks up small clots, appears in greater quantities. (Hales, 1983) The body's ability to more rapidly transport oxygen from the lungs throughout the body is improved. Blood flow to the heart may increase to five times the resting levels. The coronary arteries enlarge and develop collateral circulation. Small blood vessels are constructed to

deliver blood quickly to a heart that is working to pump during exercise. These provide alternate pathways for blood to travel around major vessels in the event of occlusion.

The character of the blood also changes. The amount of red blood cells and blood volume increases. Hemoglobin content rises, making the blood a more efficient carrier of oxygen. Aerobics raises the level of high-density lipoprotein (HDL) the substance that helps bind cholesterol and fat; settling out on the vessel walls. (Cooper, 1968) (Edlin and Golanty, 1982)

As you become more fit, your body's ability to bring in oxygen and deliver it to tissue cells improves-- the vital capacity of the lungs increases and more air is processed with less effort. The muscles of respiration are strengthened.

The bones you use to exercise are thickened and protected from osteoporosis and the appearance of your body changes. Some lose weight but most people begin to lose inches. Dieting without exercise leads to the loss of lean body mass. Exercise, even without decreasing caloric intake, increases the lean body mass and the ratio of fat to total weight usually decreases. Fats are metabolized from the liver causing an elevation in blood sugar post workout, leaving your body in an energized state, gently alert (Cooper, 1968).

But exercise isn't just for the physically unfit. The mentally unfit can benefit in a different way. Aerobics provide you with a sense of accomplishment, something to feel good about each time. Workouts sometimes produce endorphins, the morphine-like substances manufactured in the brain that evoke a feeling of well-being and increased self-awareness.

Exercise reduces physical and mental tension. Many people use aerobics as a way to encourage their creative energies. As you try to concentrate on counting laps, suddenly you realize you've been swimming for minutes oblivious to your surroundings and there floats up an answer to a question you hadn't even asked. This problem solving method is nearly without effort. It is as if you have mesmerized your body to the rhythm of footsteps or heartbeats and while you have been enjoying the gifts of your senses-- feeling the wind in your hair or the velvet of the water, your mind has been effortlessly playing with puzzles-- its own form of enjoyment. The gift of the solution or a new idea sometimes changes the direction of your life.

These changes are the result of the "training effect." The training effect is achieved with at least 20 to 30 minutes of aerobic exercise every other day. The exercise must raise the heart rate to 70 to 85 percent of the maximal rate. The maximum is 220 minus your age. (Hales, 1983) You need to begin slowly

and work up gradually to 30 minutes at a comfortable pace. You should be able to carry on a conversation as you work out.

Some exercise choices that are aerobic are walking, jogging, running, cycling, swimming, jumping rope and cross-country skiing. The exercise becomes aerobic after the first four minutes, as long as the exercise is sustained. Stopping and starting again causes the body to return to anaerobics, so it is essential to work up to thirty minutes of sustained exercise. You should start to notice the effects of training at approximately 1000 calories of exercise per week. Weekly totals of 2 1/2 hours of walking, 2 hours of swimming, 1 1/2 hours of jogging, or 1 1/4 hours of cycling will burn roughly 1000 calories. The times are for a 150 pound individual. The heavier you are, the more calories you burn. (Hales, 1983) The ideal way to achieve this is to exercise every other day.

At 1200 calories used in exercise a week, you reduce long-term risk of a first heart attack by 20 to 25 percent as compared to more sedentary men. Preliminary data from the University of Wisconsin suggests postmenopausal women increase bone density at this exercise level without estrogen or calcium supplements. Relative levels of High Density Lipids (HDL) increase at the 1200 calorie level according to work at Stanford and Baylor. (Other studies report a need of 2000 calories a week or more) This shift takes weeks or months to occur, however, and fades within weeks if exercise is ceased. Depression and anxiety also ease at this caloric use level. Improvement can be as great as with drug treatment or psychotherapy. (Hales, 1983)

It is wise, however, not to become extreme. Exercising more than five times per week triples the injury rate. Increasing exercise sessions from 30 to 45 minutes doubles the risk. Some women who run to utilize more than 2000 calories per week begin experiencing menstrual irregularities and low estrogen levels. The lower estrogen levels may contribute to loss of calcium from bones.

Conditioning should be achieved gradually. To begin a jogging program you start by alternating running and walking. Run and walk for 15 minutes or for a distance of one mile, four times per week. Eventually after 2-3 weeks your ability to jog increases. After 8 weeks most novices should be able to run continually for 10-20 minutes and after 6 months, work up to 3-4 miles, 4 times a week. (Hales, 1983)

At its best, the mental benefits of aerobic conditioning are life-changing. But every day, aerobics provide a soothing, separate space carved out of your busy, responsible life to indulge in sampling the best of yourself. Your creative imagination

flows and your tensions are soothed and quieted. Enhanced awareness adds luster to simple things. You begin to appreciate subtler, less perishable riches--the richness of warm sunlight on your face, the softness of morning raindrops. You seem to enjoy life more. Teilhard de Chardin said that "the aim of evolution is ever more perfect eyes in a world in which there is always more to see." (Ferguson, 1980) Aerobics helps you see more clearly by allowing you to momentarily break out of the cultural trance. "When too much stress accumulates without release, we lose the vividness of colors, sensitivity to sounds, peripheral vision, sensitivity to others and emotional intensity. The real alienation in our time is not from society but from self." (Ferguson, 1980) But the ability to sink in and experience the richness of life with all its beauty has a prerequisite-- a body free of tension.

STRESS MANAGEMENT

"We see things not as they are but as we are." (Keys, 1975) Ours is a fast paced, competitive society with rapidly changing values. Changes take place at an accelerated pace and touch everyone in some way. Success is a cherished goal. But often the path to success encourages life-style patterns that are harmful to our health. Stress followed by its natural antidote-- physical release-- is a catalyst for growth. Recurrent unreleased stress serves as a precipitating factor in disease onset.

Our body's physiological response to stress readies us for "fight or flight," as our cells carry the genetic tendencies of those able to survive tigers in our ancestor's jungles. During the stage of alarm and resistance our sympathetic nervous system releases norepinephrine. This raises the blood pressure and increases the rate and force of cardiac contraction providing the muscles with more more blood. It dilates the bronchii to facilitate breathing and shuts down the GI tract by inhibiting digestion. Pupils dilate to improve vision and glucose and free fatty acids are released from the liver to fuel the escape. The adrenal glands release more norepinephrine to continue the whole display as long as needed. Our body is crouched, ready to pounce (Selye, 1956).

But, because our tigers are paper and our predators a state of mind, there is no obvious chance to pounce. One is left with lingering levels of norepinephrine and free fatty acids. A body chronically crouched can lead to the stage of exhaustion with irreversible organic changes.

Hans Selye demonstrated the profound changes in vital organs due to sustained stress. The thymus gland, important in production of antibodies, atrophies. This enables antigens to stay in

the blood longer. The lymph nodes also atrophy leading to a reduction in lymphocytes of the immune system, and increased susceptibility to infection. Hospital workers are constantly in an environment full of infectious organisms. The constant elevation of blood pressure causes vascular tearing which traps cholesterol plaques, thus contributing to vessel constriction. The GI tract hypersecretes hydrochloric acid and pepsin and decreases its protective cover of mucus. We are prone to ulcers. (Selye, 1956) These are only a few of the diseases of stress.

The hospital environment is stressful. Out of 1.4 million licensed registered nurses, only half are working full time at their professions; of this half, 330,000 work outside the hospital setting. Nurses leave the profession in large numbers and stress or burnout is a major reason for this exodus. The exodus causes acute RN staffing problems in 88 percent of the nation's hospitals. This short staffing increases the stress on those remaining (Tabor, 1982).

Nurses give many reasons for leaving the profession, among them mandatory overtime, short staffing, rotating shifts, low pay, little respect, arrogant physicians, paper work, unfair scheduling, no time for break, non-nursing duties, floating, inadequate orientation, high turnover, threat of lawsuit and no promotions are the most common (Steiffel, 1981). To endure in the hospital setting, one must learn to effectively manage stress. By regularly giving yourself the time to engage in meditation, you can remember what it feels like to be out from under incessant stress. Stress management is a tool for healthy living. People who meditate or in other ways engage the relaxation response can actually deactivate their sympathetic nervous system and induce parasympathetic rebound. Regularly eliciting the relaxation response counteracts stress and has a profound influence on our health.

The relaxation response is a state of calmness during which time your body taps into the parasympathetic nervous system. Heart rate and blood pressure decrease during the period of relaxation and for a time afterward. The body's basal metabolic rate slows, decreasing the need for oxygen so oxygen consumption falls. The sympathetic nervous system is inhibited with a decrease in norepinephrine. (Benson, 1976)

These are all reasons we feel so calm and energized as we come out of meditation. Another reason may be that we have released endorphins into our blood stream. Current research is beginning to make connections between practice of meditation and creative visualization and increased endorphin levels. When we meditate or engage in more than 30 minutes of aerobic exercise, endorphines are sometimes produced.

The effects of meditation register in the limbic system which feeds into both the hypothalamus and pituitary. The hypothalamus controls the immune system and the pituitary governs hormonal release. So by practicing meditation you can affect both the immune system and the hormonal character of your body. Creative visualization can also change the limbic response. (Simonton, 1978)

We in Western cultures tend to be left-brain dominant, spending our time categorizing, planning and remembering instead of being. The left brain enables us to be logical, articulate, and precise. The right brain functions through imaging. It senses the connections, fills in the pieces, completes the whole. You need access to both to be functioning creatively. (Ferguson, 1980) Meditation acts to integrate the brain's activity making it less random, provoking it into hyperorganization. (Ferguson, 1980)

Time out for deactivation is essential. It turns the awareness from the external detail to the inner, private realms of feeling. It is a pathway to peace.

There are four parts to the relaxation response. First, it is essential to have a quiet environment, where you are free from interruption and responsibility. Keeping your eyes closed helps limit environmental stimuli. Second, you need to achieve a decrease in muscle tone. This is a natural outcome of the process and is easy to attain if you are in a comfortable position. You need to focus on some sort of mental device that is a constant stimulus, something too monotonous to be handled by the brain's analytical left half. This will shift you to your right brain. (Ferguson, 1980) You can begin by being aware of your body, following the flow of your breath. Attune to the rhythm, in and out. And linger with the breath, making each one deeper and slower than the last. You may begin saying a word or phrase over and over either audibly or silently. The word can be a chant or prayer or a word with no association. It does not matter. The purpose is to gain access to the right hemisphere. Music is often used as a background, alone or in combination with environmental sounds (i.e. waterfalls, soft rain, wind). Any restful music engages the right hemisphere. However, some researchers have developed music specifically for relaxation. Stephen Halpern has created meditative collections of sounds designed to relax, balance and attune the listener. (Halpern, 1975) Horn's "Inside" album, Andrews' "The Violet Flame," and Scott and Yuize's "Music for Zen Meditation" are also excellent.

Classical music also has harmonic structure and rhythm conducive to relaxation. Pachelbel's "Cannon in D Major" and

Vivadeli's "The Four Seasons" are particularly soothing. Some movements of Vivaldi and Bach have rhythm similar to the human heart beat. When they listen to these movements, people's pulse rates and other biological rhythms tend to synchronize themselves with the beat of the music. (Ostrancer, 1979)

Centering can also be useful for releasing tension from the body. Autogenic training focuses on subject's physical sensations rather than the thought process. In progressive relaxation- the subject pays attention to different parts of his body, notes the tension and replaces it with warmth and relaxation. A combination of mental imaging and soothing music is one of the more pleasurable methods to deactivate. With this method a tape is played with directions to imagine restful scenes. As you begin following the imagery and concentrate on it, you shift into patterns the right brain recognizes and produce alpha waves. Often the images are symbolic of life events or of the direction that your life may take.

Once you begin to meditate and experience the pervasive effect on attitude and attention you may wish to meditate more, but 20 minutes twice a day is all that is needed for physiological benefits.

The key to dealing with life stress is to change the situation that is causing the distress or to alter one's perception of the experience. Techniques that provoke the relaxation response alter one's perception. When working in acute care facilities, workloads can be unrealistic, especially when short staffed. It is important to identify areas of stress in the work environment. Alert supervisors to the needs in your area. Support flex-time and alternative scheduling patterns so that fewer people need to rotate shifts. Make suggestions to administration as to ways work could be less stressful. Often personnel know and agree how their workloads could be arranged to facilitate functioning but are not assertive in expressing ideas that could ease the tension.

The following chart, Stress Reduction Strategies, provides examples of coping strategies utilized to deal with specific situations that arise in hospitals. (see Figure 1) Draw on human resources in dealing with stress. Many hospitals have employee counseling available. Talking with someone helps to clarify the issue and provides situational support. It helps a person gain rational appraisal of the situation. New insights may be gained that will enable the person to make better choices.

Some health care providers find themselves developing Type A personalities and hurry-sickness to cope with increasing work-

TABLE 1. STRESS REDUCTION STRATEGIES*

Situation	Coping Actions
An emergency department staff nurse is confronted with multiple life or death triage decisions.	1. Periodic rotation out of the department. 2. Provision of staff group therapy sessions directed by staff psychiatrist or psychologist and/or minister.
A ward nurse takes the brunt of emotional outbursts from family members of a patient that has died.	1. Formalize group support meetings. 2. Provision of pastoral care support
Installation of new automatic data processing equipment is causing an employee to unnecessarily fear for his job.	1. Provision of instruction to the employee on what the equipment is intended to do. 2. Review with the employee how the equipment will complement the staff.
Staff in a department undergoing reorganization are apprehensive about their future.	1. Involve the staff directly in planning for the reorganization. 2. Ensure that the staff is aware of the reasons for the reorganization.
Employees are aware of a fellow employee's incompetence and possible life threatening consequences.	1. Develop a system to ensure that there is a simple course of action that any employee can initiate to make management aware of such situations. 2. Early action on the part of the supervisors when addressing these problems.

* Reprinted from G.L. Calhoun, "Hospitals are high-stress employers," HOSPITALS, 16 June 1980, by permission of the magazine.

TABLE 1 (cont.)

Situation	Coping Actions
Intimidation of staff by a large, loud or frightening patient.	1. Better training of staff in handling the violent or assaultive patient. 2. Provision of backup support to assist in controlling the potentially dangerous patient.
Promotion passover.	1. Ensure proper notification of openings is made. 2. Specify criteria for selection. 3. Inform those eligible of reasons for nonselection.
Home life problem unrelated to employment.	1. Availability of private room. 2. Counseling by staff psychiatrist, psychologist, social worker or minister.
Conflicting orders given by attending physicians and specialists.	1. Team approach to treatment plans. 2. Availability of senior staff to resolve conflict.

loads. The following are some healthful hints for Type A personalities (taken from Edlin and Golanty, 1982):

1. Become aware of your life goals and try to determine when your behavior is well-monitored progression toward these goals and when it is habitual, nonproductive hyperactivity.
2. Eliminate tasks and activities that do not contribute to the attainment of both professional and spiritual/ humanistic goals.
3. Budget time for frivolous activities, fun, chance encounters, sports, and hobbies.
4. Take time each day for you in which you think positively, meditate, or muse about the good things in life.
5. Spend less time with people who add little to your emotional well-being and spend more time with people who add a lot to it.
6. Leave work behind. Make your home and social life a separate, positive, and fulfilling experience.
7. Accept your own "flaws" and the seeming incompetency of others as part of life. No one, not even you, is perfect.
8. Try to attain a state of well-being rather than simply working for possessions and prestige.

People who are designed as functioning well in society (effective copers) tended to have five characteristic approaches to problems. They would,

1. Talk a problem out with a friend, relative or therapist. This enabled them to see more objectively and elicit emotional support from others.
2. Seek information in an effort to deal intelligently with a situation.
3. Draw on their own past experience, as well as others, in dealing with a problem.
4. Make plans or set goals, often making several alternative plans in case one doesn't work out.
5. Take assertive action. An ineffective copers tends to delay or avoid acting on a problem.
6. Engage in regular physical exercise to release tension and to promote vigor.
7. Often had some sort of belief system.

(Stress: A Fact of Life, Lippincott)

Giving thought to one's stress level and finding ways to decrease the stressors in one's life promote emotional well-being. Take time to investigate other ways to achieve relaxation.

OPTIMAL NUTRITION

Today, processed and prepackaged food is a way of life. Some of it comes to us laden with artificial flavor and color to compensate for the lack of natural color and flavor of locally grown, freshly picked produce. With more time spent away from home, there is less time to prepare nourishing food. More meals are eaten away from home. Sometimes these meals contain fried foods or other foods high in fats and sugars.

The average American diet is 70 percent fat and sugar (Ballentine, 1978) and the average American eats between three and five pounds of synthetic chemicals per year. (Garard, 1974) The sale of pastries and doughnuts has gone up 70 percent in recent years and the soft drink consumption is up 80 percent. (Lerca, 1975)

There is a better way to structure our body's environment: Provide our bodies with nutrients and foods that supply a completely balanced supply of amino acids, vitamins, minerals and other essential factors.

The following are some strategies to choose a diet that will help to supply your body's nutritional requirements and ensure a more beautiful life.

1. CUT DOWN ON WHITE TABLE SUGAR. Most Americans eat their weight in sugar every year. (Williams, 1971) In its natural form in fruit and sugar cane, sucrose is in a complex starch chain containing vitamins, minerals and fiber. Digestion is accomplished slowly, with small portions of sugar being hydrolyzed over time. A small amount of insulin is released to match each sugar unit in exact proportion. So, in the natural form, along with calories for energy, vitamins, minerals and fiber are provided.

However, transforming sugar from its natural state, the sucrose is extracted, while the fiber, which ensured an extended digestion time, is discarded. This results in the hypoglycemic syndrome. The duodenum is presented with an enormous amount of sucrose minus the fiber, all to be carried to the cells at once. Insulin surges out in tremendous amounts. Blood sugar levels elevate and the pancreatic cells respond with a stress reaction and over-produce insulin.

One half hour after the intake of sucrose, the person experiences a rush of energy, but within two hours, not only has all the sucrose been digested but the lingering insulin rapidly begins driving the blood sugar level below normal. These symptoms include a feeling of let down and exhaustion, weakness, irritability, anxiety and tremoring.

The resulting personality is characterized by nastiness and is accompanied by a distortion of judgement. Hitler, for example, was a known sugar drunkard. He was gluttonous in his consumption of sweets and desserts (Williams, 1971). Every two to three hours he needed a major "fix" for the rampaging insulin.

Our culture also nourishes this addiction. We have an abundant variety of sugar coated, white flour, deep-fried food to eat. Our entire culture is structured around our abnormal sugar craving. Airlines provide soft drinks every two hours and sugar is a hidden ingredient in most canned fruit or vegetables-- even foods that do not require sweetening contain sugar (peanut butter, ketchup, salad dressing, soup). The addiction is begun as the infant is fed the commercially available baby foods, most of which are heavily laden with "sugar!"

As sugar addiction escalates, it becomes a deeply ingrained habit. With a higher percentage of our daily calorie intake coming in empty calories, we begin to incur a nutritional debt. One takes in the sugar stripped of its corresponding amount of protein, vitamins and minerals. As supplies are depleted, the missing nutrients are pulled from tissues. The malnutrition that results encourages predictable pathology-- obesity, alcoholism, cardiovascular disease, decreased resistance to pathogens and increased colon exposure time to precancerous wastes. (Ballentine, 1978)

Obesity can coexist with malnutrition. Under a mountain of sugar-laden-fat is usually a starving uneducated person in need of nourishment. Without vitamins and minerals to create vitality, there is no desire to exercise. The result is a pasty, bloated sort of obesity that characterizes candy and soft drink addicts. (Williams, 1971)

Heavy sugar and white flour intake are associated with alcohol addiction. At Loma Linda University, Dr. U.D. Register created alcoholic rats by feeding them a "typical American teenage diet" of glazed doughnuts, sweetened soft rolls, carbonated beverages, apple pie, spaghetti, white bread, green beans, tossed salads, hot dogs, candy and cookies. Control rats fed a diet containing adequate nutrients chose water to drink. Rats fed the "teenage diet" chose alcohol. When caffeine was added, the rats drank even more alcohol. When scientists supplied vitamins, the rats reduced their alcohol intake. The heaviest drinkers among the rats could be switched in and out of their alcoholic

behavior by a change in their diet. (Cheraskin, 1978)

Heavy sugar intake is associated with an impaired immune response. Dr. Emmanuel Turaskin of the University of Pennsylvania Medical School found that the white blood cell count decreases drastically for six to eight hours after a meal loaded with refined sugar. (Laird, 1982) With three meals a day high in sugar, one's white blood cells would be in a chronic state of repression.

A diet heavy in refined foods is usually deficient in fiber. Fiber speeds the passage of feces along the colon. A diet deficient in fiber prolongs the time feces containing precancerous products of fat digestion remain next to the sensitive colon tissue.

Cutting down on sugar interrupts the drastic mood swing cycle. One way to cut down on sugar is to avoid foods that have sugar listed as the first ingredient. Corn syrup, dextrose and syrup should be deleted. Sweetner could be changed from pure sucrose to one that is a more complex carbohydrate. It will be more gradually broken down yielding small amounts of usable carbohydrates spread over several hours.

2. **REDUCE FAT INTAKE.** Fat constitutes about 45 percent of the calories that most Americans consume. When combined with the amount of sugar taken in, this means 70 percent of all of our food is either fat or sugar. This is quite risky when one considers that the remaining 30 percent must supply all the water-soluble vitamins, the minerals, the fiber and the protein we need to nourish us. (Ballentine, 1978)

Another problem with fat intake is elevated blood cholesterol and triglyceride levels concomitant with plaque deposition in major blood vessels. Also, high fat intake may lead to cancer of the colon and rectum. Dr. M. Hill's research reveals that the end products of fat digestion are carcinogenic. When bile acids and cholesterol combine with fats to be digested, the result is a substance that resembles estrogen and is pre-carcinogenic. It is postulated that receptor sites for these estrogen-resembling substances are within the breast and uterus. This would account for the extremely high incidence of breast and uterine cancer in women of the United States as compared with the incidence of those diseases among women in non-industrial countries. The lack of fiber in our diet contributes to the problem by prolonging the time these substances remain in the colon. (Cheraskin, 1978)

You can decrease your fat intake by the following strategies:

- a. Substitute fish and chicken for beef.
- b. Increase consumption of fresh, fruits, vegetables and whole grains. (Increased fiber reduces colon exposure to pre-carcinogens, helps the body excrete toxins, and provides vitamins and minerals to improve overall nutrition.)
- c. Increase vitamin E consumption. (This helps control fat deposition and may prevent increased triglyceride levels. (Ballentine, 1978))
- d. Eat more foods with Lecithin (dried peas and beans).
- e. If you eat beef, combine it with onions or garlic. (Both reduce blood viscosity and decrease blood fat levels. Garlic additionally has some antibiotic activity.)
- f. Increase the intake of B vitamins- especially B6- to decrease cholesterol.

3. REPLACE REFINED WHITE FLOUR WITH WHOLE GRAIN FLOUR AND INCREASE CONSUMPTION OF WHOLE GRAINS.

Each part of a whole grain provides us with a nutrient. The germ contains vitamins (especially vitamin E), protein, and unsaturated fats. The germ is the part of the grain that remains alive and offers vitality if it remains undamaged. Nurtured with warmth and moisture, it will sprout into a new plant.

The outer protective covering of the grain is bran. It contains minerals, a significant amount of protein, vitamins (abundant vitamin B), and fiber. The endosperm is the section in the middle and is mostly starch. It contains a small amount of protein.

White flour is made solely from the endosperm of the grain. The bran, with its vitamin B, minerals and protein, and the germ, with its vitamin E, protein, thiamine and unsaturated fats is thrown away. White flour has lost 72 percent of the whole grain's original nutrients. With the "living" part, the germ, removed, white flour can last forever on the shelf. "Enriched" white bread means that of the 20 nutrients that are taken out, four are replaced. Vitamin B6, a most valuable vitamin for keeping cholesterol in combination, is left out. The nutrients which are removed from whole grain as white flour is produced are the following:

- a. Zinc, an essential mineral found in bran
- b. 13 percent of the chromium
- c. 9 percent of the manganese
- d. 19 percent of the iron

- e. 20 percent of the thiamin
- f. 33 percent of the peridoxin and folic acid
- g. 40 percent of the pantothenic acid
- h. 14 percent of the vitamin E

(Ballentine, 1978)

Ways to increase your consumption of whole grains are:

- a. Read labels. Choose bread which has 100 percent stone ground whole grains (wheat, oat, rye) listed first.
- b. Choose cereals that are whole.
- c. Choose crackers that are whole grain.
- d. Use whole wheat flour in place of white flour. Start with half and half and progress as your taste buds accomodate.
- e. Increase use of brown rice (Polished, white rice has had the bran removed).
- f. Eliminate white flour products, white rice, minute rice, white saltines and other highly refined grains.
- g. Sunflower seeds, pumpkin seeds, dried fruit, nuts and yogurt are all healthful foods. Use them frequently as additions to cereals, as snacks, as toppings to salads and as components in breads.
- h. Whole grains combined with a small amount of beans, peas or other legumes, milk, or cheese are excellent, complete proteins and can be used in place of meat one or two times per week. (Ballentine, 1978)

An ideal diet for prevention of heart disease is a diet free of meat, low in total fat and oil, and high in whole grains, dried peas and beans, onions, fresh fruit and vegetables. By arranging to eat food that provides a complete balance of all nutrients to our bodies instead of food that is incomplete and actually depletes our bodies energy level, is one way we can care for ourselves every day.

Every day each of us chooses the habits that contribute to or take away from our health. But habits can be changed. (Ferguson, 1980) We can incorporate good eating habits, good physical fitness habits and good stress management habits into our lives and thereby increase our own health and vitality. Furthermore, we are thereby better able as health care providers to exemplify the healthful exuberant life we hope to share with our families and our patients.

"Anything that disrupts the old order of our lives has the potential to move us toward greater openness and strength." (Ferguson, 1980)

As we reach out toward a life of maximal health for ourselves and our clients, it is necessary to have a balanced life. We need a meditative time and a physical time, a balance of quiet and active times. Intense mental effort and stress must be balanced with activity and meditation. Spend time with nature. Keep your senses sharp and open. Test your physical limits. Bring beauty into your lives: the beauty of character and of belief. Balance your work with those who have disease with your study and practice of wellness. As we celebrate vibrant health within ourselves, we automatically share it with our associates and our patients.

"In our technological society in which there is a push to consume more and more material goods, wealth is equated with money and goods. But there is also a wealth of being. And in terms of how it feels to be alive, we may be among the world's poorest people." (Leonard, 1974) The choice is yours.

If you don't change direction,
you may end up
where you are heading.

-Lao Tzu

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SECTION III: Employer/Employee Relationships

This section is dedicated to two, sometimes controversial, topics; Workers' Compensation and Workers' "Right to Know." If a worker is injured or acquires an illness due to his/her exposure to ethylene oxide, pesticides, or any other substance, what is covered by Workers' Compensation? What is not? The chapter on Workers' Compensation details North Carolina's laws on this topic.

The second chapter is on Workers' "Right to Know." The concept of "right to know" as discussed outlines the nation-wide realization that workers have the right to be informed of the compounds to which they are exposed and of the potential health affects that may be caused by such exposure.

WORKERS' COMPENSATION AND OCCUPATIONAL DISEASE

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ABSTRACT

Compliance under OSHA, regardless of the degree or quality will not prevent compensable claims under workers' compensation. OSHA and Workers' Compensation Acts were passed for two totally different reasons. OSHA established safety and occupational health compliance standards for industry. While workers compensation provided for the care and compensation for the accident-injured industrial employee.

Workers' Compensation is the oldest form of social legislation in the United States. As a remedy to the abuses arising out of the change from the "trade and craft" system of production to the "industrial" system, the workers' compensation acts originally intended to free the employer and the fellow employee from having to defend against employee negligence suits. For that relief the employer guaranteed workers' compensation benefits for employee work-related injuries. The employee workers' compensation benefit is based on date of accident, employee earnings and the medical certifications about the injury. Essentially this means that the employer assumes total responsibility for the way work is supervised and performed, giving up the tort defense doctrines of negligence, fellow-employee negligence and acts of God. The employer provides immediately the benefits and the employee agrees to accept workers' compensation benefits.

This chapter is an overview of the Workers' Compensation requirements placed on the employee and employer when there has been an exposure during employment to either an "accident" or "occupational disease." It is important to remember that the medical-care or hospital facility is both a user as well as a provider of medical attention. As an employer, the medical facility must provide the same benefits in this way as any other employer.

HEALTH-CARE EMPLOYEES COVERAGE

The remedy for injury from either "accident" or occupational disease is different for the injured employee than that for the injured non-employee (i.e. general public, patient, guest, or independent contractor). North Carolina Workers' Compensation is the exclusive remedy for accident injury and occupational disease occurring to the employee, while the non-employee has other legal remedies. This chapter deals exclusively with employee issues.

The federal and other states' workers' compensation acts vary in wording, the interpretation by the courts on the decisions of the act, and the method of administering the act with the jurisdiction. The administering body, such as the North Carolina Industrial Commission, has been established by legislation to protect the injured worker by administering prompt and proper provision of the benefits and by legally resolving questions of fact and disputes that occur between the employee and the employer.

Occupational disease claims pose a potential problem and great future liability. These claims may be filed years later by the toxic substance exposed and disease-injured employee. The employer, who is unable to defend against all exposures, in all likelihood, will have to pay the workers' compensation benefit. This has been the trend in cases of asbestosis, silicosis, bysionosis and other dust related diseases. With exposure from diseased patients, medicines, radiation, noise, drugs and other new chemicals, a program for maintaining employee records of known exposures to hazards, will be a must for the cost-conscious medical facility. The medical facility and administrative staff should strive to improve the communication exchange between the facility and its employees. There is an urgent need for reporting and keeping accurate records of medical treatment provided for the accident of occupational disease injured employee. The records of those employees not exposed should also be maintained since they are equally important for claim defense of an occupational disease.

The definitions in workers' compensation are not to be confused with other forms of "compensation." Some of the requirements and definitions that apply in the North Carolina Workers' Compensation Act are itemized below:

1. Scope: Employers with four or more employees are required to provide employees Workers' Compensation benefits under the North Carolina Workers' Compensation Act. While the employee benefit is the same, employers may obtain workers' compensation coverage through an insurance company or become a self-insurer.
2. Reporting: Every injured employee or his representative shall immediately, on the occurrence of an accident- or as soon after as practical, give or cause to be given to the employer a written notice of the accident. If the employer and the injured employee or his dependents fail to reach an agreement, in regard to compensation, within 14 days after the employer has knowledge of the injury or death... either party may make an application to the Industrial Commission for a hearing in regard to the matters at issue, and for a ruling herein.
3. Recordkeeping: Every employer shall hereafter keep a record of all injuries, fatal or otherwise, received by his employees in

the course and scope of their employment on blanks approved by the commission. Within five days after the occurrence and knowledge thereof... of any injury to an employee, causing his absence from work for more than one day, report thereof shall be made in writing and mailed to the Industrial Commission... The report shall contain the name, nature and location of the business of the employer and name, age, sex and wages and occupation of the injured employee, and shall state the date and hour of the accident causing injury, the nature and cause of the injury, and other information required by the Commission. This recordkeeping is separate from the requirement of other agencies for accident recordkeeping.

4. Injury: A compensable injury is any employee injury by accident arising out of and in the course of the employment.

5. Accident: Accident is defined generally as an unlooked for and untoward event which is not expected or designed by the injured employee; also, a result produced by fortuitous cause.

6. Occupational Disease: Occupational disease shall be treated as the happening of an injury by accident within the meaning of the North Carolina Workers' Compensation Act. Occupational diseases caused by chemicals shall be deemed due to exposure of an employee to the chemicals herein mentioned only when as apart of the employment such employee is exposed to such chemicals in such form and quantity and used with such frequency as to cause the occupational disease mentioned in connection with such chemicals.

Section 97-53 defines the diseases and conditions that are to be occupational diseases, most being conditions arising from exposures to metals, dusts, fumes, mists, vapors and radiation; trauma from constant or intermittent pressure in employment, harmful noise; several specifically named fevers and diseases. One definition, §97-53(13), covers any present and future diseases and conditions that may arise in employment but "excludes all ordinary diseases of life to which the general public is equally exposed outside of the employment."

7. Disability: Disability means the incapacity because of the injury to earn the wages which the employee was receiving at the time of the injury in the same or any other employment.

8. Disablement: In all cases of occupational disease, except in asbestosis and silicosis, the term "disablement" is equivalent to "disability."

9. Workers Compensation Benefits:

- a. Medical: Benefits including medical, surgical, hospital, nursing services, medicines, sick travel,

rehabilitation services, and other treatment including medical and surgical supplies as may reasonably be required to effect a cure or give relief... shall be provided by the employer.

- b. Temporary Total Disability Compensation: Beginning on the eighth day of disability certified by the attending physician, the injured employee is entitled to weekly benefits based on his/her average weekly wage. In the event the temporary total disability duration is more than twenty-eight (28) days, the first seven days become payable beginning on the twenty-ninth (29) day of certified disability.
- c. Temporary Partial Disability Compensation: A wage supplement due when the injured employee returns to employment at a lesser rate of earning. Calculated weekly, the benefit is the difference between the weekly benefit amounts to prevent loss of earnings when the employee may be physically able to return to lesser employment.
- d. Permanent Partial Disability Compensation: In addition to the above benefits, where at the end of the healing period there remains a permanent partial loss of the body or loss of function of a part of the body, there is a schedule of injuries, rate and period of compensation (Section 97-31 of the North Carolina Act). Permanent partial disability includes payment for disfigurement. Rating of disability for the loss is made by the attending physician.
- e. Total and Permanent Disability: Where as a result of injury, the employee will never return to any employment, the medical and temporary total benefits are to be paid for the life of the injured.
- f. Death: Death resulting from the injury. In North Carolina the death benefit is 400 weeks or in the case of dependent children, 400 weeks or to the age of 18 whichever event occurs last.

10. Average Weekly Wages: The average of the earnings in the employment in which the employee was working at the time of the injury during the period of 52 weeks prior to the injury, including overtime and all other allowances. There are formulas for calculating wages for trainees, for employees of less than one year and for minors.

11. Weekly Benefit Amount: The weekly benefit amount is two-thirds of the average weekly wages; however, not less than thirty dollars (\$30.00) nor in excess of the state maximum weekly benefit amount of two hundred eighty dollars (\$280.00) effective January 1, 1985. The benefit is not taxable by federal or state governments. This benefit yields approximately ninety percent of the normal take-home pay of the employee.

12. Light Duty: An employee may return to work under the category of "light duty" if, in the opinion of the attending physician, the employee is able physically to earn wages by performing work where he does not utilize the employee's current limitation. It is the responsibility of the employer to determine the limitation from the report from the attending physician and to make the decision.

CONCLUDING REMARKS

The need for the employee to report to both the employer and the Industrial Commission once an occupational disease has been diagnosed is imperative if the employee's workers' compensation benefit is to be protected. The employer who fails to provide medical attention and to designate the attending physician may well be at the mercy of a sick, angry, unforgiving, uncooperative employee now represented by legal counsel. With an occupational disease, it may be that the injured is no longer in the employ of the exposing employer. In Workers' Compensation, the prompt communication and fair exchange of information with the employee is the best and most cost conscious approach.

Employers should take advantage of the information and courses available from their State Administrator of Workers' Compensation. In North Carolina the Industrial Commission's Safety Department offers a number of safety management courses and employee safety workshops taught in-plant and the commission is also available for safety and workers' compensation consulting. (See Appendix 1 of this chapter for a copy of a pamphlet from the North Carolina Industrial Commission on the accident prevention and safety services offered in North Carolina. There is no registration charge for instruction. The programs are designed to be taught for the employers as in-house training.) The Statistical Department has developed a nationally accepted program providing workers' compensation injury statistics. The Medical Department reviews and approves the medical charges for compliance within the fee schedule. The Claim Department handles claim questions and procedures as well as supervising the Commission's Rehabilitation Nurses. The Docket Department handles the hearing schedules for the Commissioners and Deputy Commissioners.

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SAFETY SERVICES**SAFETY COMMITTEE MEETING PROGRAMS**

The safety representatives of the Industrial Commission are available to work with the safety committees of industry, business and government agencies upon request. The programs are designed to motivate the audience in accident prevention on the job, as well as at home.

SAFETY FILM SERVICE

The Industrial Commission's Safety Department has long been recognized as a film resource for business, industry, and government in North Carolina. The library contains over one hundred films on general and specific topics of safety and health. There is no charge for using the Safety Department's films and upon written request, can be checked out for use in your safety programs. A listing of the available film titles can be obtained by contacting the office of the Director of Safety.

SAFETY BULLETIN

The first edition of the North Carolina Industrial Commission's Safety Bulletin was published October 5, 1933 and has been a leader ever since in providing accident prevention and safety information to North Carolina. The current "Safety Bulletin" features pertinent information on accident prevention, workmen's compensation updates, fatalities and injury statistics in North Carolina. Published quarterly, it is distributed to business and industry upon request. To receive the publication and/or submit articles, contact the office of the Director of Safety.

REGIONAL AND STATEWIDE PROGRAMS**NORTH CAROLINA STATEWIDE SAFETY CONFERENCE**

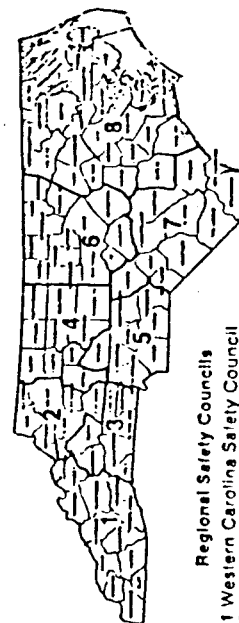
The Annual Safety Conference, organized in 1930, is the oldest safety conference of its kind in the South, and enjoys a reputation of being one of the best in the Nation. Held each year in May, the Conference has been hosted in recent years by Charlotte, Greensboro, Winston-Salem, Wilmington, Asheville. The success of the Statewide Safety Conference is attributed to the strong participation of between 900 and 1000 safety professionals, industrial nurses, personnel managers and industry leaders in North Carolina. It features nationally known speakers as well as having over sixty exhibitors. For additional information on the Conference workshops and industrial section seminars, contact the Industrial Commission's Director of Safety.

NORTH CAROLINA REGIONAL SAFETY COUNCILS

The Industrial Commission's Safety Department helped organize and sponsor eight regional safety councils that represent the hundred counties of North Carolina. With an acting board of directors and officers, each council organizes and presents programs that will assist industry in North Carolina in achieving a successful safety and loss control program. Since the first council was organized in 1931, each has met quarterly with many sponsoring an annual workshop on workmen's compensation or accident prevention for their area of the State. The councils also sponsor local Foremen's Safety Talk Contests with the winner representing the council at the Annual Statewide Foremen's Safety Talk Contest. For information on the council in your area, contact the Industrial Commission's Director of Safety.

SAFETY/SECURITY HEALTH CARE COUNCIL

The council was established in 1978 to promote the common interest in safety and security in health care facilities throughout North Carolina. This council is designed to provide information on current legislative matters, safety regulations, and special workshops. For information on the Safety/Security Health Care Council, contact the Industrial Commission's Director of Safety.



- Regional Safety Councils**
- 1 Western Carolina Safety Council
 - 2 Western Piedmont Safety Council
 - 3 Blue Ridge Safety Council
 - 4 Central Piedmont Safety Council
 - 5 Southern Piedmont Safety Council
 - 6 Mid State Safety Council
 - 7 Eastern Carolina Safety Council
 - 8 Southeastern Safety Council

NORTH CAROLINA INDUSTRIAL COMMISSION

A DIVISION OF THE
N. C. DEPARTMENT OF COMMERCE

**STATEWIDE SAFETY DEPARTMENT**

W. E. VAUGHAN-LLOYD, JR.

Director of Safety

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GENERAL INFORMATION

The accident prevention and safety services offered by the Safety Department of the North Carolina Industrial Commission are established to provide competent, practical instruction in accident prevention and workmen's compensation. The courses and workshops are specifically designed for the supervisor and employee in the interest of reducing accidents and their cost in North Carolina.

Our schedule offers professional programs with experienced safety representatives of the Industrial Commission as instructors. There is no registration fee or instruction charge for the courses offered by the Industrial Commission. All programs are set up to best meet the production schedule of the individual companies. It is requested that as much lead time as possible be given for course scheduling.

SAFETY REPRESENTATIVES

ARNOLD "Bud" HOWE
P.O. Box 446
Princeton, N.C. 27569
919-936-7261 Eastern Area

BOYD LANE
Route 4, Box 35D
Rutherfordton, N.C. 28139
704-286-2408 Western Area

WILLIAM J. DAMERON
2637 Phillips Street
Winston-Salem, N.C. 27103
919-725-6373 Piedmont Area

LOSS CONTROL COURSES

• ACCIDENT PREVENTION COURSE

Directed at the first-line supervisors and management, the course relates accident cost to the production required to pay for the injuries and illnesses. Special emphasis is placed on workmen's compensation, accident prevention, work habits, and supervisory methods needed to obtain a desired goal of accident and injury free performance. A four or five day schedule with two or two and one half hours per session is recommended. Eight hours are required to satisfactorily complete the course.

• FIRE PREVENTION AND PROTECTION COURSE

The course is designed to train supervisors and employees in the modern methods of fire prevention, protection, and extinguishment. Emphasis is placed on the importance and formation of an effective fire brigade in plants. The course is taught in live sessions with a minimum of one and one half hours per session. Seven hours are required to successfully complete the course.

• COMMUNICATIONS AND ATTITUDES COURSE

This is a six hour course for supervisors and is designed to equip each participant with additional training in human relations, interpersonal communications skills and safety attitudes. Self evaluation and problem recognition skills enable the participant to analyze communication gaps.

ACCIDENT PREVENTION WORKSHOP

• EYE SAFETY WORKSHOP

A special workshop designed to give the participants a broad exposure to the proper methods of maintaining an eye protection program. The one and one half hour workshop is specifically oriented to supervisors, foremen, and the employers. Proper use of the personal protective equipment is reviewed.

• ACCIDENT INVESTIGATION COURSE

The training is for all first-line supervisors and management personnel who are responsible for accident and worker's compensation reporting. The workshop covers the principles of investigation, basic questions to ask, and the process of using the report to eliminate the causes of the accidents. The workshop is scheduled for one and one half hours.

• LIFTING SAFETY WORKSHOP

The training is directed at teaching supervisors and employees the basics of lifting and handling objects for the prevention of back and muscular injuries. The one hour workshop includes films and skills demonstrations, and is an excellent program for industries and municipalities.

• FORK LIFT SAFETY WORKSHOP

The workshop is directed to assist supervisors and operators in the safe operations of power industrial trucks and recertification of their drivers. A minimum of three hours classroom instruction is re-

quired with certificates presented to those successfully completing the training. Special assistance will be provided to companies in setting up an effective obstacle course demonstration, but the skills testing will be under the supervision and guidelines of the individual companies.

• WORKER'S COMPENSATION WORKSHOP

A unique workshop designed to assist management in reducing the cost and number of compensation claims. Explores the responsibilities of the employer and the claimants, and the benefits of managing and properly monitoring your compensation program. The workshop is normally scheduled for approximately one and one half hours. Additional consulting activities can be arranged upon request.

• HAND SAFETY WORKSHOP

The workshop is designed to give the participants a broad exposure to the hazards to fingers and hands. The one hour program emphasizes amputations, ring injuries and point of operation guarding.

• JOB SAFETY ANALYSIS WORKSHOP

A workshop for first-line supervisors and management teaching the process of analyzing the physical problems and potential errors, too many result in damage or injury accidents to determine and establish the potential accident cause. The course gives the supervisor practice in the method of analyzing a job and completing a JAS form.

WORKERS RIGHT TO KNOW

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ABSTRACT

Workers throughout the United States are becoming increasingly concerned about possible health affects they may incur due to exposure to various toxic substances in the course of performing their work. The more than six million employees of health care facilities are a major segment of the U.S. labor force. They are potentially exposed to an array of toxic substances such as anesthesia gases, ethylene oxide, antineoplastic substances, asbestos and radio-isotopes.

The "Workers Right to Know" legislation already enacted in some states and by various municipalities is an indication of the societal response to the workplace risks associated with these and the thousands of other substances to which workers may be exposed.

WORKERS HAVE RIGHTS TOO

In this paper, I discuss what has come to be known as workers' "Right to Know". This is in fact a social movement on the part of workers and health specialists in occupational health and safety for legislation at the local, state and federal level to guarantee open access to information about workplace hazards. The passage of such legislation has been, in my estimation, the most important single event in shaping the health and safety of workers in this country since the passage of the OSHA act in 1970.

To explain this statement, I would like to review a few situations I have encountered in the health industry during ten years of work with labor unions, with the National Institute of Occupational Safety and Health, and in medical training in a research institution.

In one hospital asbestos was being removed during renovation in the labor and delivery room. It was literally showering down on the patients and their infants and on the staff. None of them had any idea what the substance was, including the workers in the maintenance department who were doing the asbestos removal.

In another case, maintenance workers were spraying pesticides in hospital wards while patients were in their beds. The staff caring for them were also exposed; when they observed the pesticides being applied and experienced symptoms, they asked for information. Another case may be even more familiar to you, because I have accounted this practice often; it pertains to pediatric nurses in infant intensive care units who hold the infants while portable x-rays are taken. In this case the nurses were aware that this might present a potential risk and were working with hospital management to develop alternative procedures, such as having parents hold the infants instead of the nurses.

In a more research-related episode, we investigated a case where dimethyl sulfoxide (DMSO) was being used in an intensive care unit to control cerebral edema. The DMSO on the exhaled breath of the patient was causing nausea, dizziness and vomiting among the nursing staff caring for these patients. The staff was extremely alarmed.

These brief anecdotes illustrate some of the special and very knotty problems in hospital occupational safety and health. First of all, both patients and staff may incur many of these same risks. Secondly, the staff may incur risks in order to protect patients, particularly if alternatives are not provided for them. Thirdly, the hospital and biomedical research center are entire cities within themselves. They represent almost every type of hazard confronting the American work force.

Interest in and work toward the protection of hospital worker health and safety has made great strides in the last ten years since NIOSH conducted its hospital survey. In that survey, only about one in five hospitals were found to have the rudiments of an adequate program for employee health and safety, training and protection. Today, with more than four percent of the total U.S. work force employed by hospitals, an estimated 4.1 million employees, and another two million are employed in nursing homes, clinics and other health care institutions this is obviously a significant employment branch to be protected.

Like the rest of American society, hospital workers have grown much more conscious of the possible harm that chemicals and other substances at work may do them, either acutely or over years of exposure. They are often worried and they definitely do want to know what risks they are facing. It was, in fact, labor unions that stimulated early work by NIOSH in developing health and safety training manuals. We should remember that the "Right to Know" program being developed and implemented in health care facilities are in response to genuine concerns on the part of the workers.

The "Right to Know" standards give workers the right to know certain information on health and safety aspects of their exposure at work. Concomitantly, those same standards impose on employers the need to provide information.

Hospital and research workers are not covered by the Hazards Communications Standard. However, more than 17 states have passed state laws, and in most cases these do apply to health service workers. The federal standard may serve as a model for hospital administrators in states where there is no state standard. Therefore, I would like to consider the federal standard briefly here.

Since 1970, the specific chemicals promulgated all contained product labeling requirements. Thus only 20 substances are regulated under OSHA standards which meet some of the objectives of the "Right to Know" laws. In 1974, OSHA convened an advisory committee to again consider the possibility of and the need for a "Right to Know" standard. In the same year, the findings of the NIOSH National Occupational Hazard Survey became available.

In the NIOSH survey we found that one of four workers in the entire work force in the United States, an estimated 25 million workers are exposed to hazardous substances on the job. Seventy percent of these exposures were to trade name products. In other words, the contents were not listed on the container. For 90% of these there was no information available in the workplace on the chemical name of the substance or of the potential hazards to the workers from exposure to these products.

In the second round of that survey, conducted in 1981, we found that the situation was worse; 76 percent of the exposures were to trade name products, up from 70 percent.

In 1976, NIOSH published a Criteria Document recommending to OSHA a standard called, "Identification System for Occupationally Hazardous Materials." This was the first formal presentation of what we now know as material safety data sheets (MSDS). In 1977 OSHA began the process of standard development in response to the recommendation.

One of the issues in this process was what groups of workers should be covered. Laboratory work, in particular, was identified as a potential problem. On January 13, 1981 OSHA finally proposed the standard for further review and revision. It was not until March 1982 that OSHA proposed the Federal Hazard Communication Standard. On November 25, 1983 the Hazard Communication Standard was finally promulgated.

The provisions of the federal standards required all chemical producers to provide MSDS for users of their product,

and for all employers to have information regarding hazardous substances in their workplace.

Coverage was extended only to the manufacturing sector, SIC codes 20 to 39. Within the manufacturing sector, research labs (i.e. research labs within a chemical plant) are covered, but the duties are limited. They are required only to maintain incoming labels, that is, not to change the labels on goods that are purchased, to compile MSDS received from other employers, and to train their employees.

Hazardous chemicals were defined as those restricted by OSHA including those for which Threshold Limit Values (TLV's) were adopted in 1971. (These lists, compiled by the American Conference of Governmental Hygienists, are readily available. All substances which are suspect or confirmed carcinogens according to the National Toxicology Program are included.)

In addition, the employer is responsible for identifying and evaluating the health hazards associated with all other substances. This is where, especially in a hospital setting, we find a tremendous number of substances used. The task of evaluation becomes very difficult. In the Federal Standard, a substance should be considered hazardous (and the employer must evaluate the hazard) if one positive, significant and scientifically valid study exists for that substance.

The Federal Standard requires labeling of all products used in a place of employment with the exact chemical name, and if the label does not contain all of the specific health information, this information must be obtained from the MSDS.

"Trade secrets" can be a basis for limiting information about the specific constituents of a compound. However, health professionals are specifically allowed access to that information. If this information is not provided in the MSDS, a clinician can obtain the trade secrets information in order to evaluate the potential toxicity, but must sign a statement that he/she will not disclose this information. Finally, the employer must develop a written program containing a list of the hazardous substances and plans for training the workers in the proper and safe usage of those substances.

In commenting on the standard, NIOSH made several recommendations for improvements. First of all, we feel that it should be expanded to other industry code groups including hospitals. Secondly, we feel that laboratories should be included and that chemicals used in research, analytical, chemical and diagnostic laboratories should not be exempt from this standard. Special provisions should be made for the labeling of new compounds. In a research laboratory, if you are working with compounds that

are not well characterized yet, it may be impossible to provide the full range of data that we would like to see for more routinely used chemicals. Thirdly, NIOSH commented on the inadequacies of the MSDS's. In a NIOSH survey of 3,000 MSDS's supplied to the General Services Administration, we found that less than 30 percent of them met minimal standards for adequate worker information. The Federal Standard should call for a fixed format for the MSDS's and for a different approach to determining what information must be covered in them.

While the federal standard was being developed, a number of states and local communities also created their own laws and regulations. The states that have "right to know" laws currently include New Jersey, Alaska, California, Connecticut, Illinois, Maine, Massachusetts, Michigan, Minnesota, New Hampshire, New York, Oregon, Rhode Island, West Virginia and Wisconsin. Some cities, such as Philadelphia, Cincinnati and Santa Monica have also passed "right to know" regulations.

Many state laws cover health services workers, hospital workers and biomedical research workers. Many state plans compile separate lists of hazardous substances which must be labeled and treated according to their "Right to Know" laws. In some states this process will evolve over time. For example, in New Jersey there is an initial list of approximately 1,000 compounds that have to be labeled and dealt with in the first year. At that time, all other chemicals become subject to the "Right to Know" legislation as well. Most state laws do not provide for community or citizen access to this information, but some states and cities have followed this model; 13 cities in California have enacted "Citizens' Right to Know" or "Community Right to Know" laws. Most of the regulations require the provision of this information to the health department or the fire department and to others requesting it. The New Jersey "Right to Know" law has proceeded further; it permits the worker the right to refuse work if the worker requests information and is not provided it within five working days. This issue was taken to court in New York, where there is also a "right to know" law. The court ruled that the worker who had requested the information, was denied it, refused to work, and was then fired; had total redress under the law and had to be reinstated with back pay. Many other state laws include provisions against such retaliatory discrimination.

It is crucially important to develop a program in advance, to have the information available as workers begin to ask about their exposures, and to approach this as an organized training program. A practical problem arises from the number of substances we must address. The total number of synthetic chemicals, and, among them, the number of suspect carcinogens, in use since World War II has escalated dramatically. The Toxic Substance Control Administration's inventory of substances used

for commercial purposes cited more than 55,000 such substances. The NIOSH Registry of Toxic Effects, which compiles a listing of all chemicals for which there are toxicity data, has 39,000 chemicals registered.

The National Research Council recently completed a major review of the quality of the data which had been submitted to EPA under TSCA, and to other regulatory agencies regarding the toxic effects of chemicals, and found gross inadequacies. For example, among pesticides, only 10 percent of all pesticides registered have acceptable toxicity data.

A further problem in implementing "Right to Know" programs is the lack of trained personnel. A review of medical training on occupational and environmental health found that in 1979, less than 50 percent of medical schools required any training in occupational health. For those requiring such training, the average time allocated in four years of schooling was only four hours! Many supervisors of employee health programs, and others who do not have a medical background, assume that when they give MSDS to a physician and ask for an interpretation of the health hazards of a particular chemical, they will receive competent assistance. Unfortunately we find, not only in health institutions, but in every sector, that we just do not have enough trained personnel to evaluate the potential health risks of chemicals and to incorporate that knowledge in the design of the health care programs.

In conclusion, I would like to touch briefly on some moral considerations of "Workers' Right to Know." How do we value worker health? Experience has taught us that knowledge is essential to the intelligent action of human beings to protect themselves. We cannot expect workers to avoid contact with a substance and to use protective procedures and equipment if they do not understand what the hazard is.

When I started working in hospital health and safety ten years ago, the adage I most frequently heard from hospital administrations was "a little knowledge is a dangerous thing;" and that is true. I think that very limited knowledge can create tremendous problems. But the difficulty now, ten years later, is that workers have the little knowledge they have been able to obtain by their own reading and by help from their unions and therefore have a greater consciousness of health and safety. We have the problems that a little knowledge has engendered, and the "Right to Know" laws are challenging us to provide more complete information.

Morally, administrators have been forced to abandon the practice of providing only certain types of information that workers "ought to have." By common law, and by growing public

sentiment, workers have the right to know about substances that they work with and about the potential harmful affects of these substances. This consensus raises some very troubling problems in terms of what information is provided and how this information is made available. I would like to give three examples of these moral and ethical problems.

First of all, let us take the case of asbestos. We already know a lot about asbestos. Workers need information on asbestos, but it is one of the substances for which most hospitals have developed some programs because of the very stringent OSHA requirements and general community consciousness about asbestos. Yet, many health care institutions have not done much about removing asbestos. Thus the moral questions raised by "Right to Know" programs are not just what you tell people, but also what action you take to correct the problem. The need for action is implied in giving people certain kinds of information.

The second example touches on anesthetic waste gases. The knowledge of potential adverse affects of anesthetic waste gases is much more recent. In the late 1960's and early 1970's we began to learn about the adverse reproductive affects of anesthetic waste gases. Immense numbers of workers are potentially exposed to these gases. Unlike asbestos however, a person cannot see the gases. The "Right to Know" in this example includes telling workers that they are exposed as well as telling them the hazards of the exposure.

The case of ethylene oxide raises a third problem. We now know that it is associated with spontaneous abortion and other health affects. We are able also to detect chromosomal changes (sister chromatid exchanges). Here we confront another moral problem; what do we tell workers when we don't know what the tests mean? We do not know yet what sister chromatid exchange tests really tell us. We do know that it has an affect on the genetic material of the individual, but the association of this affect with future reproductive and other affects is not known. This is a very troublesome situation especially since these are experimental programs; but the workers being examined naturally want to know what the test results mean.

We are also financially troubled by these regulations. Dispensing information costs money in this society. The establishment of a good information system costs a significant amount of money. In most cases, computerized information systems, specially trained personnel and employees paid time for attending the training sessions represent considerable expenditures. There may be expensive personnel transfers, as in the case of chemicals with potentially adverse reproductive affects. Placement, transfers and pregnancy policies all raise financial and logistical considerations as well as scientific and moral questions.

Finally, there is the issue of record keeping and worker access to the records- both medical records and exposure records- which is covered by another federal standard, the Medical Records Access Standard. This standard mandates that records not only be maintained, but that employees have access to them.

I hope that I have managed to impress upon you the urgency of this problem. Many institutions have done a great deal to develop "Right to Know" programs and are making real progress in implementing both the letter and the spirit of "Right to Know". Much remains to be done, however, on all levels of these complex and critical issues confronting us in this highly technical society. A society that, until recently, almost unquestioningly, embraced all new substances with the motto, Better Life Thru Chemistry. Now, we are realizing that throughout our society, workers, citizens and the community at large, all have a right to know about the potential health risks associated with each substance they utilize.

Health care administrators have special opportunities to set the pace for all other industries. After all, they and their staffs should be more concerned about and aware of the health affects due to exposure to toxic substances. Furthermore, they should be in the forefront in devising educational and procedural approaches so that worker's practices result in minimal exposure to these substances.

SECTION IV: Hazards Faced by Health Care Providers

The following section encompasses the largest number of chapters. The eight chapters detail hazards for employees in health care providers. It should be noted, however, that people not directly associated with the specific area detailed can still benefit by reading the chapter. For example, housekeeping needs to be knowledgeable about the recommended precautions for handling antineoplastics because, if the proper procedures are not followed, the housekeeping staff faces the risk of exposure.

A few of the chapters are short and may not cover the topic as thoroughly as the topic warrants. We hope to remedy this in our next version. It is important to remember that even the shortest chapters have valid and important information and are deserving of your attention.

INHALATIONAL ANESTHETIC TOXICITY: CONTROLLING OCCUPATIONAL
EXPOSURE IN THE CLINICAL ENVIRONMENT

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ABSTRACT

Anesthesia gases may produce toxic effects in both the anesthetized patient and in those health professionals caring for the patient. Recently, evidence has accumulated relating many diseases to trace concentrations of waste anesthetic gases in the clinical environment. As a result of these potential health problems, the National Institute for Occupational Safety and Health (NIOSH) has made specific recommendations for reducing and documenting chronic exposure to trace levels in clinical environments where inhalational anesthetics are used.

In this chapter we will discuss the accumulating evidence linking exposure to inhalational anesthetic agents with specific disease; present guidelines for a comprehensive program to reduce exposure in the clinical environment; and propose ways to monitor and document the effectiveness of such a program for waste anesthetic gas control.

INTRODUCTION

All known anesthetics can produce serious toxic reactions in man. The mechanisms for these toxic reactions may be either direct or indirect. Directly, inhalational anesthetics produce a dose related depression in overall physiological function. Paradoxically the remarkable phenomenon of "anesthesia" itself may be regarded as a severe temporary toxic drug reaction which results in reversible nervous system dysfunction. The indirect toxic effects of an anesthetic involve complex biochemical interactions which ultimately may produce damage to sensitive cells. Fortunately, many of the direct toxic effects of anesthetics can be controlled by utilizing proper methods of administration of anesthesia and careful physiological monitoring of the anesthetized patient. Unfortunately, many of the indirect toxic effects of anesthetics may not always be immediately obvious and become recognized as syndromes, which evolve only with time and clinical practice. For over a century, physicians have been constantly aware of the potentially toxic effects of anesthetics in surgical patients. Only in the past two decades has it become apparent that health professionals who are exposed chronically to trace concentrations of anesthetics may also be at risk for toxic effects.

Our objectives in this chapter are threefold. First, we will review some of the potential toxic effects associated with inhalational anesthetic drugs, with emphasis on recent observations of specific diseases related to chronic exposure of

trace concentrations of inhalational anesthetics in the clinical environment. Second, we will examine the engineering principles and anesthetist work practices for reducing concentrations of the potentially toxic inhalational gases in the clinical environment. Finally, we will review monitoring procedures used to evaluate the effectiveness of a waste anesthetic gas control program.

TOXICITY TO THE PATIENT

The First Inhalational Anesthetics: Ether, Chloroform, and Nitrous Oxide

The inherent toxicity of inhalational anesthetics has been well recognized since 1842 when Crawford Long first used diethyl ether to induce surgical anesthesia. Shortly after the discovery of ether anesthesia, both chloroform and nitrous oxide were introduced clinically into surgical and dental practice. Tragically, the induction of the anesthetic state with these potent drugs sometimes produced acute toxic reactions which were unpredictable and rapidly lethal. Such was the case with Hannah Greene, a healthy fifteen year old, who in 1848 underwent the induction of anesthesia with chloroform for the removal of an ingrown toenail (Sibson, 1848). Within thirty seconds after the inhalation of chloroform vapor she developed irreversible cardiovascular collapse and sudden death. This first death under anesthesia clearly conveys the wisdom in the cliché that there are no "minor" anesthetics, only minor operations!

The early administration of anesthesia had little scientific basis. With both ether and chloroform anesthesia, dangerous central depression of respiration and failure of the circulatory system was related to toxicity. These unwanted toxic effects appeared to be dose related and were exaggerated by unknown metabolic factors and the health status of a particular patient. In the latter part of the 19th century, the recognition of both cardiac and respiratory toxicity is well depicted in the classic aphorisms: with chloroform, "watch the pulse," and with ether, "attend to the respiration, never mind the pulse." (Collins, 1976)

Two pioneers in the development of anesthesiology emerged. John Snow became intensely interested in the toxic states of anesthesia and summarized his astute clinical observations on the effects of anesthesia in his classical work, "On the Inhalation of the Vapor of Ether." (Snow, 1858) This was to be followed by Arthur Guedel's classic work in which he correlated observable physiologic changes with the specific stages of ether anesthesia (Guedel, 1937). These critical observations provided the early

foundation for the scientific study of anesthetic toxicity. With the application of the principles and observations of Snow and Guedel the acute respiratory and cardiac toxicity of anesthesia was greatly reduced. Anesthesia was made safer as some of the toxic side effects became more predictable and could be controlled by skillful administration of the anesthetic drug.

Anesthesia with ether produced many undesirable toxic effects: irritation of the respiratory tract, copious secretions, nausea, and vomiting. Ether, because of its flammability, occasionally caused tragic fires in operating theatres. Anesthetic flammability will become increasingly a problem as both surgical and anesthesia techniques demand the usage of various electrical devices to care for the patient. For over a century, however, ether will remain a very popular anesthetic.

Chloroform, although not flammable, produced serious cardiac dysrhythmias which sometimes resulted in irreversible ventricular fibrillation and cardiac arrest. Direct damage to the liver was also soon recognized as a severe toxic reaction of chloroform. Such toxicity finally resulted in the removal of chloroform from clinical practice in 1957. As a result of this problem with chloroform, anesthesiologists will closely scrutinize all subsequent inhalational anesthetics for liver toxicity.

Nitrous oxide or "laughing gas" became a very popular anesthetic because of its very potent pain relieving properties. Cardiorespiratory toxicity did not occur if an appropriate inspired concentration of oxygen was provided to the patient. Nitrous oxide was considered to be inert, nontoxic and very safe. The only apparent disadvantage of nitrous oxide was that it did not consistently produce adequate anesthesia. The valuable technique of combining nitrous oxide with a more potent inhalational anesthetic or a narcotic soon developed and remains popular today. The advantage of this technique is that an anesthetic synergism is established which allows one to reduce the concentration of the more potent inhalational agent. Thus, undesirable effects such as cardiorespiratory depression are reduced. As we shall see later, nitrous oxide will remain as the only surviving first generation anesthetic, and continues today as the most commonly used anesthetic drug.

Advances in anesthesia during the early twentieth century were directed principally at refining the use of the available anesthetics: ether, chloroform and nitrous oxide. The evolution of the "anesthesia machine" occurred as apparatus developed to accurately control the flow of gases and to vaporize the volatile anesthetics. A particularly important component of the anesthesia machine was the development of "the circle system." This consisted of a valved arrangement to recirculate gases, to

remove carbon dioxide, and to provide a reservoir system with which respiration could be either spontaneous or manually controlled. A soda lime cannister was used in "the circle system" to absorb carbon dioxide. "Open Drop" methods of administering inhalational anesthesia were replaced by newer techniques. Throughout the history of anesthesia, there was disregard for exhausting of waste anesthetics. Common practice allowed the excess anesthetic gases to escape into the operating room atmosphere. As we shall see later such a practice will be related to new problems in toxicity.

The Second Generation: Cyclopropane and Trichloroethylene

During the 1930's two new anesthetic drugs were developed: cyclopropane and trichloroethylene. Cyclopropane was a useful drug characterized by a smooth, rapid induction and generally stable maintenance of anesthesia. Sympathomimetic properties of the drug tended to support the blood pressure during anesthesia, but, with hypoventilation, serious bizarre cardiac dysrhythmias occurred. The greatest disadvantage of cyclopropane was the extreme flammability leading to disaster in numerous operating room explosions. This frightening environmental problem later resulted in removal of this hazardous drug from clinical practice.

Trichloroethylene, or trilene, was introduced in 1934 as a new inhalational anesthetic agent, and was soon associated with a number of toxic manifestations in man. The frequent occurrence of cardiac dysrhythmias was one such adverse effect. Most remarkable, however, was the chemical reactivity of trichloroethylene. Under certain environmental conditions, trichloroethylene breaks down to form: "phosgene, carbon monoxide dichloroacetylene, TCE ozonides, hydrochloric acid, and TCE epoxide" (Page and Arthur, 1978). In the presence of an electrocautery, trichloroethylene reacts to produce toxic levels of the nerve gas, phosgene. Another particularly disturbing reaction is the interaction of trichloroethylene with soda lime in the anesthesia machine, to produce another nerve poison, dichloroacetylene. Trichloroethylene, under certain circumstances induces carcinogenicity in laboratory animals (Baden and Simmon, 1980). Because of all these many hazards, trichloroethylene never became widely used as a general anesthetic agent in the United States.

The Halogenated Hydrocarbons: Fluroxene, Halothane, Methoxyflurane, Enflurane, and Isoflurane

New generations of inhalational anesthetics began with the development of fluroxene in 1954 and halothane in 1956. Combinations of the halogens: fluorine, bromine, and chlorine were substituted with hydrocarbon linkage to synthesize these new inhalational anesthetics. Chemists developed these newer "halogenated hydrocarbons" with the intention of producing the "perfect inhalational anesthetic," a drug which would induce anesthesia, be biologically nontoxic, nonflammable, and chemically stable. The "perfect anesthetic" had not yet been produced. Fluroxene produced nauseous side effects postoperatively and, because of its weak flammable properties, has been removed from clinical practice. Halothane, however, became very popular and is perhaps the most well known and widely used potent inhalational anesthetic in the world today. Unfortunately, after a decade of clinical use, the problem of liver toxicity began to be associated with exposure to halothane anesthesia. Some reports of hepatitis were described as "fulminant" leading to massive hepatic necrosis and occasional death. The national halothane study reviewed over 850,000 patients and concluded that, if the syndrome of "halothane hepatitis", did occur it was extremely rare (Bunker, Forrest, Mostseller et al., 1969). The "halothane hepatitis" controversy continues today as researchers continue in animal models to investigate possible mechanisms for the induction of liver toxicity.

Metabolism of Inhalational Anesthetics

Investigations into the metabolism of inhalational anesthetics introduced a new era in the study of anesthetic toxicity. The preconceived and traditional thought that all inhalational anesthetics were biochemically inert was disputed as sophistication in measurement showed that surprisingly many anesthetics were metabolized or biotransformed in the body by the liver and other organs. In a recent textbook of anesthesia, Baden and Rice have thoroughly reviewed the interesting metabolism and potential mechanisms of the toxicity of halothane and many other inhalational anesthetics (1981). The biotransformation of inhalational anesthetics into reactive intermediate toxic compounds and the potential for immune mediated response through hypersensitivity reactions are the most important current mechanisms by which anesthetics produce cellular toxicity.

An example of the toxicity associated with the biotransformation of an anesthetic is most well demonstrated with one of the newer generation anesthetic drugs, methoxyflurane.

Occasionally following methoxyflurane anesthesia, a syndrome of high output renal failure developed. Investigations have conclusively shown renal toxicity is induced following the metabolism of methoxyflurane (Mazze, 1983). Interestingly, such a toxic effect is related to several important chemical properties of methoxyflurane. First, methoxyflurane is a highly lipid soluble drug, and, secondly, its metabolism results in dehalogenation. The lipid solubility is an important factor since this prolongs the time available in the body for metabolism to occur. During metabolism, the fluoride ion is released to produce a direct toxic effect on renal tubular cells.

The most recently introduced inhalational anesthetics, ethrane and isoflurane, are also halogenated hydrocarbons which, like halothane, appear to be closer to what would be considered the "perfect inhalational anesthetic." Prior to the release of isoflurane, one disturbing report linked an increased incidence of liver tumors in male mice to exposure to the drug (Corbett, 1976). A follow-up study in mice found no such relationship to indicate that isoflurane had carcinogenic potential (Eger, White, Brown et al., 1978). Although ethrane and isoflurane undergo very limited metabolism permanent toxic effects to specific organ systems have not been clearly demonstrated.

TOXICITY OF EXPOSED HEALTH PERSONNEL

The Problem of Chronic Trace Exposure

Over the past two decades, the focus on the toxicity of inhalational anesthetics has shifted from the anesthetized patient to those caring for the patient. Much has been written about the potential health hazards of chronic exposure to trace concentrations of the inhalation anesthetic drugs. The problem of trace exposure to inhalational anesthetics is a significant one since it may affect a very large population of health care providers. It is estimated that, in the United States, 215,000 people are exposed daily to this potential health hazard (DHEW, 1977). This unique population includes those who work in clinical areas wherever inhalational anesthetics are administered. This includes numerous anesthetizing areas throughout hospitals, outpatient surgical facilities, dental offices, veterinary clinics, and research laboratories.

Voluminous reports have implicated, but not proven conclusively, that chronic exposure to trace concentrations of inhalational anesthetics produces a variety of health problems. These abnormalities are summarized in Table I. The great majority of these reports are related to trace concentrations of

Table I: Abnormalities associated with exposure to trace concentrations of anesthesia.

I. Reproductive

- a. Spontaneous abortion
- b. Infertility
- c. Birth Defects

II. Neurological

- a. Psychomotor impairment
- b. Nerve defects

III. Hematological

- a. Bone marrow depression
- b. Altered immune response

IV. Liver disease

V. Renal disease

VI. Cancer

halothane and nitrous oxide in the clinical environment. The rate of spontaneous abortion, infertility and birth defects has been shown to be increased in those working in clinical areas wherever anesthetics are administered. Diverse pathology from trace anesthetic exposure has been related to almost every organ system. Diseases of the liver, kidney, heart, nervous system and blood cells have all been associated with chronic exposure. The association of the potential ability of modern inhalational anesthetics to induce mutation and carcinogenicity continues to be investigated, but currently seems unlikely (Baden and Simmon, 1980).

Evolution of the NIOSH Recommendations

Prior to 1967, a few sporadic reports discussed adverse personality and mental disturbances in medical personnel who were exposed to anesthetic vapors while working in poorly ventilated operating rooms. A Russian researcher published a report which was the first to specifically relate an increase in spontaneous abortion in females working in an operating room environment (Vaisman, 1967). Soon to follow in the United States, another investigation reported on some unusual causes of death in anesthesiologists (Bruce, Eide, Linde et al., 1968). This information set into rapid motion intense interest and investigation of the potential problems related to the toxicity of chronic exposure to trace concentrations of inhalational anesthetics in the clinical environment.

The accumulating evidence was so convincing that various medical organizations and governmental agencies became intensely concerned because of the obvious impact of these findings on environmental health and safety. In a 1974 survey, the American Society of Anesthesiologists compared the health of an exposed group consisting of 49,585 operating room personnel to a group of 23,911 unexposed hospital personnel (Cohen, 1974). They reported: "The results indicate that female members in the operating room exposed group were subject to increased risks of spontaneous abortion, congenital abnormalities in their children, cancer, and hepatic and renal disease." In the exposed males, an increased risk of hepatic and renal disease was found, however the risks for cancer in males were not increased. Also significant was the finding that unexposed wives of exposed males surprisingly had an increased incidence of congenital abnormalities. Because of the epidemiological nature of the study, a direct cause-effect relationship between anesthetic exposure and abnormalities could not be clearly established. However, as a result of the study and collective evidence in animal experiments, a strong recommendation was made for the collection and exhausting of all waste anesthetic gases wherever inhalational anesthesia was administered. This report briefly

discussed two obvious implications of such a recommendation. What should be the acceptable level of trace anesthetic gases in the atmospheric environment, and what would be the cost of such scavenging? In March of 1977, the former issue was addressed in an important publication of the United States Department of Health, Education and Welfare (DHEW, 1977). A review committee of the National Institute for Occupational Safety and Health (NIOSH) set forth specific criteria for a recommended standard as related to occupational exposure to waste anesthetics, gases and vapors. At the time of the NIOSH recommendations, the potent halogenated hydrocarbons were intuitively suspected as the cause of toxicity in the clinical environment.

The occupational exposure limits recommended in the NIOSH recommendations were not defined as the "safe" level of exposure since information on the adverse health effects was not completely definitive and many unknown factors still existed. Therefore, NIOSH recommended that the halogenated agents be controlled at the lowest detectable level, 2 parts per million (ppm), using charcoal adsorption sample collection and gas chromatographic analysis. The 25 ppm recommended for nitrous oxide was based on impaired audiovisual ability, cognition, and dexterity which was observed in humans at 50 ppm but not 25 ppm (DHEW, 1977). A more recent investigation has failed to reproduce such adverse effects even at 1600 ppm of nitrous oxide (Frankhuizen, Vlek, Burm et al., 1978).

The Discovery of Nitrous Oxide Toxicity

Investigations continued to explore the possible relationships between disease and trace exposure to inhalational anesthetics. In a particularly interesting study of nitrous oxide exposure, Cohen performed a survey of 30,650 dentists and 30,547 dental assistants (Cohen, Brown, Wu et al., 1980). A health record comparison was made between a group who routinely used nitrous oxide and a group who did not. For both females and males who were exposed to nitrous oxide, a higher incidence of renal, hepatic, and neurologic disease was present. A 2.3 fold increase in the incidence of spontaneous abortion was found in exposed females. In unexposed wives of exposed males, a 1.5 fold increase in spontaneous abortion rate occurred. This information was particularly enlightening in that nitrous oxide was the only anesthetic gas present in the environment. The findings were remarkably similar to the earlier cited national study of operating room personnel. Earlier epidemiological studies were in environments which contained both trace concentrations of nitrous oxide and a mixture of the halogenated hydrocarbons. Was nitrous oxide the toxin causing the reported health problems?

For over a century, nitrous oxide was considered an inert, nontoxic anesthetic. In 1956, Lassen first described severe bone marrow depression in patients chronically exposed to high concentrations of nitrous oxide (Lassen, Henriksen, Neukirch et al., 1956). These particular patients were being treated for tetanus utilizing controlled mechanical ventilation and paralysis with cuare. The patients received nitrous oxide "to avoid long continued psychological strain." Serious aplastic anemias developed following 50-75% nitrous oxide for 5 to 7 days. (Did megaloblastic changes in the bone marrow suggest vitamin B12 deficiency?) Shortly after this report, cultures of mouse heart myoblasts were experimentally exposed to various concentrations of nitrous oxide (Kieler, Mortenson and Peterson, 1957). The author concluded: "nitrous oxide was found to be a mitotic poison, preventing interphase cells from entering mitosis and causing spindle destruction and chromosomal abnormalities in dividing cells". Are there problems with replication of DNA following nitrous oxide exposure?

In 1963, two reports again demonstrated the toxic hematological effects of nitrous oxide. In an animal experiment, white rats were exposed to 80% nitrous oxide for six days (Green and Eastwood, 1963). The animals exposed to nitrous oxide had greatly reduced peripheral white blood counts and obvious toxic changes in the bone marrow. The mechanism for such pathology was unknown. In a human study, two patients with leukemia received prolonged administration of nitrous oxide and responded with reductions in white cell production (Eastwood, Green, Lambdin et al., 1963).

A significant development occurred when, experimentally, it was discovered that vitamin B12 could be oxidized into an inactive form by interaction with nitrous oxide (Banks, Henderson and Pratt, 1968). To understand the biological implications of the effects of nitrous oxide on inactivation of vitamin B12, it is necessary to briefly summarize the biochemical interactions of vitamin B12 in cellular metabolism. Figure 1 schematically shows the very pivotal role of vitamin B12 in cellular metabolism. Methionine synthetase (a B12 enzyme) and folate compounds are linked to synthesize essential amino acids and the genetic material DNA (deoxyribonucleic acid). Vitamin B12 is also critical in other important pathways which regulate carbohydrate and lipid metabolism. Either a dietary deficiency or inactivation of vitamin B12 by nitrous oxide can produce serious disorders in the formation of blood cells and the structural integrity of nervous tissue.

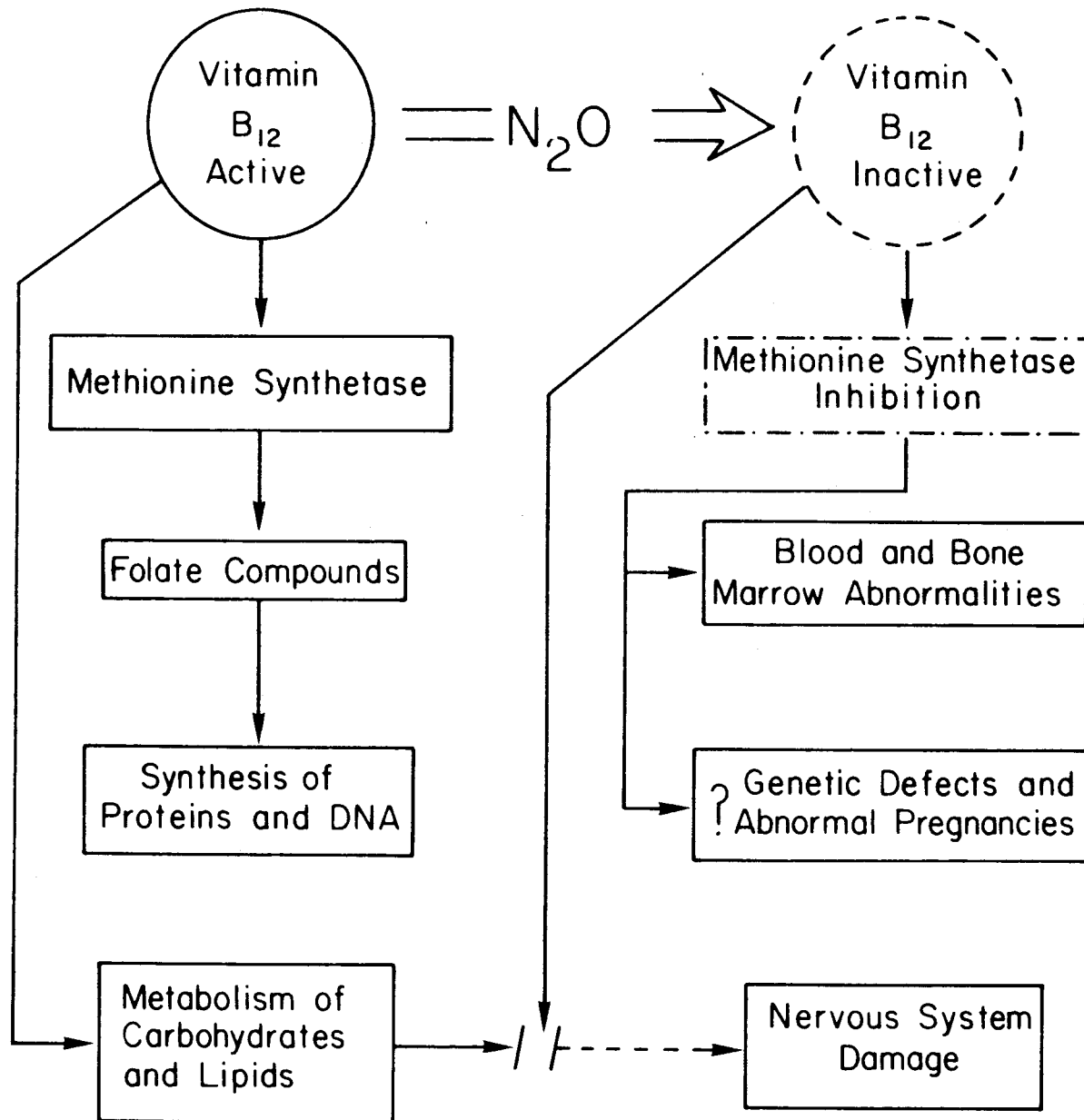
Remarkably, ten years passed before the inactivation of vitamin B12 by nitrous oxide was specifically related to patients receiving high concentrations of nitrous oxide. Patients in London received twenty-four hour administration of 50% nitrous

FIGURE 1

The inactivation of Vitamin B₁₂ by Nitrous Oxide (N₂O)
leads to the disruption of important metabolic processes.

Normal Cellular Metabolism:

Vitamin B₁₂ Deficiency:



oxide following cardiopulmonary bypass procedures (Amess, Burman and Rees, 1978). These patients all developed megaloblastic bone marrow changes and abnormal deoxyuridine suppression tests. The deoxyuridine suppression test measures the ability of cells to link deoxyuridine into DNA. Vitamin B12 and folate are both necessary for such synthesis. The investigators concluded that nitrous oxide interfered with vitamin B12 metabolism. The cause and effect relationships between nitrous oxide, vitamin B12 and biological toxicity became even stronger as numerous reports of neuropathy following abuse of nitrous oxide began to appear in the literature (Layzer, 1978; Sahenk, Mendell, Couri et al., 1978). In numerous rat experiments, it has been consistently shown that nitrous oxide inactivates the intracellular B12 enzyme methionine synthetase (Deacon, Lumb, Perry et al., 1978; Deacon, Lumb, Perry et al., 1980; Kondo, Osborne, Kolhouse et al., 1981). In an excellent recent text, Nunn has discussed the details of the inactivation of methionine synthetase by nitrous oxide (Eger, 1985).

In man, it is now clearly established that chronic exposure to high concentrations of nitrous oxide produces serious toxic effects in the bone marrow and in nervous system tissue, not unlike the effect of dietary deficiency of vitamin B12. The important question remains: Can exposure to trace concentrations of nitrous oxide induce the types of abnormalities which were found in earlier epidemiological studies?

This question was studied in rats exposed to 1100 parts per million (ppm) of nitrous oxide. Exposure from 8 to 22 days produced only small changes in liver and brain methionine synthetase activity which returned to control levels within a few days following removal of nitrous oxide. The authors concluded: "If these results can be extrapolated to the clinical situation, they suggest that inhibition of methionine-synthetase actively per se is more directly related to the apparent anemia and polyneuropathy seen in patients and abusers exposed to high concentrations of nitrous oxide than to the harmful effects occurring in those chronically exposed to trace levels" (Koblin, Osborne, Kolhouse et al., 1981). The same group of investigators measured methionine synthetase in anesthetized humans following periods of 50-70% nitrous oxide. Inactivation of methionine synthetase was related to the product of nitrous oxide concentrations and the time of exposure. They stated: "The inactivation of methionine synthetase may potentially impair DNA and protein synthesis. If recovery from inactivation of methionine synthetase occurs slowly in humans, deleterious effects may arise from even short exposures to nitrous oxide" (Koblin, Waskell, Watson et al., 1982).

Anesthetists working in areas without scavenging devices were studied for possible reductions in serum amino acids. When compared to an unexposed control group, there was no difference in methionine, leucine, isoleucine and valine. The normal methionine serum concentration was attributed to dietary intake and possibly an alternate pathway of methylation of homocysteine (Nunn, Sharer, Royston et al., 1982). In studies of rat hepatic methionine synthase, exposure to 450 ppm of nitrous oxide for 48 hours was necessary before any detectable change in the enzyme could be found. The authors stated: "These results suggest that the limit of exposure of 25 ppm recommended by the American National Institute of Occupational Safety and Health may be unduly restrictive" (Sharer, Nunn, Royston et al., 1983).

Most recently, investigators are performing animal experiments to study the teratogenic effects of exposure to nitrous oxide. A most interesting experiment studied thymidine and methionine synthesis in pregnant rats exposed to nitrous oxide (Baden, Rice, Serra et al., 1983). Pregnant Sprague-Dawley rats were exposed on the ninth day of pregnancy to 0.75%, 7.5% or 75% nitrous oxide for 24 hours. A deoxyuridine suppression test showed inhibition of thymidine synthesis at 7.5% and 75% nitrous oxide with recovery 72 hours after exposure. In addition, methionine synthetase could not be measured following 0.75%, 7.5% and 75% nitrous oxide, and over 72 hours, the enzyme concentration did not return to normal. There were no obvious resultant teratogenic effects or changes in birth weight following the 24 hour exposure to nitrous oxide (Baden, 1983). The biochemical changes that were observed, however, may be responsible for the teratogenic effects which have been observed by other investigators who used higher concentrations and longer exposure to nitrous oxide (Lane, Nahrwold, Tait et al., 1980; Shepard and Fink, 1968).

Many important questions remain concerning the toxicity of exposure to trace concentrations of nitrous oxide in man. However, the developments leading to the NIOSH recommendations and the discovery of nitrous oxide toxicity provide a firm rationale for controlling and monitoring waste gas exposure in the clinical environment.

CONTROLLING THE WASTE GAS EXPOSURE

Sources of Contamination

Having identified the potentially hazardous effects of long-term exposure to trace levels of the waste anesthetic gases, we must now address ways to continue using inhalation anesthesia

while reducing the risk to medical personnel. The first, and hopefully obvious solution, is to eliminate sources of contamination. These sources include the supply piping, the anesthesia machine, the anesthetic vaporizers, the breathing circuit, and the patient himself (See Figure 2). If a scavenging system is used to collect and exhaust waste anesthetic gases, it may also be a source of leaks and contamination.

The piping and hoses which supply nitrous oxide to the anesthesia machine can be a source of contamination due to misconnection, wear of fittings, or failure due to age or abuse (Beynen, Knopp, Rehder et al., 1978; Torda, Jones and Englert, 1978). It only takes a small leak, one which is probably imperceptible by listening or feeling, to cause significant contamination. If the rate of air change in the room is 10 changes of fresh air per minute, a leak of only 100 ml/min can give a level of 5 ppm (parts per million) (Whitcher, 1977). Such a small leak would have to be identified by pressure testing, bubble detection, or trace gas analysis. And since supply hoses are constantly being disconnected and reconnected, it is likely that such a leak could occur between testing intervals.

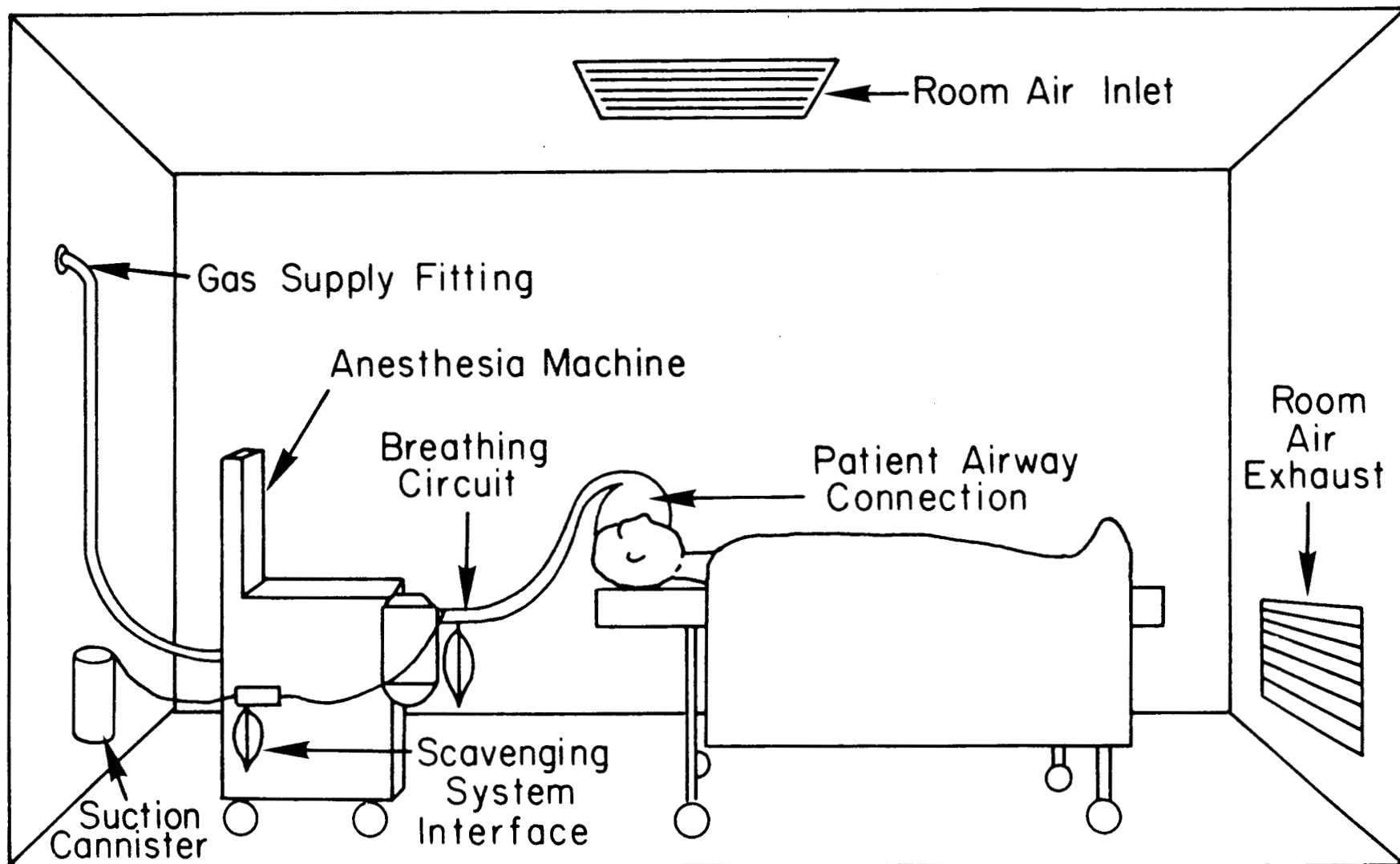
The anesthesia machine also contains a considerable amount of piping and fittings which may develop leaks (Whitcher, Piziali, Sher et al., 1975; Sass-Kortsak, Wheeler, and Purdham, 1981; Torda, Jones, and Englert, 1978; Berner, 1978a). However, most of these leaks should become apparent if an adequate machine check-out is performed before use. Checking for contaminating leaks should be part of routine anesthesia machine maintenance.

The potent inhalation anesthetic agents -- other than nitrous oxide -- are liquids at room temperature with high vapor pressures. These volatile agents are vaporized in the anesthesia machine in specially designed vaporizers. Contamination of air can occur during filling of these vaporizers if the liquid is spilled. The vaporizer should also be checked before use to be sure that the filler cap is firmly in place and that there are no vaporizer leaks.

The breathing circuit is used to conduct the mixture of anesthetic and respiratory gases to the patient. Usually, the connection to the patient's airway is made by an endotracheal tube with a sealing cuff. However, sometimes uncuffed tubes or a breathing mask are used. In all cases, the anesthetist needs to be aware of breathing circuit leaks and avoid contamination of ambient air, especially when using positive-pressure ventilation. Use of a mask or uncuffed tube contributes to waste gas contamination. Poor technique also contributes such as not turning off the gas flows when changing breathing circuit connections or manipulating the breathing circuit (Sass-Kortsak, Wheeler, and Purdham, 1981; Torda, Jones, and Englert, 1978).

FIGURE 2

Schematic diagram of a typical operating room showing potential anesthetic leak sources and an active scavenging system using the existing room suction.



A scavenging system is used to collect the overflow anesthetic and respiratory gases and exhaust them from the operating room. However, an improperly designed or malfunctioning scavenging system can be a source of contamination (Beynen, Knopp and Rehder, 1978; Sass-Kortsak, Wheeler and Purdham, 1981; McIntyre, Purdham and Hosein, 1978). This is particularly true of scavenging systems which require adjustment of suction flow. If they are not readjusted when anesthetic gas flow rates are changed, spillage into the room may result. And use of activated charcoal filters is of no benefit in removing nitrous oxide.

Finally, the patient is a source of contamination. During an anesthetic, the body distributes and stores the anesthetic agents. When the procedure is completed, these agents exit the body in the exhaled breath. Although the majority of the anesthetic is exhausted before the patient emerges from anesthesia, release of lower levels may continue for hours or even days after the procedure. This should be considered in design of postoperative recovery areas (Berner, 1978b).

There are also sources of contamination not associated with the anesthesia delivery system itself. These may include cryosurgery units which use nitrous oxide to freeze tissue and laparoscopic units which use nitrous oxide for insufflation (Wray, 1980). Consideration should also be given to clinical gas analyzers, such as end-tidal carbon dioxide monitors, which may remove a sample flow from the breathing circuit and exhaust it to the room air. If such monitors are to be used, they should recirculate their sample flow to the breathing circuit.

The Five-Part Solution

Reducing exposure to waste anesthetic gases can be accomplished fairly easily by applying the five principals outlined below.

1. Modification of anesthetic technique.

There are several procedures which, if implemented by the anesthetist, can help prevent contamination of the operating room by anesthetic gases. First of all, certain anesthetic techniques and procedures allow free flow of gases into the ambient air. These techniques make scavenging difficult or impossible and should be avoided whenever practical. For example, if nitrous oxide is used when ventilating through the side-arm of a bronchoscope, it is very difficult to prevent contamination of the operating room air. Use of intravenous techniques would avoid this problem. Care must also be taken to assure that the

mask fit is good or that there are no leaks around the endotracheal tube, when one is used. The anesthetic gases should be turned off before the breathing circuit is disconnected to prevent flow into the room. Care should be taken when filling vaporizers to avoid spilling the volatile agent. The scavenging system should be checked before the case is begun, along with a check of the anesthesia machine and breathing circuit for leaks. Anesthetic gases should be washed out of the breathing circuit by oxygenation at the end of the case before extubation or removal of the breathing mask. And finally, lower gas flows can be used to lessen the amount of overflow gas exhausted from the breathing circuit. It is currently common practice to use fresh gas flows into the circuit which are well above the metabolic needs or uptake and distribution rates of the patient. Use of low-flow or closed-circuit techniques reduce the amount of exhausted gas, waste less anesthetic agent and oxygen, and help to preserve breathing circuit warmth and humidity (Dorsch and Dorsch, 1984; Waterson, 1984).

2. Proper Maintenance of Gas Supply, Anesthesia Machine, Breathing Circuit, Ventilator, and Scavenging System.

Once the inevitable leaks caused by the use of the anesthesia machine by the anesthetist have been reduced, the next contamination source to address is the leaks which may occur in the anesthesia delivery equipment. The hoses and fittings in the room are frequently neglected, but require routine inspection and repair. The anesthesia machine and associated accessories should be maintained on a regular (usually quarterly) basis. This maintenance should include the scavenging system, anesthesia ventilator, absorber, and breathing circuit components.

3. Use a Properly Designed Scavenging System.

All inhalation anesthesia techniques produce some waste gases which must be exhausted from the breathing circuit. The objective of a scavenging system is to collect this gas and conduct it safely out of the operating room. To do this, the scavenging system connects to the pop-off valve of the breathing circuit and/or ventilator at one end and to one of three types of exhaust systems at the other through a safety interface (Dorsch and Dorsch, 1984; McIntyre, 1978).

No matter what type of exhaust system is used to scavenge the waste anesthetic gases, a safety interface such as that shown in Figure 3 should be used. Such an interface prevents continuous suction on the patient breathing circuit, positive pressure buildup, and spillage of gases in the event of transient high flows. Failure to use a proper scavenging safety interface can introduce additional and unnecessary risk to the patient

during inhalation anesthesia (Patel and Dalal, 1979; Sharrock and Leith, 1977; Sharrock and Gabel, 1978; Miller and Cullen, 1979; Ward, 1981; Flowerdew, 1981; Tavakoli and Habeeb, 1978).

The simplest, and usually least expensive, scavenging system is a passive system which uses the room ventilation exhaust. Tubing conducts the waste gases from the scavenging interface to the exhaust grills or to fittings attached to the air ducts. While these systems can provide adequate performance, there are some concerns to be addressed. First, if partially or full recirculating air conditioning is used, the scavenging system attachment must not be in the recirculating path. Second, since the gases flow to the exhaust grill by positive pressure, any leaks will cause gases to contaminate the room. Third, the conducting hose adds resistance to the breathing circuit exhaust path. Fourth, the exhaust grill may not be conveniently located. And finally, a safety interface must still be used to protect the breathing circuit and patient in the even of an occlusion of the exhaust tubing.

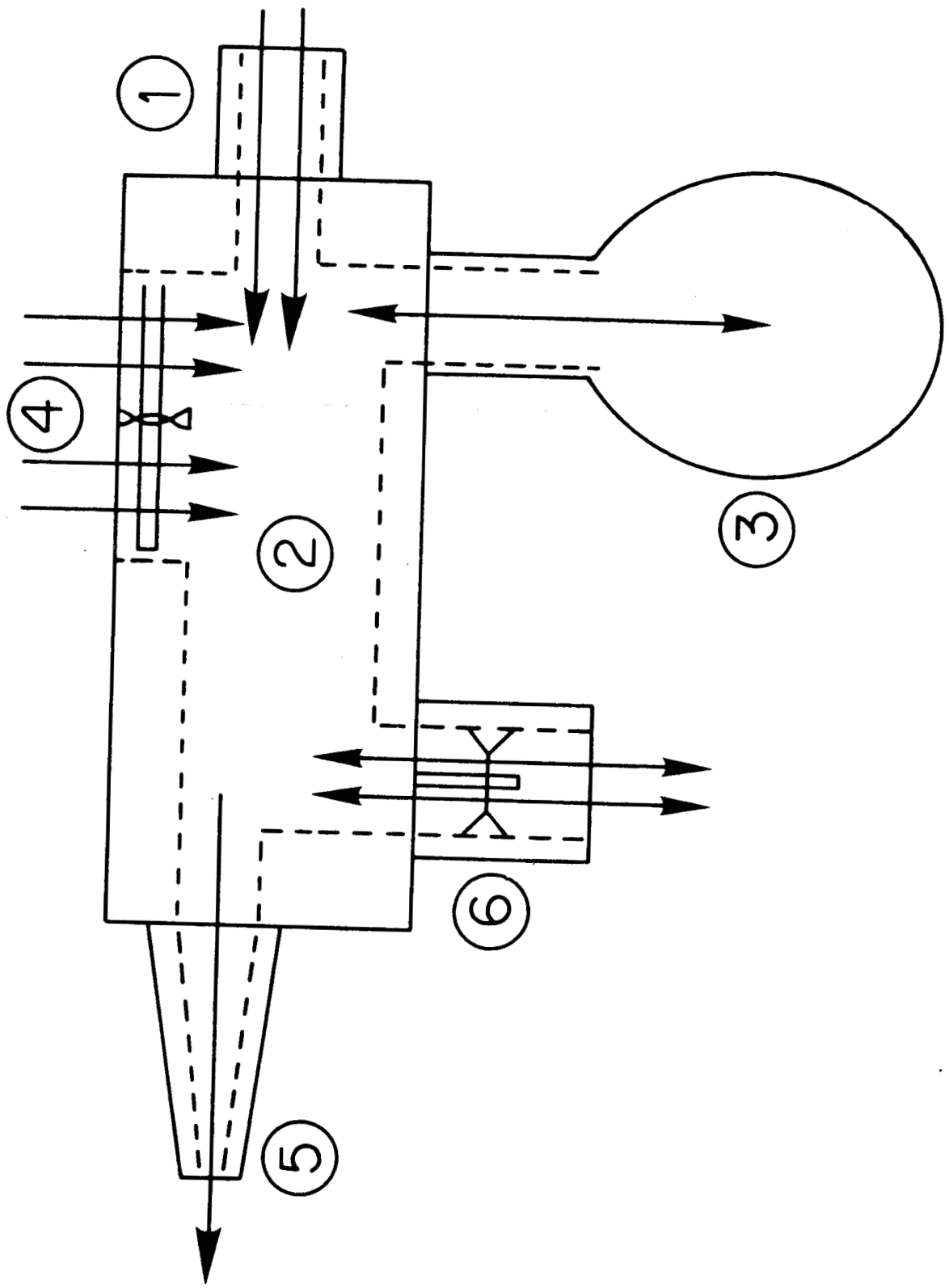
The most common type of scavenging system is an active system which uses the operating room suction system. While a fairly inexpensive alternative, because it uses the existing suction system, such a system requires an interface which can control the exhaust flow to avoid high flow rates which can unbalance the vacuum system and possibly overload the vacuum pumps. This interface also provides both positive and negative pressure relief to protect the patient and a reservoir bag to accommodate transient high flows such as those occurring with expiration or during an oxygen flush. Again, certain concerns must be addressed. First, there may not be enough suction fittings available. Second, flow must be controlled to keep the system balanced. And finally, the suction system pumps must be of appropriate design to avoid damage from the chemicals in the inhalation agents, must be able to accommodate the added load, and must exhaust to a safe location outside the hospital.

The most effective type of scavenging system is an active design with a dedicated blower and ductwork. This type of system provides a low-pressure/ high-flow characteristic (approximately 3 inches H₂O vacuum at 20 or more liters per minute, (Waterson, personal observations)). The same type of safety interface is used as described above. As with the suction system alternative, any leaks will be into the system. Also, this type of system can accommodate a local hood to collect vapors which have escaped the breathing circuit or were introduced from some other source (Nilsson, Stengvist, Lindberg et al., 1980). However, a new installation can be expensive and separate maintenance is required. It is probably best to consider such a system for new construction.

FIGURE 3

Schematic of a scavenging interface for the anesthetic machine. Overflow gas enters at (1) and collects in the reservoir bag (3), or is pulled out through the flow-control orifice to the vacuum system (5). Pressure inside the interface (2) is controlled by a one-way valve which opens at $-0.5 \text{ cm H}_2\text{O}$ (4). Further safety is provided by a relief valve which opens at -1.0 or $+4.0 \text{ cm H}_2\text{O}$ (6).

FIGURE 3



4. Maintain an Adequate Turnover of Fresh Room Air.

Most operating rooms are supplied with 100% non-recirculating air at turnover rates of greater than 15 air changes per hour. However, in the interest of energy conservation, partial recirculation of air may be considered or in use. It must be realized that room ventilation is a part of a total plan to control waste gas accumulation. If air is to be recirculated, a further burden is placed on anesthetic technique, equipment maintenance, and scavenging system performance.

Also, waste anesthetic gases may be released into the air in places other than the operating room. Recently, concern has been raised about levels in recovery rooms due to excretion of gases by patients emerging from anesthesia. Anesthetic procedures are also often frequently performed outside the operating suite in places such as radiology, nuclear medicine, radiation oncology, cardiology, or the emergency area. Such places may not have either scavenging systems or adequate ventilation with non-recirculating air. Dental suites are another such location.

5. Monitor and Document Waste Gas Exposure Levels.

A program of routine monitoring of waste anesthetic gases can provide several benefits. First, it can assess scavenging system efficiency. Second, it can identify sources of contamination and serve as a quality assurance check on preventive maintenance. Third, it can provide educational information about individual technique. And fourth, it can provide documentation of personal exposure levels to waste anesthetic gases. A complete program, to be discussed further, consists of both spot checks of equipment with ambient air analysis, and long-term monitoring of time-weighted personnel exposure levels. Both types of information are necessary to provide feedback about the effectiveness of efforts to control waste anesthetic gases.

MONITORING FOR WASTE ANESTHETIC GAS LEVELS

Distribution and Concentration of Gases

Room ventilation usually serves to uniformly distribute waste anesthetic gases within an operating room. However, some variations in concentrations do occur and may result in personnel exposures that differ among members of the operating room team. These variations depend upon the ventilation rate of the air

conditioning system, the sites and rates of leakage, locations of equipment and furniture, and movement of OR personnel. At low room ventilation rates (5 air changes per hour) some areas can have gas concentrations 10-15 times higher than the average room concentration. At higher ventilation rates (greater than 10 air changes per hour) these "hot spots" can still occur but generally less frequently and at lower concentrations. After anesthesia begins, gas levels tend to rise until an equilibrium is reached as a net result of system leaks, scavenger efficiency, personnel movement, and the ventilation rate (Piziali, Whitcher, Sher et al., 1976; Whitcher, Piziali, Sher et al., 1975). Various studies have reported average concentrations in operating rooms without scavenging systems in ranges between 400 ppm and 3000 ppm for nitrous oxide and between 1 ppm and 10 ppm for halothane (Dorsch and Dorsch, 1984; DHEW, 1977). Levels in dental operatories have been even higher (DHEW, 1977). Control measures such as scavenging systems and anesthetist's work practices have been shown to greatly reduce anesthetic gas levels in the operating room. Whitcher and co-workers (1975) measured average nitrous oxide concentrations below 1 ppm under tightly controlled conditions. Under more routine conditions but with an implemented control program, the average nitrous oxide concentration was 15 ppm.

Monitoring for Nitrous Oxide

Nitrous oxide is the anesthetic agent recommended for monitoring (DHEW, 1977). Although its popularity is diminishing, it is still used the most frequently and in the largest quantities. Room concentrations of other agents used in conjunction with nitrous oxide can be predicted from nitrous oxide concentrations using the ratios of the agents as they are introduced (Piziali, 1976). There may be some error in these calculations since vapors introduced into the room by spillage at the canisters would not be included and nitrous oxide leaks in high pressure hose connections would not involve other anesthetic agents (Dorsch and Dorsch, 1984; McGill, Rivera and Howard, 1980). The NIOSH recommended standard for control of waste anesthetic gases requires that only the agent most frequently used be monitored (DHEW, 1977). Monitoring performed at least every three months will usually provide an adequate interval for evaluation of the control program. If an institution is just beginning a control program, more frequent monitoring may be necessary.

Techniques for Gas Analysis

The analytical techniques employed for monitoring anesthetic gases must be specific for the gases and vapors that are being used without interferences from other compounds that may also be present. The techniques should also be sensitive enough to detect concentrations at least as low as the recommended exposure limits (25 ppm for nitrous oxide and 2 ppm for halogenated agents). Ideally, the analytical method should provide the results at the time of monitoring so that corrections can be made when problems are detected. Some sampling methods, however, depend upon sending an air sample to an outside laboratory for analysis resulting in an obvious time lapse before the results are known. One such method is gas chromatography analysis of charcoal sampling tubes used to adsorb organic vapors present in the air. This method is useful for monitoring the halogenated agents, but nitrous oxide will not be adsorbed by the charcoal. Mass spectroscopy has been used to measure anesthetic gas concentrations but is too expensive for most hospitals (Whitcher, Cohen and Trudell, 1971; Dorsch and Dorsch, 1984). Halogen leak detectors are relatively inexpensive and are small enough to be taken into the operating room but can not be used for nitrous oxide. Other halogenated compounds present in the room may interfere in measurements made with a halogen leak detector (Dorsch and Dorsch, 1984; DHEW, 1977).

The most practical method for monitoring waste anesthetic gas levels during administration of anesthesia is with a portable infrared (IR) gas analyzer (Dorsch and Dorsch, 1984; Walters, 1976; Whitcher and Piziali, 1977). A battery powered instrument can be easily moved from one location to another in an operating room area. Alternatively, the analyzer can be stationed in the adjacent corridor or utility room and sample tubing run into the OR to sample at various sites. Communication between the person carrying the probe and the person reading and recording the measurements can easily be accomplished with inexpensive radio headsets. This arrangement has the advantage of not having to bring relatively large pieces of equipment into the OR thereby reducing the risk of disrupting operating room routine. The sample pump on the analyzer must be able to pull a large enough volume through the long sample tube so that there is a reasonable analyzer response time (30 sec to 1 minute). The analyzer must be zero adjusted with a gas known to be free of anesthetic agents before entering the room for measurements. With non-recirculating ventilation systems the sampling tube can be inserted into an air supply vent (Whitcher, Piziali, Sher et al., 1975). Alternatively, an oxygen gas cylinder or the central oxygen supply can be used (DHEW, 1977; Whitcher, Piziali, Sher et al., 1975). Infrared gas analyzers are well suited for nitrous oxide. The halogenated agents can also be monitored with an IR analyzer but interference from alcohols, freons, and halogenated

cleaning solutions can result in error in the measurements (DHEW, 1977; Whitcher and Piziali, 1977; Whitcher, Piziali, Sher et al., 1975). The use of infrared gas analyzers for monitoring waste anesthetic gases is reviewed in two NIOSH documents: CRITERIA FOR A RECOMMENDED STANDARD...OCCUPATIONAL EXPOSURE TO WASTE ANESTHETIC GASES AND VAPORS, DHEW (NIOSH) Publication No. 77-140; and DEVELOPMENT AND EVALUATION OF METHODS FOR THE ELIMINATION OF WASTE ANESTHETIC GASES AND VOPORS IN HOSPITALS, DHEW (NIOSH) Publication No. 75-137. A list of suppliers of IR analyzers is provided in both documents.

Room Survey Monitoring

A monitoring program should include both room surveys and time-weighted average measurements. Room surveys are performed using a portable IR analyzer to spot check anesthetic gas levels for both personal breathing zones and general room levels. When elevated levels are detected, especially levels above the recommended exposure limits, the potential sources of leaks discussed earlier can be checked by placing the analyzer probe at suspected leak sites. Room surveys provide immediate information about the gas levels in the room and identify the sources of contamination. These surveys can be performed relatively quickly, allowing many rooms to be surveyed in a short period of time.

Room surveys should not be started until anesthesia has been administered for at least 30 minutes to allow the system leaks to reach equilibrium with the room ventilation (Walters, 1976; Whitcher, Piziali, Sher et al., 1975). The breathing zones of the most heavily exposed should be evaluated. The anesthetist is usually exposed to the highest concentration and is likely to remain in the room during the entire administration of anesthesia (Dorsch and Dorsch, 1984; Whitcher, Piziali, Sher et al., 1975). The circulating nurse is also often selected for monitoring (Kramer, 1982). This sampling is accomplished by placing the sampling probe near the area of the person's inspired air. Clipping the probe to the collar, shoulder, eyeglasses, or behind the neck will approximate the breathing zone (Dorsch and Dorsch, 1984; Kaarakka, Malischke and Kreut, 1981). Care should be taken not to sample too near the person's expired air since high levels of carbon dioxide and water vapors will interfere with the infrared analyzer (Whitcher, Piziali, Sher et al., 1975). Sampling in the close proximity of a person or at his/her work station may also provide an appropriate area for evaluating personnel exposures (Kaarakka, Malischke and Kreut, 1981; Whitcher, Piziali, Sher et al., 1975).

Since it is not reasonable to sample the breathing zones of all the surgeons and nurses, area samples should be taken which would indicate the general gas concentration in the room. Inserting the sampling tube in the air conditioning exhaust vent or at the hinge of the door to the room are good locations for measuring the room levels (Walters, 1976; Whitcher, Piziali, Sher et al., 1975). All samples should be taken for a period of one to two minutes to allow for stabilization of the gas analyzer (Whitcher, Piziali, Sher et al., 1975).

It is essential that monitoring personnel understand sterile technique and that they be known and accepted by the operating team. Some OR personnel may be disturbed by the risk that the sampling equipment may interfere with their work or contaminate a sterile area (Dorsch and Dorsch, 1984). Environmental monitoring should be conducted so that an accurate assessment of contamination levels is obtained without hindering OR personnel.

Time-Weighted Average Measurements

For the purpose of measuring personnel exposures, instantaneous or "one minute" sampling assumes that the exposure levels measured will remain constant during the anesthesia administration. Although anesthetic gas levels in the room are fairly well distributed, "hot spots" can develop which are higher than the average room concentration. In addition, some releases of anesthetic gases are transient. Time-weighted average (TWA) measurements should be taken to more accurately document personnel exposures. The entire time period required for a surgical case, or at least a significant portion of it, should be sampled. One method is to continuously pump ambient air from a breathing zone or work station into a gas tight inert container (such as a sampling bag of at least 17 liter capacity), at a low flow rate (about 300 cc per minute) (Dorsch and Dorsch, 1984; Kramer, 1982; DHEW, 1977; Whitcher, Piziali, Sher et al., 1975). The sample can then be analyzed with the infrared gas analyzer. Another method is to attach a recorder to the analyzer and sample continuously throughout the day. The TWA can be determined by integrating the recorded measurements or averaging the measurements at equal time intervals (Dorsch and Dorsch, 1984; McGill, Rivera, and Howard, 1980; DHEW, 1977). Continuous monitoring with an IR analyzer and recorder also provides information about peak concentrations and when they occur. Another method, though less accurate, is to average a large number of "one minute" samples (Dorsch and Dorsch, 1984; McGill, Rivera, and Howard, 1980). Finally, passive dosimeters for nitrous oxide can be worn on a shirt pocket for an OR employee during anesthesia administration. Some have shown to give accurate TWA measurements when compared with continuous infrared

analysis recordings (Bishop and Hossoin, 1984). The dosimeters are sent back to the manufacturer or an outside laboratory for analysis. OR personnel must keep accurate records of their exposure times when using passive dosimeters.

Monitoring Background Levels

It may also be useful to monitor the rooms when anesthesia is not being administered to obtain background levels of nitrous oxide due to high pressure system leakage. To do this test, high pressure hoses must be attached and the anesthesia machine not used for one hour. The nitrous oxide concentration measured will be the background level due to high pressure system leakage. A relatively leak free system will be less than 1 ppm. Concentrations in excess of 5 ppm indicate leakage problems which should be corrected (DHEW, 1977).

Reporting Monitoring Results

A report of the monitoring results should be prepared and sent to all concerned personnel. The following information should be recorded for each room surveyed: room no.; anesthesia machine no.; anesthesiologist; anesthetic agents employed; mask or endotracheal tube; nitrous oxide and oxygen flow rates; manual, mechanical, assisted, or spontaneous ventilation; period of anesthesia; date and time; measured gas concentrations at various sites; leak sites detected; and any comments of special note.

Legal Considerations and Regulatory Agencies

A number of national organizations are concerned about the potential occupational hazards associated with exposure to waste anesthetic gases and vapors. The National Institute of Occupational Safety and Health (NIOSH) is the research agency for the Occupational Safety and Health Administration (OSHA). As previously discussed, in 1977, NIOSH published and sent to OSHA a criteria document with a recommended standard for controlling occupational exposures to waste inhalational anesthetics (DHEW, 1977) (summarized in Appendix A). This proposed standard by NIOSH has not been adopted by OSHA as a regulated standard. However, OSHA can still inspect and cite conditions in hospital operating rooms under the general duty clause. Under this section, the Department of Labor requires that an employer provide a work place free from recognized hazards. Several hospitals have already been cited for having high levels of anesthetic gases in their operating rooms (Mazze, 1980). Even

though the Department of Labor has not legislated specific OSHA standards, health care facilities are still responsible for instituting a waste anesthetic gas control program.

Other legal considerations arise when an employee suffers from an illness or other health problem thought to be occupationally acquired. To date, attempts to sue employers have not been successful. However, potential suits may arise against a third party thought to be responsible for the injury. For example, a nurse working in an operating room could file suit against an anesthesiologist because of improper work practices contributing to high levels of waste anesthetics. Or, an anesthesiologist might sue a hospital for not providing scavenging equipment, preventive maintenance, and a monitoring program (Mazze, 1980).

The Joint Commission on the Accreditation of Hospitals (JCAH) is another agency which is concerned about waste anesthetic gases. JCAH recommends, but does not require, that each anesthesia machine be equipped with a gas scavenging device. Each anesthesia machine should be inspected and tested for leaks by the anesthetist before use (JCAH, 1984).

Although not a regulatory agency, the Ad Hoc Committee on Effects of Trace Anesthetic Agents on Health of Operating Room Personnel of the American Society of Anesthesiologists has proposed a recommended program to reduce exposure of operating room personnel (Mazze, Cascorbi, Jones et al., 1981). This program embraces many of the same guidelines presented in this chapter.

CONCLUSION

Although the scientific community continues to debate the precise threshold levels and mechanisms through which chronic exposure to waste anesthetic gases in the ambient air may produce toxicity, there seems to be sufficient evidence to warrant efforts at reducing the risk. A conscientiously applied program of scavenging, equipment maintenance, careful anesthetic technique, operating room ventilation, and ambient air analysis can be effective in controlling this potential hazard.

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Monitoring. Air monitoring is to be conducted on a quarterly basis in areas where inhalational anesthetics are used. The sampling sites are to be representative of the breathing zones of the exposed workers. The agent most frequently used is to be selected for sampling and analysis.

Recordkeeping. Medical surveillance records and air monitoring results are to be maintained for at least 20 years after a worker's termination of employment.

APPENDIX A

RECOMMENDED STANDARD FOR CONTROL OF WASTE ANESTHETIC GASES

The National Institute for Occupational Safety and Health (NIOSH) has published a recommended standard for control of waste anesthetic gases (DHEW, 1977). This standard is summarized below:

Occupational Exposure Limits. Occupational exposures to anesthetic gases and vapors are to be controlled so that no employee is exposed to time-weighted average concentrations in excess of 25 ppm for nitrous oxide and 2 ppm for halogenated agents during anesthesia administration. Halogenated agents should be kept below .5 ppm when used in combination with nitrous oxide.

Engineering Controls. Anesthetic delivery systems are to be equipped for scavenging and proper disposal of waste anesthetic gases.

Anesthetist Work Practices. Before beginning anesthesia administration, the scavenging and disposal systems are to be connected and the proper operation determined. Face masks are to have as effective a seal as possible. Vaporizers are to be filled in a manner to minimize spillage of the liquid agent and are to be turned off when not in use. Low pressure leak tests are to be conducted daily for the complete anesthetic machine and leaks corrected before use. Anesthetic gas flow is not to be started before induction of anesthesia. When the breathing circuit is disconnected from the patient after administration of the anesthetic agents has been started, anesthetic flowmeters are to be turned off or the Y-piece sealed. The breathing bag is to be emptied into the scavenging system before it is disconnected from the anesthetic delivery system.

Preventive Maintenance. High pressure system components are to be tested quarterly. After each cleaning, face masks, tubing, breathing bags, and endotracheal tubes are to be inspected for cracks and other leak sources.

Medical Surveillance. Comprehensive preplacement medical and occupational histories are to be obtained and maintained in the employees' medical records. Annual physical exams are recommended. Employees are to be informed of the potential health effects of exposure to waste anesthetic gases.

APPENDIX B

CONSULTANT SERVICES IN NORTH CAROLINA

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(919) 733-3680

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PRECAUTIONS AND PROCEDURES FOR THE
PREPARATION, ADMINISTRATION, AND DISPOSAL
OF ANTINEOPLASTIC COMPOUNDS

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ABSTRACT

In many situations where chemicals are utilized, there are inherent risks to the employees who have contact with them. In some instances, it may be possible to substitute less toxic chemicals for the more toxic ones. This is not possible with the use of antineoplastic compounds. The effectiveness of drug therapy through the use of these agents is a function of the drug's ability to exert lethal effects on malignant cells through interference with cell division. Some cancer cells divide rapidly. Antineoplastic agents destroy rapidly dividing cells but have no particular specificity for cancer cells. Both malignant and normal rapidly-dividing cells are altered with the concomitant side effects of alopecia, bone marrow suppression, and stomatitis. Many of the antineoplastics used today in the treatment of cancer are known carcinogens, mutagens, and teratogens. The possible future risk to the patient being treated with these compounds is considered to be far outweighed by the possible immediate benefits of the eradication of the immediate pathology.

Health care professionals who are involved with the reconstitution and administration of these drugs may also be at risk, however, and their risk is not justifiable. Several studies have been performed to attempt to quantify the risks of exposure. In the following chapter, the results of some of these studies are reviewed and contrasted.

The health and safety of personnel who work with these drugs is contingent upon their knowledge of the drugs' actions and the precautions they take to avoid personal exposure to the drugs.

The reconstitution and administration of these drugs must be accomplished under safe conditions with the least exposure possible. As Michael A. Mattia and Sheila Blake, have stated, "Until scientific inquiry resolves whether or not an occupational hazard exists, however, an ounce of prevention may well be worth more than a pound of cure" (Mattia and Blake, 1983).

Several hospitals and other health care organizations have devised policies and procedures for the safe handling of antineoplastic compounds. We present the "Ten Commandments" for the safe reconstitution, administration, and disposal of antineoplastic compounds we prepared based upon the policies and procedures of approximately 15 health care organizations' procedures.

"THE TEN COMMANDMENTS"

FOR THE SAFE USE OF ANTINEOPLASTIC COMPOUNDS

1. ALL HOSPITALS SHOULD HAVE WRITTEN POLICIES AND PROCEDURES FOR THE SAFE HANDLING OF ANTINEOPLASTIC COMPOUNDS.
2. A CLASS IIA BIOLOGICAL SAFETY CABINET SHOULD BE UTILIZED WHENEVER FEASIBLE. HOODS ARE A SUPPLEMENT TO, NOT A REPLACEMENT FOR, PROPER SAFETY TECHNIQUE.
3. FOR THE PROTECTION OF BOTH PATIENT AND EMPLOYEE, ALL INDIVIDUALS ASSOCIATED WITH THE USE OF ANTINEOPLASTICS SHOULD BE SPECIFICALLY TRAINED FOR THEIR WORK. (THIS INCLUDES THE ASSISTANTS THAT WILL BE HELPING WITH THE DISPOSAL OF THE URINE.)
4. GLOVES ARE A NECESSITY AT ALL STAGES OF WORK WITH ANTINEOPLASTIC COMPOUNDS:
 - a. Preparation
 - b. Administration
 - c. Disposal

HANDS SHOULD BE WASHED BEFORE PUTTING ON GLOVES AND AFTER REMOVING THEM; GLOVES ARE NOT A SUBSTITUTE FOR HANDWASHING.

5. CARE SHOULD BE TAKEN TO ENSURE THAT THE PRECAUTIONS TAKEN TO PROTECT THE EMPLOYEE DO NOT FRIGHTEN THE PATIENT, ESPECIALLY CHILDREN, AND ALSO THEY SHOULD NOT FRIGHTEN THE PATIENT'S FAMILY.
6. ALL SYRINGES FILLED WITH ANTINEOPLASTIC SOLUTIONS SHOULD CONTAIN THE FOLLOWING INFORMATION ON THE LABEL: PATIENT'S NAME, DRUG NAME, DRUG DOSAGE, TIME OF PREPARATION, NAME OF PREPARER, EXPIRATION TIME OF DRUG, AND CLEAR INSTRUCTIONS FOR THE ADMINISTRATION OF THESE DRUGS. THE LABEL SHOULD CLEARLY INDICATE "CHEMOTHERAPY DRUGS", SO PROPER CARE IS TAKEN.
7. IF THE PHARMACIST PREPARING THE ANTINEOPLASTICS HAS ANY DOUBT IN THE INSTRUCTIONS, THE DOCTOR SHOULD BE CONSULTED. IF THE PERSON ADMINISTERING THE DRUG HAS ANY DOUBTS, THE PHARMACIST AND DOCTOR SHOULD BOTH BE CONSULTED.
8. NO EATING, DRINKING, CHEWING GUM, OR SMOKING SHOULD BE ALLOWED IN THE DRUG PREPARATION ROOM. THE REFRIGERATOR USED TO STORE THE ANTINEOPLASTICS SHOULD BE MAINTAINED SOLELY FOR THIS PURPOSE. NO FOOD OR DRINK SHOULD BE STORED THERE.
9. TO PREVENT POSSIBLE SELF INNOCULATION OR AEROSOL PRODUCTION, NEEDLES SHOULD NOT BE RECAPPED OR CLIPPED.
10. ANTINEOPLASTIC WASTE SHOULD BE RECOGNIZED AS HIGHLY TOXIC, AND SHOULD BE TREATED WITH CARE. ALL DRUGS, DISPOSABLE EQUIPMENT (VIALS, SYRINGES, GLOVES, ETC.), AND EXCRETA FROM PATIENTS SHOULD BE DISPOSED OF PROPERLY. THE DISPOSAL PRACTICE GENERALLY RECOMMENDED IS PROPER INCINERATION.

INTRODUCTION

The comprehensive approach to the treatment of cancer may involve an array of therapies. It is known that many antineoplastic agents, such as nitrogen mustard, are carcinogens, but the use of these drugs is acceptable due to the fact that, for the patient, the therapeutic effects outweigh the potential risks. However, these compounds are increasingly becoming known as a threat to another group of people at the hospital- the staff that prepares and administers the drugs, and those involved with the disposal of all materials associated with them. This includes, not only the unused chemicals, but also the vials and needles that still contain traces of the drug, and the excreta of the patients undergoing treatment.

In addition to the antineoplastic substances, some studies have demonstrated that other compounds used in health care facilities may also be carcinogenic. These compounds include disinfectants, polishes, floor cleaners, toilet cleaners, fungicides, and even some shampoos (Kubinski, 1981). Though these may also be used by the public at large, they are particularly dangerous in hospitals due to the decreased resistance of the patients as a result of their diseases or some of the medication used to treat their diseases. Because antineoplastics affect rapidly-dividing cells, those in the bone marrow are suppressed. With severe granulocytopenia, there is particular risk for developing serious infection.

In this chapter, these concerns will be addressed with primary emphasis on antineoplastics. Studies involving hospital personnel who reconstitute and administer antineoplastics will be reviewed and contrasted. Major areas of concern and corresponding precautions will be highlighted. It is our hope that the safety and health of all hospital personnel who work with antineoplastics will be enhanced through the use of these guidelines.

LITERATURE REVIEW

Many investigators have utilized the Ames test to determine a compound's potential carcinogenicity. The Ames test is a bioassay that "assesses the ability of a substance to induce revertants(mutants) in bacteria." (Macek,1982) Since extensive research has demonstrated that 83 to 89 percent of all carcinogens are also mutagens, an abnormally high rate of mutations, as revealed through the Ames test, is considered a positive test of a substances' potential carcinogenicity.

While the results of the research designed to determine the work related risks associated with antineoplastics seem, at first reading, to contradict each other, on further inspection, this does not appear to be the case.

In 1979, a study was conducted by the Helsinki University Hospital and the Finnish Institute of Occupational Health. In this study nurses administering the chemotherapy drugs and an unexposed control group were studied. Urine samples were collected from the nurses and controls on Thursday afternoon--after four complete days of exposure-- and on the next Monday morning-- following a non-working weekend. Mutagenicity was clearly evident in the Thursday samples from the nurses working with the antineoplastics. A slightly higher than normal mutagenicity rate was still evident in the Monday samples (Facek et al, 1979).

Another study conducted to determine whether or not nurses who handled antineoplastics faced any risks was conducted in 1981 by Dennis M. Hoffman. He compared the urine from ten nurses who routinely administered pharmacy prepared doses of antineoplastics with urine from fifteen nurses who did not come in contact with the drugs. Urine was collected for an entire eight hour shift on the third or fourth day of the work week. The urine was then examined using the Ames test. No significant difference in the mutation rates of the two groups was found. Hoffman concluded that nurses, trained specifically for work with antineoplastics that had been previously prepared in the pharmacy, received "no more exposure to mutagenic substances than nurses who did not handle these drugs"(Hoffman, 1983).

The results of the Finnish study and of the Hoffman study seem to be incongruous, but they are not. In the Finnish study, the nurses prepared and administered the drugs, while in the Hoffman study the nurses administered previously prepared drugs. The exposure of the workers examined in the Finnish study was probably due to the preparation of the drugs or possibly due to the technique of the nurses administering the drugs. The nurses in the Hoffman study were specifically trained to administer the drug which led to the minimization of their exposure.

Another study was conducted by Staiano of the National Institutes of Health (NIH) in 1981. He performed urine mutagenicity tests on eight pharmacists 48 hours before and 48 hours after they reconstituted chemotherapy compounds. His tests revealed no increase in the mutagenic activities in the urine of the pharmacists regardless of whether a vertical or horizontal flow hood was utilized (Staiano et al, 1981).

Another point to consider is the length of exposure prior to testing for urine mutagenicity. The increase in exposure from

"on the third or fourth day of exposure" to "after four complete days of exposure" may seem insignificant, but could actually be extremely important. The research conducted by Dr. Jeffrey C. Theiss is an example.

Utilizing the Ames test, Theiss tested urine samples of nine pharmacists from the M.D. Anderson Hospital and Tumor Institute of Houston. Six (Group A) did the actual reconstitution while the other three (Group B) were administrators who were not exposed to the compounds. Group B served as the control. Urine samples were taken from all of the nine men each day for eight days. For the first six days, antineoplastic agents were prepared by Group A, while no preparations were made on the final two days.

On day 1, no significant increase in the mutagenic potential was noted in the urine of either group. However, beginning on day 2, Group A began to exhibit increasingly elevated rates of mutations that were particularly significant on day 4 through day 7. The mutagenic potential rose to twice the normal rate. By day 8, however, after two days away from the preparation of the compounds, the rates of mutations had returned to normal. Throughout the eight days, Group B showed no changes in the frequency of mutations in their urine.

This study seems to show the effects of exposure time on the mutagenic potential of the urine. When compared to the NIH study, it is easy to see the possibility of Theiss not finding any increased mutagenic potential had he only tested on day 2 and day 8-- the days of his research that correspond with those of the NIH study. The dramatic increases occurring during days 4 through 7 may have gone unnoticed.

Theiss' study demonstrated the effects of the type of hood utilized for the reconstitution of antineoplastic compounds on the potential exposure of the employee. The above mentioned results were obtained by studying pharmacists utilizing a horizontal flow hood. In a horizontal flow hood, sterile air is blown from the back of the hood, over the work surface, and out towards the employee. This type of hood, while protecting the compounds in the hood from contamination, increases the potential for the exposure of the employee to the compounds. When Theiss performed the same experiment on the same personnel using a vertical flow containment hood and gloves (no gloves were utilized in the previous experiment), the mutagenicity was not noticed. In a vertical laminar flow hood, a downward air flow is created that carries sterile air from the top of the hood, down towards the drugs (thus keeping the drugs free from contaminants) and then exiting down through the rear and front grills at the bottom of the hood (thus protecting the worker from exposure to the compounds.)

These studies suggest possible solutions to the very problem they address:

- a. Use a vertical laminar flow hood during the preparation of all antineoplastic compounds.
- b. Better technique and special procedures should be carefully followed when working with antineoplastic compounds.

This would help preclude the increased level of urine mutagenicity found to occur in some hospital personnel after the third or fourth day of exposure to the compounds.

Several health professionals believe that too much of a scare is being raised about this matter. MAJ James Wilson at the Walter Reed Army Medical Center in Washington, D.C. detected no increase in the mutagenicity in urine from pharmacists at his facility. (He studied pharmacists who utilized an horizontal flow hood.) He believes that contact with the drugs should be avoided, however, and that the workers should not "slop the drugs all over themselves" (Macek, 1982) as he had seen happen in the past.

The controversy over whether these compounds present a risk to health care workers working with them may continue for a long time. Nonetheless, everyone agrees that unnecessary contact with these or any drugs should be avoided. Unfortunately, according to a number of surveys, safety equipment and safe procedures are often not utilized; although the use of precautionary methods and protective equipment seems to have increased over the past several years.

A survey was conducted in 1981 by Anneke deWerk Neal, et al (Neal, et al, 1983) of eleven cancer chemotherapy units in the Chicago area. Air samples were taken in some of the hospitals as well as a written survey that assessed the precautions available and utilized. One of the areas tested was an oncology outpatient area at a major cancer center in the Chicago area. The air samples did reveal the existence of the drugs in the breathing zone of the worker. The preparation of the antineoplastics was conducted in a small windowless room on a counter top. The only vent in the room was connected to the central air-conditioning system for the hospital.

The survey results indicated that only one out of the eleven institutions surveyed in the Chicago area has an institutional safe-handling policy while three were developing them. The major problem areas, revealed in the survey, were the lack of safety devices and the lack of use of available safety devices by the people preparing the drugs. Of the 11 institutions surveyed, 10

had gloves available to its employees, but gloves were utilized routinely in only 4. In 3 institutions gloves were worn during the use of doxorubicin hydrochloride and mechlorethamine hydrochloride (nitrogen mustard). Masks were available for use by employees in 8 of the institutions, but utilized regularly in only 1. A hood was used for drug preparation in only 1 of the 11 institutions. (No information was given on how many of these institutions had hoods available).

Four of the facilities allowed for the disposal of the used ampoules and vials--often containing some of the unused compound-- into uncovered waste containers. In 3 of 11 locations one refrigerator was used for both food and the antineoplastic drugs, thus greatly increasing the risk of exposure by ingestion. Seven of the 11 cancer treatment centers had eating and drinking occurring in the drug preparation room.

According to a 1982 survey, 20 of the 21 cancer treatment facilities surveyed utilized gloves in the preparation of the anti-neoplastics (Marie LeRoy, et al, 1983). This is an improvement over the results of the Tortorici survey in 1979 and the deWerk Neal survey in 1981 in which only 8 of the 20 and 4 of the 11, respectively, routinely utilized gloves. Other results of the 1982 study showed that employees at 8 of the 21 institutions did not use masks routinely when preparing the drugs. Personnel at 10 institutions did not wear gowns, at 14 they did not wear goggles, and at 15 they did not wear lab coats. Only 4 of the institutions had a hood utilized solely for the purpose of preparation of antineoplastics.

CONCLUDING REMARKS

This research represents initial efforts to validate the suspicion that exposure to antineoplastics by direct contact, inhalation, or accidental injection is harmful to the employees working with the compounds. The information may appear inconclusive due to the numerous variables present in the research. However, what is conclusive is that there are effects of using these drugs. This research demonstrates that under certain conditions and exposure times, there are increased quantities of Ames test positive substances present in the urine of the pharmacists and nurses who have been exposed to antineoplastic compounds. Exposure to certain antineoplastics carries potential risk for development of chromosomal damage, hair loss, and of cancer. (Mattia and Blake, 1983) Therefore, it is imperative that safety protocols be established and utilized in the preparation, utili-

zation, and disposal of these compounds, and all materials associated with their use. This will minimize the inadvertant exposure to these potentially hazardous substances.

Although the controversy continues over the risks to health care providers from the preparation and administration of antineoplastic drugs, the fact that many antineoplastics are carcinogens, mutagens, and teratogens is not disputed. Because therapeutic doses are often quite toxic, we have organized a protocol for the handling of these drugs. These procedures are a composite of policies obtained from facilities responding to our questionnaire or found through our research.

POLICIES AND PROCEDURES FOR MANAGEMENT OF ANTINEOPLASTIC AGENTS

I. Preparation Room and Equipment

A. Room

1. There should be limited access to the room where antineoplastics are stored and where they are reconstituted.
2. The room should be located away from heavy traffic areas and from food preparation areas.
3. Stethoscopes, thermometers, and other equipment commonly shared between patients should not be located near the reconstitution area.
4. Patients' charts should not be placed in the area where drugs are reconstituted.
5. For more details on room if no hood available, see section IC.

B. Equipment

1. Procedures should be performed in a Class II vertical, laminar flow biological safety cabinet.

Type A- protects both product from contamination and the person preparing the drug from aerosol production.

Type B- same as Type A except discharges air to outside rather recirculating it back into room.

2. The hood should be inspected regularly, at least annually, if a worker feels it is not operating properly, or if the cabinet is moved, whichever comes first.
3. The hood should be utilized solely for the purpose of preparing antineoplastic compounds.
4. The hood should be left on, with the fan blowing, twenty-four hours per day, seven days per week.
5. The hood should be large enough to accomodate all equipment necessary for the reconstitution procedures. (Once the preparation has begun, it should not be necessary to move any equipment in or out of the safety cabinet)
6. The air intake to the hoods should not be blocked.
7. Once the equipment to be utilized for the reconstitution process is put into place in the hood, the air should be allowed to flow for two to three minutes before drug preparation begins.
8. Hand movement in and out of the hood should be kept to a minimum.

-
9. The work surface should be covered with sterile absorbent towels backed with plastic. This paper should be changed whenever any of the following occur:
 - a. an overt spill
 - b. a change in chemicals being reconstituted
 - c. the end of a work shift
 10. A non-splash collection vessel should be available within the safety cabinet for disposal of excess drug solution.
 11. The cabinet should be wiped with a 70% isopropyl alcohol solution before and after use.

C. If hood is unavailable:

1. The room should be as far away from traffic areas and food preparation areas as possible.
2. The room should preferably be windowless or the windows should be closed during the preparation of the antineoplastic compounds.
3. During the drug preparation, the door should remain closed to prevent a draft.
4. The preparer should not work under air vents.
5. The counter top should be laminated or stainless-steel and all edges should be intact (A split or chip in the edge could be a collection point for the drugs.)
6. A sterile disposable drape should be placed on the counter.
7. See section IIC-6 for special precautions in personal protection equipment.

II. Reconstitution

A. General Precautions

1. All personnel using biological safety cabinets should be completely aware of all limitations and should be well trained on proper procedures for use of the hood.
2. No eating, drinking, chewing gum, or smoking should be allowed in the drug preparation area. (These practices would greatly increase the chance of ingestion of these compounds. Smoking has the added risk of combusting these compounds into different, possibly more harmful, compounds.)
3. The refrigerator used to store antineoplastic compounds should be utilized solely for this purpose. NO food or drink should be stored there. (This would also increase the risk of ingestion.)
4. Cosmetics should not be applied, or opened, in the drug preparation room. (Personnel would face the risk of continual exposure to the antineoplastics if the cosmetics were to become contaminated.)

B. Reconstitution Responsibilities

1. Reconstitution duties should be performed on a rotating basis. (This does not entail a large number of people, since a smaller, well-trained group would be optimum. If possible no one should prepare the drugs more than three days in a row- particularly if a vertical flow hood is unavailable.)
2. Detailed records should be kept on all people reconstituting compounds. These records will help in the future for epidemiological studies and should contain the following:
 - a. compound being prepared
 - b. length of exposure
 - c. any accidents leading to additional exposure

- d. any ill-effects of working with the drugs (irritation of eyes or mucous membranes, dermatitis, headaches, etc.)
3. The prepared drugs should have the following information on the labeled syringe:
 - a. patient's name
 - b. drug name
 - c. drug dosage
 - d. time of preparation
 - e. name of preparer
 - f. instabilities or expiration time
 - g. clear instructions for administration
 - h. clear designation that the drug is a chemotherapy compound.
4. Pregnant or breast-feeding personnel should avoid contact with these drugs.
5. The person preparing the drug should consult the physician if there are ANY doubts about the preparation instructions.

C. Protective Clothing

1. Surgical or latex gloves should be utilized when preparing these compounds. (Latex gloves are generally preferred.)
2. A closed front gown with knit cuffs should be worn. The gloves should be tucked into the cuffs.
3. Hands should be washed thoroughly before and after using gloves. (GLOVES ARE NOT A SUBSTITUTE FOR HAND WASHING.)
4. All protective garments should be removed and disposed of properly before leaving the preparation area.
5. Contaminated clothing (non-disposable) should be kept separate from the regular laundry and should be properly decontaminated.

6. If a vertical flow hood is unavailable, protective eyewear (goggles or a shield—preferably a shield), and a mask that can filter droplets should be **MANDATORY**.

D. First-Aid Procedures

1. If any drug solution contacts the skin, the area should be washed thoroughly with soap and water.
2. If the compound is nitrogen mustard, the affected area should be washed with a 5% sodium thiosulfate solution.
3. All accidents should be reported so exposure to the drugs may be monitored.

E. Administration Techniques

1. Special care should be taken to prevent needle stick injuries or any other punctures through protective clothing. **NEEDLES SHOULD NOT BE CLIPPED.**
2. Use luer-lock fittings whenever possible to ensure needles are firmly attached to syringes. (Luer lock fittings prevent separation of the needle and syringe as a result of the pressure elevations from the mixing.)
3. Ampoules should be held away from the face and covered with sterile gauze before opening.
4. All vials, ampoules, etc. should be wiped down with 70% isopropyl alcohol solution and allowed to air dry before being used.
5. Before breaking ampoule, the health care professional should be certain that no powder or liquid is in the neck of the ampoule.
6. Large bore needles should be utilized to ensure high pressure syringing of the solutions is avoided (separation of the needle and syringe are avoided.)

7. Vials should be vented with a hydrophobic needle to eliminate internal pressure build up or vacuum. When venting, an alcohol dampened pledget should be placed over the needle tip. The needle should be held vertical for maximum air flow and minimum fluid flow. Negative pressure techniques can also be used.
8. An alcohol dampened sterile cotton pledget should be wrapped around needle and vial top during removal of the needle from the vial septum. Another should be placed around the needle when air bubbles are removed from syringes. (These procedures reduce aerosol production.)
9. Patients' charts should not be carried into drug preparation areas
10. Diluent should be introduced slowly down the side of the vial to ensure that the powder is thoroughly wet before agitation.
11. The needle should be removed before agitation.
12. Final drug measurement should be made before removing needle from vial.
13. All equipment utilized for the drug administration should be placed in a zip-lock bag for transport to disposal unit.

THE HOOD IS A SUPPLEMENT TO, NOT A SUBSTITUTE FOR, GOOD
SAFETY TECHNIQUE

III. Administration

A. Personnel

1. It is the responsibility of the person reconstituting/distributing the antineoplasics to inform the person administering the drug of any short stability period so the drug can be administered promptly. However, the person administering the drug should ask questions if there is ANY doubt.

2. Nurses, or any other person administering the drugs, should always be certain that the dosage, patient name, and drug name on the syringe match the patient's chart. Once again, if there are ANY doubts, the physician and the pharmacist should be consulted.
3. Personnel who handle these drugs should be specifically trained to handle these drugs. This will greatly reduce any risk to both patient and employee.
4. Pregnant and breast feeding personnel should avoid contact with these drugs.

B. Preparation for Administration

1. Syringes and I.V. sets with luer-lock fittings should be utilized whenever feasible.
2. After filling syringe, a new needle should be attached before injecting the patient.
3. Priming of I.V. sets should be done into a sterile gauze or sponge which should then be discarded with chemotherapy wastes. Priming should not occur in patient's room.

C. Clothing

1. Surgical gloves should be worn whenever contact with antineoplastic drugs is possible (including: injecting patient, priming I.V. sets, disconnecting I.V. tubing, removing air bubbles from syringes and I.V. tubing, or troubleshooting leaking tubing and syringe connections.)
2. Hands must be washed before gloves are put on and after they are removed- GLOVES ARE NOT A SUBSTITUTE FOR HAND WASHING
3. A closed front surgical gown with knit cuffs is recommended, but at least a long sleeve nursing uniform or white medical coat should be worn when administering these drugs.

4. Masks are strongly recommended.
5. Needles should not be recapped. This reduces risk of needle stick injuries.

CARE SHOULD BE TAKEN TO ENSURE THAT THE UTILIZATION OF THESE SAFETY PRECAUTIONS IS NOT AT THE EXPENSE OF PATIENT WELL BEING. CARE SHOULD BE TAKEN NOT TO FRIGHTEN THE PATIENTS- PARTICULARLY CHILDREN*

D. Disposal

1. DO NOT CLIP NEEDLES OR SYRINGES. Needles should be disposed of intact to prevent possible aerosol production. They should be put in leak-proof, puncture-resistant containers and incinerated, if possible.
2. Disposable gowns, masks, gloves, etc. should also be incinerated.

IV. Storage and Disposal

A. Storage

1. Drugs should be stored in a limited access room in accordance with manufacturer's requirements. (i.e. under refrigeration)
2. Drugs should be clearly labeled and any instability noted on the package.
3. Once a drug has been reconstituted, care should be taken to ensure its administration while still potent.

*Patients need a brief explanation and rationale for your use of gloves and gowns; it prevents them from contamination, too! Children should have a chance to express their concern and utilize play therapy to familiarize themselves with some of the potentially frightening equipment.

4. The prepared drug should have the following information on the labeled syringe:
 - a. patient's name
 - b. drug name
 - c. drug dosage
 - d. time of preparation
 - e. name of preparer
 - f. instabilities or expiration time
 - g. clear instructions for administration
 - h. clear label of chemotherapeutic contents
5. If damaged antineoplastic drug supplies are received, they should be isolated and left for manufacturer to handle. CALL MANUFACTURER IMMEDIATELY. DO NOT SEND DAMAGED GOODS BACK TO MANUFACTURER THROUGH THE MAIL.

B. Disposal

1. Since some of the antineoplastics are dangerous to incinerate, while others can be chemically neutralized, it is important to check with the manufacturer for detailed disposal procedures.
2. All needles, vials, syringes, gowns, gloves, etc. should be considered hazardous waste and disposed of properly, preferably incinerated.
3. Uncapped needles should be enclosed in a firm container not just a double bag.
4. The packages containing these materials should be clearly marked with large, easily readable labels such as "CAUTION- CHEMOTHERAPY COMPOUNDS. DISPOSE OF PROPERLY."
5. Personnel should be knowledgeable about the cancer drugs that are excreted in high concentrations in the excreta of the treated patient. Great care should be taken to reduce exposure to the excreta. Gloves should be worn and all measures to prevent aerosol generation should be utilized.

C. Spills

1. Use rubber or polythene gloves when cleaning up a spill. Double gloving is highly recommended. A polythene and a rubber glove on each hand is the recommended procedure at some hospitals.
2. Face masks and gowns should be **MANDATORY**.
3. Use double bagging with each bag sealed separately to hold spilled material.

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STERILIZING GASES: ETHYLENE OXIDE

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INTRODUCTION

Ethylene Oxide (EO) is a major industrial chemical. Current production volume is estimated at over six billion pounds/ year. This puts EO among the 25 highest production chemicals in the United States. The largest consumption of ethylene oxide is in the production of ethylene glycol for antifreeze (30%) and polyester (30%). Production of laundry detergents and dishwashing preparations (12%) is another major use. Ethylene oxide (0.5%) is also used by industry and hospitals to sterilize a broad array of medical devices that are moisture and heat sensitive (Korpela, 1983).

EO is being utilized in an estimated 10,000 sterilizing units in approximately 6500 health care facilities, resulting in the potential exposure of about 100,000 workers. A recent survey identified 250 different devices representing 10 billion units per year sterilized by EO. Although pure ethylene oxide is used in some sterilizing units, it is also frequently diluted to reduce the explosion hazard and to reduce self polymerization. Commonly, the dilution ratio is a gaseous mixture of 12% EO and 88% freon (Korpela, 1983).

Based on scientific studies indicating its potential as a human carcinogen and mutagen, and the possible genotoxic, reproductive, neurologic, and sensitization hazards associated with EO exposure, the Occupational Safety and Health Administration has recently lowered the permissible exposure limit (P.E.L.) from 50 p.p.m. to 1 p.p.m. as an 8 hour time-weighted average (T.W.A.) (Loving, 1984).

POTENTIAL HEALTH AFFECTS

Chemically, ethylene oxide is an alkylating agent. This means EO can chemically unite with components of living cells. Once united with a cell, EO interferes with its metabolism, affecting the cells normal physiological activity and ultimately causing death. This is the reason it is an effective sterilant. The danger exists when EO comes in contact with a human cell. The cell may die or survive in its changed or mutant form. The mutant cells have been discovered in many types of cancer growths (Mattia, 1983).

The National Institute of Occupational Safety and Health (N.I.O.S.H.) has recommended that EO be considered a mutagenic

and potentially carcinogenic substance, primarily because of its inherent mutagenic properties as an alkylating agent (Mattia, 1983).

Studies of Workers Exposed to Ethylene Oxide

In May 1981, N.I.O.S.H. published a report that showed evidence of carcinogenicity of EO. The report highlighted studies of workers and animals exposed to EO levels lower than 50 p.p.m. 8 hour T.W.A. (This was the O.S.H.A. standard at that time.) These studies found an increased mortality from leukemia and other cancers in factory workers, and leukemia and tumors in experimental rats exposed to similar concentrations. Due to these findings, EO was officially regarded as a potential carcinogen in the workplace (N.I.O.S.H. Bulletin #35, 1981).

Also in 1981, the American Hospital Supply Corporation conducted cytogenic studies in their employees. There was compliance with the current O.S.H.A. standard of 50 p.p.m. The results of these studies showed a significantly higher number of chromosomal aberrations in the exposed employees as compared with the nonexposed, control group (Mattia, 1983).

In 1979 a Swedish study of workers exposed to EO for 16 years was published. The findings indicated 23 deaths were observed, compared to 13.5 deaths expected. Of the 23 deaths, 9 cancer deaths were observed as compared with 3.4 deaths expected. Two leukemia deaths were observed compared with the 0.14 deaths expected. There were also 3 deaths from cancer of the stomach compared with 0.4 deaths expected (N.I.O.S.H. Bulletin #35).

Chronic exposure to EO is suspected to be responsible for a decrease in sperm count. Exposure to extremely high levels can also cause immediate depression and death (Samuels, 1981).

Routes of Exposure and Symptomology

Body surfaces exposed to ethylene oxide, such as the skin, mucous and serous membranes, may be irritated, blistered, and burned as a result of a reaction of the oxirane ring with proteins. Inhaled EO may damage the epithelial lining of the air sacs within the lungs, resulting in pulmonary edema. The second mechanism of toxic action by EO depends upon its hydration to form ethylene glycol, which may have a direct depressant action on the function of the brain. EO may also be converted within the body to glycoaldehyde by alcohol dehydrogenase. The glycoaldehyde may be oxidized further to such poisonous substances as glycolic, glyoxylic, and oxalic acids, with deleterious affects

on the structure and function of the liver and kidneys (Samuels, 1981).

It is not known whether occupational exposure to EO can produce adverse reproductive affects. Reproductive and teratogenic affects were recently addressed in a preliminary report of the Carnegie-Mellon toxicological study. It was interpreted from the results of this study that exposure to EO may be hazardous to the reproductive capabilities of humans (Samuels, 1981). An important point to remember is that the employee may not report a pregnancy until after the third month of pregnancy. The first three months, or first trimester, is the period when the fetus is at the greatest risk. If an employee's physician requests a job relocation, then the employer should reassign that employee to a location where EO exposure will not occur (Samuels, 1981).

Three cases of hypersensitivity or allergic reactions to EO are documented in the literature. Handling improperly or incompletely aerated material without proper protective gloves can cause skin reactions such as erythema and burns (Samuels, 1982).

Acute Inhalation

Acute inhalation may cause nausea, vomiting (either immediate or delayed), dizziness, weakness, chest pain, irritation of the respiratory tract, and neurotoxic affects. Repeated exposure may result in olfactory fatigue and reduced tolerance to vapors (3M, 1982).

Chronic Inhalation

Results of animal toxicity and human epidemiology studies indicate that long term exposure may be hazardous to humans (3M, 1982).

Liquid EO/Eye Contact

Contact with liquid EO may cause severe eye injury. High concentrations of EO vapor may also cause eye irritation (3M, 1982).

Liquid EO/Skin Contact

This may cause delayed chemical burns taking the form of blisters (second degree) (3M, 1982).

Ethylene Oxide Exposure Acute Systemic Affects (Gary, 1984)

Acute exposure to significant levels of ethylene oxide commonly provoke the following responses (Gary, 1984):

- irritation of eyes, nose
- headache
- coughing
- pulmonary edema
- nausea, repeated vomiting, diarrhea
- drowsiness, weakness (anesthesia-like affect)
- peculiar metallic taste in mouth
- incoordination
- ECG abnormalities

Ethylene Oxide Exposure- Chronic Affects

The majority of chronic affects observed deal with examples pathophysiological affects on the eye, the central nervous system and the skin. Affects on the central nervous system are listed in Table 1 while the affects on the skin is detailed in Table 2.

Table 1. Ethylene Oxide Exposure- Neurotoxicity Case Reports

Investigators	Findings
Gross et al. 1979	<u>Acute</u> : Weakness, fatigue, headache, seizures, trouble with memory and thinking. <u>Subchronic</u> : Sensory motor polyneuropathy (based on delayed nerve impulse conduction studies). <u>Chronic</u> : Not known definitely.
Salines et al. 1981	<u>Acute</u> : (total of four cases reported) Seizures, inability to perform minor tasks.
Kuzuhara et al. 1983	Sensory motor polyneuropathy (two cases): sural nerve biopsy compatible with axonal degradation. (Gary, 1984)

Table 2. Ethylene Oxide- Skin Response (Gary, 1984)

1. <u>Vesicant injury</u> (non-allergic dermatitis): latent period of 1 to 5 hours with development of erythema, edema, and vesiculation; noted after prolonged contact with EO in water.		
2. <u>Hypersensitivity reactions-</u> case reports:		
<u>Type</u>	<u>Authors</u>	<u>Findings</u>
delayed hypersensitivity	Shupack et al.	recurrent skin flare 3 weeks after exposure in one patient
	Alomar et al. 1981	patch test (+) at 96 hours in one patient
	Boonk et al. 1981	patch test (+) at 48 and at 72 hours in one patient
immediate hypersensitivity	Poothullil et al, 1975.	sensitization to EO sterilized in dialysis tubing and albumin exposed to EO (one patient)

With respect to the ocular affects, increased corneal thickness has been noted. Findings of another investigation suggested an association with cataract formation. There is some evidence that may serve to link epithelial keratitis with EO exposure. Together these reports involved a total of four or five patients (Gary, 1984).

MEDICAL SURVEILLANCE

Medical surveillance may be appropriate for employees who believe they have been significantly exposed to EO. If one decides that medical surveillance is appropriate, the following recommended medical strategy could be used as a guideline (Gary, 1984):

Medical History

First and foremost is the identification of a history of exposure to EO. This history should include answers to the following questions:

1. How long has the employee worked with EO?
2. How many times per day, per week, per month, and per year has the employee worked with the substance?
3. What are/were the ambient EO concentrations?
4. What exactly did the employee do and how were the employee work tasks performed?

There should be documentation of exposure to EO by monitoring to establish routine levels of exposure for a given work environment. In terms of the best scientific documentation, a combination of area monitoring and personal dosimetry (passive diffusion badges) gives optimal information regarding EO exposure.

Specific details of the worker's medical history and physical examination should include attention to possible ocular, neurologic, and dermatologic manifestations of EO exposure. A reproductive history should be considered as part of any routine exam. The exam should also include SCE analysis of peripheral blood lymphocytes, preferably both prior to and after job placement in an EO facility. There should also be an annual follow-up which includes SCE analysis with CBC, reproductive history; neural and dermatologic evaluation.

Regular medical studies conducted in the clinical laboratory do not lend themselves to detection or surveillance of EO exposure. Several major medical centers, however, perform analyses of sister chromatid exchanges on blood samples. This procedure affords the detection of EO affects in individuals exposed to EO.

The major advantage of this test procedure is the ability to identify which individuals may be engaged in improper work practices relative to EO exposure. A second advantage of chromosomal analyses is to provide the medical practitioner with a biological check on the analytical data gathered by air monitoring for EO.

POTENTIAL SOURCES OF ETHYLENE OXIDE EXPOSURE

The principle sources of exposure of employees to EO are as follows (Vance, 1984 and Samuels, 1984):

1. The areas in front of the sterilizer when the door is opened upon completion of the sterilization cycle.
2. Freshly sterilized goods.
3. The aeration cabinet.
4. The sterilizer itself if the following are not properly maintained:
 - a. gaskets
 - b. vacuum pumps
 - c. valves and fittings
 - d. piping
5. The floor drain.
6. The supply tanks or cartridges.
7. The safety valve.
8. During the process of changing the tank and/or cartridges.

The greatest exposure to the employee is around the sterilizer door. The highest level occurs immediately upon opening the door or a few minutes afterwards, while the EO residue is concentrated at the drain during the exhaust cycle (Hospital Environment, 1984).

CONTROL MEASURES FOR POTENTIAL SOURCES OF EO EXPOSURE

The following are effective solutions for reducing EO exposure of employees (Samuels, 1981 and 1984):

1. Reduction of exposure to EO in front of the sterilizer door can be achieved by:
 - a. Using a sterilizer which combines sterilization and aeration.
 - b. Providing a local exhaust hood above the door.
 - c. Providing cycle purges to reduce the residual EO on goods removed from the sterilizer.
2. Reduction of exposure to EO from freshly sterilized goods can be achieved by:
 - a. Utilizing a combined sterilizer-aerator.

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- b. Transferring goods rapidly from the sterilizer to the aeration cabinet.
 3. Reduction of EO exposure from the aeration cabinet can be achieved by:
 - a. Venting the cabinet to the outside.
 - b. Not opening cabinet until aeration has been completed. (if mandatory, wait at least 2 hours).
 - c. Performing preventative maintenance by assuring proper temperature and airflow.
 4. Reduction of EO exposure from the sterilizer itself can be achieved by:
 - a. Venting the sterilizer to the outside.
 - b. Performing routine maintenance checks.
 - c. Storing gas in cool/dry place.
 - d. Locating the sterilizer in a room of limited space.
 - e. Providing at least ten air changes per hour in the area in which the sterilizer is located.
 5. Reduction of EO exposure at the floor drain can be achieved by:
 - a. Installing a liquid/gas separator.
 - b. Providing local exhaust over the sanitary sewer (use copper tubing).
 6. Reduction of EO exposure from the supply tanks and cartridges.
 - a. Storing the tanks in a cool/dry place (preferably not behind the sterilizer).
 - b. Purchasing the tanks in small quantities so as to reduce the storage time.
 - c. Using the oldest tanks first.
 7. Reduction of EO exposure from the safety valves can be achieved by:
 - a. Venting to the outside.
 - b. Installing local exhaust ventilation.
 8. Reduction of EO exposure during the procedure for changing the tank and/or the cartridge can be achieved by:
 - a. Providing local exhaust over the tanks.
 - b. Providing one way valves on the drain.
 - c. Performing leak tests on all tanks.
 - d. Aerating the small cartridge before it is discarded.
 - e. Wearing protective gloves and goggles while performing these operations.

Venting to the Outside

Venting waste EO to the outside must be constructed to ensure that the exhaust line does not terminate near the source of any building's air intake (A.A.M.I. recommends a minimum of 25 feet), or near areas of pedestrian traffic. The rule of thumb is to comply with the manufacturer's specifications (Morford, 1984).

Discharging Into a Sewer Drain

Most built-in or wall mounted EO sterilizers in hospitals, which use steam to achieve the proper heat and humidity inside the chamber, have been designed to discharge the waste EO into a sanitary sewer drain by means of a water-sealed vacuum pump. Nonetheless, environmental monitoring results show us that a significant amount of the residual EO escapes from the air gap between the discharge line and the sanitary drain. Although EO is soluble in water, it does not dissolve or react with water very rapidly at normal temperatures. When the sterilizer is vented in this manner, it is crucial that it is done in a room separate from the workplace (Morford, 1984).

Preventing Discharge of EO from the Equipment to the Room

The three primary ways to prevent diffusion of EO from equipment rooms into the workplace are:

1. Providing negative pressure in the equipment room.
2. Installing a liquid/gas separator. This should be installed on the terminal end of the discharge line leading from the water-sealed vacuum pump in order to separate entrained EO from waste water. The gaseous EO is directed to an exhaust ventilation duct and the water runs down the drain.
3. Utilizing local exhaust ventilation around the terminal end of the discharge line in order to capture the escaping EO gas as it emerges from the drain (Morford, 1984).

GUIDELINES FOR SAFE USE OF ETHYLENE OXIDE

A crucial element of an EO Control Program concentrates on the importance of proper workplace operating practices, as they apply to operator training, the use of protective equipment such as respirators, equipment operation, material handling techniques and emergency procedures.

Proper procedures for using EO safely must be available in writing. All personnel must be thoroughly trained to use these procedures and in the operation and maintenance of EO sterilizers. Basic procedures should include the following (Hospital Environment, 1983):

1. Technicians working with EO should have adequate and intensive orientation related to EO. They must be directed to follow manufacturer's written instructions. The manufacturer of a sterilizer should be required to conduct a training session including safe use and precautions before placing the unit in service.
2. The EO sterilizer door must be opened as soon as possible after completion of the cycle. If the load is left in the chamber after cycle completion, EO levels will build up due to desorption from the sterilized goods.
3. A regularly scheduled preventative maintenance program for every sterilizer and aerator should be conducted by properly trained personnel. Documented records of inspection and modification should be maintained.
4. EO tanks should be stored upright and should be securely fastened to a solid structure with straps or chains.
5. During changing of cylinders, caution should be exercised to avoid contact with liquid sterilant that may remain in the connecting lines and should also avoid prolonged or acute exposure to sterilizing gas vapor.

Packaging

All packaging used for EO sterilization should meet the following criteria:

1. EO permeable.
2. Impervious to microorganisms of 0.5 microns.
3. Allow aeration of contents by ambient temperature or chamber aeration.
4. Opened or unwrapped and allow for aseptic removal.

(Hospital Environment, 1983)

Monitoring

Biological Testing

A biological spore test containing Bacillus subtilis should be tested in each load of materials to be sterilized by EO. This biological spore test, plus a biological control, should be incubated according to the manufacturer's instructions. Following incubation, test results should be recorded in the sterilizer's procedure records (Buonicore, 1984).

Mechanical Controls

Some sterilizers have a mechanical recording chart that records time, temperature, and pressure. The chart should be changed at least once a day or as necessary. For sterilizers with preset controls without mechanical recording charts, manufacturer's guidelines for operation should be followed (Buonicore, 1984).

Chemical Indicators

A chemical indicator should be included with every package that is EO sterilized. Unless otherwise stated on the package, EO gas sterilizer tape should be used on every package sterilized where the contents are intended to be delivered sterile to the patient (Buonicore, 1984).

RECOMMENDED PROCEDURES FOR STERILIZATION WITH EO

1. Avoid being close to an EO sterilizer that is operating or has just finished a cycle, except as necessary to operate the unit.
2. Report any skin, eye, or throat irritation, as well as nausea, dizziness, or disorientation. These may be caused by exposure to excessive concentrations of EO.
3. Sterilize with EO only those items that will not tolerate sterilization by steam or hot air.
4. Weigh EO cartridge before use, and return any cartridges that are more than 10% underweight.
5. If the sterilizer is equipped with indicators for temperature, vacuum pressure, or time, check them during the sterilization cycle.

(Health Devices, vol. 5)

RECOMMENDED PROCEDURES FOR TRANSPORTING STERILE ITEMS FROM THE STERILIZER TO THE AERATOR

1. Control personnel traffic so as to minimize exposure to EO gases.
2. Upon completion of the EO sterilization cycle, the sterilizer door should be opened at least six inches and no items should be removed for at least 15 minutes.
3. Personnel must wear gloves when handling items taken directly out of the gas sterilizer. Rubber gloves should not be used. Polyvinyl alcohol or cotton gloves may be used. The protective gloves should be washed daily (EO in Hospitals, 1980).
4. Minimize the handling of the sterilized goods by using metal carts or baskets.
5. Pull the load out of the aerator. Do not push. (Anderson, 1984).

AERATION

Complete aeration after sterilization is better ensured if the items were appropriately prepared for the sterilization process (Meeker, 1984):

1. Items must be thoroughly cleaned and towel or air dried, so that no visible droplets of moisture remain before being packaged for placement in the sterilizer. This will prevent the formation of ethylene glycol and ethylene chlorhydrin.
2. Items should be arranged in such a way that the operator will be able to transfer to the aerator the basket or cart of sterilized items without touching the goods.
3. Do not overload the sterilizer. Compression of packages can prevent penetration as well as subsequent release of gas.
4. To the extent practical, sterilize a full load of items having a common aeration time.
5. Unwrapped items that are impervious to EO, such as metal and glass, do not require aeration, but should be segregated in the sterilizer load for easy retrieval. Metal or glass items wrapped in EO absorbent material, however, must be aerated.
6. Polyvinyl chloride (PVC) supplies require the longest aeration time. Aeration times depend on the material and length of exposure to EO.

EMERGENCY RESPONSES

All employees should be trained in the proper action to be taken in the event of an EO emergency such as an accidental spill. Also, specific personal protective equipment to include mask (preferably an air supplied respirator), gloves, goggles and body suit should be assembled and stored in a convenient location

that is readily accessible to those potentially needing it. A documented respirator program is required in the event of a spill or if the employees are being exposed to greater than 1 ppm as a temporary measure to reduce their exposure below this limit (Vance, 1984). NIOSH recommends air supplied respirators for use above the 1 ppm limit (Gurnberg).

Several cannister gas masks are available for protection against EO. However, as of December 1984, none of these masks has been approved by NIOSH as required by OSHA standards (Gurnberg, 1984).

Recommended Procedure to be Followed in the Event of an Accidental Spill of EO

1. Avoid direct contact with liquid EO.
2. Evacuate personnel from the immediate area.
3. Initiate hospital's fire emergency response procedures.
4. Do not re-enter the affected area without proper personal protection equipment (i.e. mask, gloves, goggles, body suit). Re-entry should only be initiated after fire or health safety personnel have determined that re-entry is safe.
5. If the spill is associated with the sterilizer, contact the sterilizer manufacturer's representative.
6. Do not wear EO contaminated clothing again until it has been laundered. Discard contaminated leather shoes.

(3M, 1982)

Practical Emergency Treatment in Cases of Personal Exposure
(3M, 1982)

1. Inhalation

- a. Get the victim to fresh air immediately. If nausea or vomiting occurs, keep the person quiet and call physician.
- b. If breathing is difficult, give oxygen.
- c. If breathing has stopped, give artificial respiration, preferably mouth to mouth, then administer oxygen.
- d. Acute exposure causing nausea and vomiting should be treated by a physician.

2. Eyes

- a. If liquid EO or a high concentration of vapor contacts the eyes, immediately flush the eyes with water for a minimum of 15 minutes.
- b. Contact a physician at once.

3. Skin Contact

- a. Immediately remove contaminated clothing and thoroughly flush the area of contact with water for a minimum of 10 minutes.
- b. Aerate the contaminated clothing thoroughly and launder prior to wearing it again.

Precautions to be Observed in Handling EO Cartridges

1. Do not incinerate the EO cartridges. This applies to empty as well as full cartridges.
2. Puncture the cartridge only in the cartridge section of the sterilizer.
3. Do not place a leaking cartridge in the aeration cabinet.

TECHNIQUES FOR ENVIRONMENTAL AND EMPLOYEE MONITORING

The recently implemented OSHA standard for EO specifies that the monitoring of employee exposure to EO should be made within the breathing zone using a technique that is accurate to within plus or minus 25 percent at the 1 part per million (p.p.m.) level and to within plus or minus 35 percent at the 0.5 p.p.m. level. In addition to accuracy and reliability, hospitals would prefer to be able to rely upon monitoring methods that are simple and relatively inexpensive. There are two general types of ethylene oxide monitors: Personal and Area Monitoring (Ridgeway, 1984).

Personal Monitoring

The personal type monitor is usually worn by the worker in the breathing zone area for a specified period of time. This type of monitoring provides a measure of the amount of EO inhaled during that time period. The results are expressed as a time weighted average (TWA) concentration, for an eight hour work shift. The disadvantages with this type of monitor are that separate analytical processing of the exposure monitor must be performed and therefore there is a delay in obtaining the exposure results. If there was a serious leak and/or exposure, there would be a delay in knowing this. Also the results are reported as an average concentration and therefore do not yield information about concentration variations within specific segments of the sampling period (example: 100 ppm exposure for 10 minutes and 0 ppm exposure the rest of the 8 hours) (A.A.M.I., no date).

Area Monitoring

These are electronically controlled devices which measure, more or less instantaneously, the EO present at the sampling point. Both single and multiple point sampling "probes" are available. Some area monitors can measure more than one kind of air contaminant (e.g. waste anesthetic gases and EO). These types of monitors may not provide a TWA so the results do not necessarily represent personal exposure. Which of the two types of monitors is better? OSHA prefers personal monitoring results. However, area monitors, can detect high level concentrations, indicating ventilation system malfunctions, gasket leakages, etc., which in turn increases personal exposure. Perhaps the best is to utilize a combination of both types of monitoring devices. As an aid to hospital administrators charged with the responsibility of selecting equipment, the following section summarizes information about the major approaches available (A.A.M.I. Publication).

Area Monitors

1. Solid State Sensors

- a. Incorporates solid state elements which allow permeation of the selected air contaminants. A change in electrical resistance of the element, produced by the presence of the air contaminant is measured. The measured change is related to the concentration of the air contaminant.
- b. Prices: several hundred to several thousand dollars, depending on features.
- c. Portability: both portable and stationary models are available.
- d. Accuracy: variable.
- e. EO Specificity: usually poor, most also measure other contaminants than EO).
- f. Lower Detectable Limits for EO: low ppm, usually not less than 1 ppm.

2. Gas Chromatography

- a. This method draws in a sample of air and passes it through a packed column which separates the desired airborne component and routes the component to a detector. Detectors are usually flame ionization detectors or photoionization detectors. In the presence of the component, the detector measures the

generated ions. The measured response is proportional to the concentration of the component being detected.

- b. Prices: \$7,000.00 - \$50,000.00
- c. Portability: Most are stationary.
- d. Ease of Operation: Require properly trained personnel.
- e. EO Specificity: Excellent.
- f. Lower Detectable Limit For EO: Below 1 ppm for some photoionization detectors. For most flame ionization detectors, the detection limit is 1-5 ppm.

3. Photoionization Detectors (without Gas Chromatographs)

- a. Air is supplied to a detector where contaminants interact with u.v. light, producing ions. These ions are responsible for the production of an electric current, the strength of which is related to the concentration of the contaminant.
- b. Prices: \$2,000.00 - \$8,000.00
- c. Portability: Most are portable.
- d. Accuracy: Variable
- e. EO Specificity: Numerous contaminants other than EO may produce positive interferences.
- f. Lower Detectable Limit For EO: Some are capable of detecting less than 1 ppm.

4. Infrared Spectrometers

- a. A sample of air is drawn into a cell where it is exposed to infrared light. Contaminants absorb at specific wavelengths of infrared light. By measuring the amount of absorption, the concentration of the contaminant can be determined.
- b. Prices: \$2,000.00 - \$5,000.00
- c. EO Specificity: Variable.
- d. Lower Detectable Limit For EO: Less expensive units usually do not detect less than 50 ppm. More expensive units are capable of detecting levels of approximately 1-5 ppm.

5. Gas Detector Tubes

- a. Air is drawn through specially packed column with substances that react with EO and give color changes proportional to concentration in air that has been passed through it.
- b. Prices:

- c. Portability: Easily used anywhere
- d. Accuracy: Usually poor at low EO concentrations.
- e. EO Specificity: Substances other than EO may react with the color changing chemical.
- f. Lower Detectable Limits for EO: 1-10 ppm for some tubes; other are designed for concentrations greater than 10 ppm.

Personal Monitoring Devices

1. Charcoal Tubes

- a. A small, battery powered suction pump with plastic tubing is connected to a glass tube which is packed with a special type of activated charcoal. The pump draws a known volume of air through a glass tube and the contaminants, including EO, are absorbed by the charcoal. The charcoal tube is subsequently analyzed for EO concentration.
- b. Prices: Pump - \$400.00 - \$700.00
Charcoal Tubes - \$1.00 - \$2.00 each.
Laboratory Analysis- \$20.00- \$50.00 per tube
- c. EO Specificity: Specific to EO.
- d. Lower Detectable Limit for EO: Levels of less than 1 ppm.
- e. Other comments: The pumps should be calibrated prior to and after each use.

2. Passive Sampling Devices

- a. These "badges" are clipped to the worker's lapel and are usually worn for 8 hours. The badge is sent to a laboratory for analysis.
- b. Blank and Control samples should also be collected with a passive sampling device.
- c. Prices: Badge - \$11.00 - \$30.00 each.
Analysis - \$15.00 - \$35.00
- d. Accuracy: Variable, contact the supplier for specifications.
- e. EO Specificity: A few air contaminants can interfere. Write manufacturer to get a list of interfering contaminants.
- f. Lower Detectable Limit for EO: Some devices are capable of detecting less than 1 ppm as an 8 hour TWA.

3. Other Personnel Monitoring Services

- a. Non-permeable bags: A portable pump (similar to that used with charcoal tubes) collects breathing zone air and pumps it into a bag which is non-permeable to EO (i.e. Tedlar or Teflon). At the conclusion of the sampling period, the bag is sent to the laboratory for gas chromatographic analysis.
- b. Impingers: Air is drawn through a vial which contains an acidic solution. The EO from the air is converted to a derivative which is then analyzed with a gas chromatograph.

OSHA FINAL STANDARD (CONDENSED) OCCUPATIONAL EXPOSURE TO EO

The following provides a condensed summary of the final OSHA standard on occupational exposure to ethylene oxide. This standard in its complete form is: 29 CFR Part 1910; "Occupational Exposure to Ethylene Oxide; Final Standard" (OSHA, 1984).

Scope and Application

Applies to any exposures except where objective data show the product cannot release EO at or above the action level, including workplaces infrequently using EO.

Permissible Exposure Level

The Permissible Exposure Level (PEL) of EO is established at 1 ppm (8 hour TWA) and an action level is established at 0.5 ppm TWA. No Short Term Exposure Limit is established.

Exposure Monitoring

Will be made from one or more breathing zone air samples that are representative of the 8 hour TWA for each employee without respiratory protection on each shift, for each job classification, in each work area.

Initial Monitoring

Must be accomplished to accurately determine the airborne concentrations of EO to which employees are exposed.

Monitoring Frequency

If initial monitoring finds that exposure levels are above the action level but below the PEL, monitoring must be performed each 6 months. If it shows that exposure levels are above 1 ppm, monitoring must be performed each 3 months.

Termination of Monitoring

Is permitted if two successive monitorings (at least 7 days between) or the initial monitoring indicates levels below the action level. However, regular monitoring is strongly recommended by OSHA.

Additional Monitoring

Required if processes have been changed, personnel have changed, control equipment changes have been made, or if for any other reason new or additional exposures are suspected.

Accuracy of Monitoring

Sampling and analytical methods used to demonstrate compliance must be plus or minus 25% for 1.0 ppm and plus or minus 35% for 0.5 ppm. This accuracy is required at a confidence level of 95% and evidence of accuracy/precision must be provided.

Employee Notification of Results

Results must be reported in writing or by posting within 15 days of the report. Notify employee of corrective action if PEL is exceeded. Affected employee or designated representative may observe monitoring procedures.

Regulated Area

Established wherever occupational exposure may exceed TWA. Demarcate area and limit access to authorized persons.

Methods of Compliance

Where feasible, institute engineering controls, and work practices to reduce and maintain employee exposure to or below the TWA. If not feasible, use respiratory protection. If the

TWA is exceeded, establish and implement a written compliance program.

Respiratory Protection

Supply approved respiratory protection for specified circumstances and ensure the use of them; rely on respiratory protection only where engineering controls are not feasible or in case of an emergency.

Emergency Situations

Develop and employ an emergency plan whenever an emergency occurs. Provide a means of alerting and evacuating employees promptly if emergency occurs. After the emergency, prompt corrective action should be taken in order to minimize the chances of recurrence.

Medical Surveillance

Institute a medical surveillance program if action level is not achieved and maintained or on occurrences of emergency. Provide for medical exams before, during (at least annually) and after employment if action level may be (or was) exceeded at least 30 days in one year.

Training

Thorough safety training must be provided for all employees who may be exposed to EO at or above the action level regarding: a. methods/observations that may be used to detect the presence or release of EO, e.g. periodic monitoring or continuous monitoring devices, b. physical and health hazards of EO, c. procedures and protective equipment to be used, d. details of hazard communication program.

Recordkeeping

Objective data and records must be prepared to support exemption of any areas from this Standard and for areas or employees not exempted - including exposure measurements performed and medical surveillance performed. All records are to be made available to the employee or other appropriate individuals or agencies upon request.

Communication of Hazard to Employees

Signs

All regulated areas must be posted with well-maintained legible signs demarcating the regulated entrances and access ways.

Information

All employees who may be exposed to EO at or above the action level must be provided information regarding: a. information/training requirements, b. EO presence in areas, c. location of available OSHA Standards, d. medical surveillance requirements. If more information is needed, the following individuals should be contacted:

Dr. James Melius
NIOSH Hazard Evaluation and Technical
Assistance Program
4676 Columbia Parkway
Cincinnati, Ohio 45226
513-684-4382

Dr. Tom Samuels
Associate Director
Director of Pharmacy and Supply
University Hospital
Arizona Health Sciences Center
Tucson, Arizona 85724
602-626-6127

SUMMARY

This chapter contains information about the health affects of human exposure to excessive amounts of gaseous or liquid EO. Recommended practices are outlined for normal and emergency conditions. Procedures and equipment for personal and area EO monitoring are described. A series of educational, procedural and engineering approaches are outlined that should, if followed, help hospital safety personnel reduce the risk of exposure of their staff to excessive concentrations of EO.

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BIOHAZARDS/HOSPITAL EPIDEMIOLOGY

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ABSTRACT

Personnel have contracted infections in health care facilities throughout history. Pike (1976) published a summary of 3921 reported laboratory-acquired infections which occurred between 1924-1974. Staff members working closely with patients with communicable diseases or with their clinical specimens may also be at increased risk of acquiring infection. The unusual mode of transmission and/or length of time between exposure and manifestation of symptoms may mask the association.

To reduce exposure of laboratory workers to potentially hazardous biological agents, three methods of containment are used: laboratory practice and technique, safety equipment, and facility design. The basic means of prevention of hospital acquired infections in personnel with direct patient contact is the isolation of patients with communicable diseases as per recommendations from the Centers for Disease Control (CDC). Perhaps the most effective means of personal protection for laboratory workers as well as those with direct patient contact is that provided by immunization.

Methods of sterilization of equipment for use or contaminated items include autoclaving, dry heat, and chemical vapors. Common disinfectants used are alcohol, formaldehyde, phenolics, quaternary ammonium compounds, and halogens (iodine and chlorine). Infectious wastes should be handled so that they do not cause risk of disease during transport or at their final disposal site (as per N. C. Statutory Authority G.S. 130A-294).

An ongoing personnel education program is imperative to augment an effective infection prevention program. It is important that the Infection Control personnel become a visible source of information to provide proper prevention methods.

BIOLOGICAL RISKS IN A HEALTH CARE FACILITY

Laboratory-Associated Infections

Personnel have contracted infections in the laboratory throughout history. Wedum (1975) writes about reports at the turn of the century describing laboratory-associated cases of typhoid, cholera, glanders, brucellosis, and tetanus. More recently, Pike (1976) published a summary of 3921 reported laboratory-acquired infections which occurred between 1924-1974.

Interesting trends can be identified as to the kinds of microorganisms reported as causing laboratory-associated infections. Since 1924, the incidence of bacterial infections has decreased from 67% of reported infections to only 13% of the cases (Pike, 1976). The most reported bacterial diseases have been brucellosis, tularemia, tuberculosis, and typhoid fever. Recently, 25 cases of typhoid fever developed in laboratory workers who received Salmonella typhi cultures in the mail as part of a proficiency testing program (US HHS, 1979). In 1976, Harrington and Shannon (1976) indicated that medical laboratory workers in England had a "five times increased risk of acquiring tuberculosis compared with the general population". In the same report, laboratory workers were also shown to have an increased risk for shigellosis and hepatitis.

The recognition of hepatitis as a viral disease, the identification of more viral agents, and the increase in laboratories working with viruses contribute to the increased incidence of laboratory-acquired viral infections from 13% in 1924-1934 to 59% in the 1970s (Pike, 1976). Hepatitis leads the list of causative agents with one reported incidence of 2.3 cases per 1000 employees per year (Skinhoj, 1974).

Rickettsial diseases also contribute to numbers of laboratory-associated infections. Pike's (1976) summary indicates that Q fever is the second most commonly reported laboratory-associated infection with outbreaks involving 15 or more persons recorded in several institutions. The number of deaths caused by Rocky Mountain Spotted Fever in proportion to the number of cases is extremely high (11 deaths/63 reported cases).

In recent years, there have also been reports of laboratory-acquired gonorrhea (Diena, et al., 1976), rabies (Winkler, 1973), lymphocytic choriomeningitis (Bowen, et al., 1975), and parasitic diseases such as trypanosomiasis (Robertson, et al., 1980). Unlike accidents involving chemicals where the cause and effect are apparent, it is often difficult to determine that an illness has been acquired in a laboratory. The unusual mode of transmission and/or length of time between exposure and manifestation of symptoms may mask the association. Therefore, it can be reasonably assumed that there have been many more laboratory-associated infections than those reported in the literature.

Modes of Transmission

The first step in transmission is the discharge of an infective agent from infected material or hosts. For the laboratory worker, biological agents may pose a particular problem in that they can grow and multiply under favorable conditions and are often concentrated to extremely high levels in the laboratory. In this situation, the organism may be more hazardous than in the natural state where the organism may be in blood, feces, urine, spinal fluid, sputum and tissues.

Transmission may occur by direct transfer of infectious material by conveyance on an inanimate object, by an animal vector, or by transport in air. Access to the body may be gained through ingestion, breaks or penetration through the skin, or by inhalation. Pike's survey (1976) reported that fewer than 20% of all reported laboratory-acquired infections could be associated with a known accident. The majority of these were related to mouth pipetting and use of needle and syringe. Exposure to

infectious aerosols was considered to be the unconfirmed source of infection for the remaining 80% of the cases where the infected person had merely "worked with the agent".

Hanson et al. (1967) reported 428 laboratory-associated infections with arboviruses. Exposure to infectious aerosols was considered the most common source of infection.

Whether the transmission of the organism results in disease (i.e., the "hazard") depends on several factors:

1. Virulence characteristic of the organism.
2. Size of the inoculum.
3. Native resistance of the host.
4. Modified resistance of the host.

These factors must therefore be evaluated when determining the risk to the technologist and the means of control used in the laboratory.

Hospital-Acquired Infections

Hospital-acquired, or "nosocomial infections" are those originating in a medical facility and may affect three groups of people: the patient, the visitor, and the hospital employee. Nearly two million patients succumb to nosocomial infections each year in the United States reflecting more than one billion dollars in extra cost for additional health care. In addition, nearly 3% of these patients die as a result of the hospital-acquired infection. Sources of these infections, types of organisms involved, and means of prevention are discussed in detail in other texts (Bennett and Brachmann, 1979; Wenzel, 1981; and Palmer, 1984).

Staff members working closely with patients with communicable diseases or with their clinical specimens may be at increased risk of acquiring infection. In general, the most common infections affecting hospital personnel are those from patients with Hepatitis B, chickenpox, tuberculosis (TB), Cytomegalovirus (CMV), and Neisseria meningitis. Chickenpox and TB may be transmitted by the aerosol route, Hepatitis B and CMV require more direct

contact with body fluids, while Neisseria meningitis infection is most likely to occur after mouth-to-mouth resuscitation. Any of these infections may become serious illnesses or even lead to death. Unfortunately, many patients incubating Hepatitis B, CMV, or TB may be asymptomatic and never identified, posing a covert health risk for hospital employees.

Additionally, new diseases or forms of diseases resulting from variants of common organisms may present unforeseen potential for disease transmission to hospital staff. For example, the increasing number of patients with Acquired Immune Deficiency Syndrome (AIDS) since 1979 poses an unknown threat to those workers caring for them. One nurse seroconverted after a needlestick exposure from an AIDS patient in England and her ultimate fate is still unknown (Anonymous, 1984).

MEANS OF PROTECTION

Laboratory-Associated Infections

To reduce exposure of laboratory workers to potentially hazardous biological agents, three methods of containment are used: a) laboratory practice and technique, b) safety equipment, and c) facility design.

The most important element of containment is strict adherence to standard microbiological practices and techniques. Such practices include (US HEW, 1978):

- 1) Laboratory doors shall be kept closed while experiments are in progress.
- 2) Work surfaces shall be decontaminated daily, and immediately following spills of organisms.
- 3) Mechanical pipetting devices shall be used; pipetting by mouth is prohibited.
- 4) Eating, drinking, smoking, and storage of foods are not permitted in the laboratory area.
- 5) Persons shall wash their hands after handling organisms and when they leave the laboratory.

- 6) Care shall be taken in the conduct of all procedures to minimize the creation of aerosols.
- 7) Contaminated materials that are to be decontaminated at a site away from the laboratory shall be placed in a durable leak-proof container, which is closed before removal from the laboratory.
- 8) Use of the hypodermic needle and syringe shall be avoided when alternative methods are available.
- 9) The laboratory shall be kept neat and clean.

Each laboratory should develop a biosafety manual which identifies hazards that will be encountered and specifies practices designed to minimize risks. It is imperative that an ongoing educational program be designed to instruct personnel on appropriate laboratory techniques.

Additional safety practices may be necessary to control hazards associated with a particular agent or laboratory procedure. In these situations, laboratory techniques must be supplemented by safety equipment and appropriate facility design.

Safety equipment (primary barriers) includes biological safety cabinets and a variety of enclosed containers. The biological safety cabinet is designed to contain infectious aerosols generated by many microbiological procedures. Open-fronted Class I and Class II biological safety cabinets are partial containment cabinets, offering significant protection to laboratory personnel as well as decreasing environmental contamination of the experimental material within the cabinet. The gas-tight Class III biological safety cabinet provides the highest attainable level of protection to personnel, the environment, and the experimental material. For a detailed description of biological safety cabinets, refer to the CDC publication, Biosafety in Microbiological and Biomedical Laboratories (US HHS, 1984). Note: It is important that a maintenance program be developed to insure that cabinets are certified annually for air flow velocity and checked for leaks (Refer to Appendix A).

Other safety equipment includes devices for personnel protection such as gowns, gloves, safety glasses, and face shields. These may, of course, be used in conjunction with biological safety cabinets to ensure even greater personnel protection.

Appropriate facility design (secondary barriers) protect workers and the environment outside the laboratory from inadvertent release of hazardous agents within the laboratory. Three facility designs provide different levels of containment: (1) the basic laboratory provides an environment for working with agents which are not associated with disease in healthy adults, (2) the containment laboratory provides special engineering features that allow workers to handle hazardous agents without endangering themselves or the environment, and (3) the maximum containment laboratory provides the highest containment features, allowing work with infectious agents considered extremely hazardous to the laboratory worker or that may cause serious epidemics in the community.

Biosafety in Microbiological and Biomedical Laboratories provides specific descriptions of combinations of microbiological practices, laboratory facilities, and safety equipment within four categories or biosafety levels as outlined in Table 1. Recommendations for biosafety levels for specific agents are included in this publication and are made on the basis of the potential hazard of the agent and of the laboratory function or activity.

TABLE 1. Summary of recommended biosafety levels for infectious agents. *

Biosafety Level	Practices and Techniques	Safety Equipment	Facilities
1	Standard microbiological practices	None: primary containment provided by adherence to standard laboratory practices during open bench operations.	Basic
2	Level 1 practices plus: Laboratory coats; decontamination of all infectious wastes; limited access; protective gloves and biohazard warning signs as indicated.	Partial containment equipment (i.e., Class I or II Biological Safety Cabinets) used to conduct mechanical and manipulative procedures that have high aerosol potential that may increase the risk of exposure to personnel.	Basic
3	Level 2 practices plus: special laboratory clothing; controlled access.	Partial containment equipment used for all manipulations of infectious material.	Containment
4	Level 3 practices plus: entrance through change room where street clothing is removed and laboratory clothing is put on; shower on exit; all wastes are decontaminated on exit from the facility.	Maximum containment equipment (i.e., Class III biological safety cabinet or partial containment equipment in combination with full-body, air-supplied, positive-pressure personnel suit) used for all procedures and activities.	Maximum Containment

* U.S. Department of Health and Human Services (1984) BIOSAFETY IN MICROBIOLOGICAL AND BIOMEDICAL LABORATORIES. U.S. Government Printing Office, Washington, D.C.

Hospital-Acquired Infections

The basic means of prevention of hospital-acquired infections in hospital personnel is the isolation of patients with communicable diseases. The recommendations for the various types of isolation are based on available information on the mode of transmission of the agents involved in the infections. At Duke Medical Center, seven isolation categories are used as specified by the CDC. The categories and examples of types of diseases included in the categories are:

Strict Isolation

Strict Isolation is an isolation category designed to prevent transmission of highly contagious or virulent infections that may be spread by both air and contact.

Specifications for Strict Isolation include:

1. Private room is indicated, door should be kept closed.
2. Masks, gowns, and gloves are indicated for all persons entering the room.
3. Hands must be washed after touching the patient or potentially contaminated articles and before taking care of another patient.
4. Articles contaminated with infective material should be discarded or bagged and labeled before being sent for decontamination and reprocessing.

Diseases requiring Strict Isolation:

Diphtheria, pharyngeal
Lassa fever and other viral hemorrhagic fevers, such as
Marburg virus disease
Plague, pneumonic
Smallpox
Varicella (chickenpox)
Zoster, localized in immunocompromised patient or
disseminated

Contact Isolation

Contact Isolation is designed to prevent transmission of highly transmissible or epidemiologically important infections (or colonization) that do not warrant Strict Isolation. All diseases or conditions included in this category are spread primarily by close or direct contact.

Specifications for Contact Isolation:

1. Private room is indicated.
2. Masks are indicated for those who come close to the patient.
3. Gowns are indicated if soiling is likely.
4. Gloves are indicated for touching infective material.
5. Hands must be washed after touching the patient or potentially contaminated articles and before taking care of another patient.
6. Articles contaminated with infective material should be discarded or bagged and labeled before being sent for decontamination and reprocessing.

Diseases or Conditions requiring Contact Isolation:

Acute respiratory infections in infants and young children
Conjunctivitis, gonococcal, in newborns
Diphtheria, cutaneous
Endometritis, group A Streptococcus
Furunculosis, staphylococcal, in newborns
Herpes simplex, disseminated, severe primary or neonatal
Impetigo
Influenza, in infants and young children
Multiply-resistant bacteria, infection or colonization
Pediculosis
Pharyngitis, infectious, in infants and young children
Pneumonia, viral, in infants and young children
Pneumonia, Staphylococcus aureus or group A Streptococcus
Rabies
Rubella, congenital and other
Scabies
Scalded skin syndrome, staphylococcal
Skin, wound, or burn infection, major, including those infected with Staphylococcus aureus or group A Streptococcus
Vaccinia

Respiratory Isolation

Respiratory Isolation is designed to prevent transmission of infectious diseases primarily over short distances through the air (droplet transmission). Direct and indirect contact transmission occurs with some infections in this isolation category but is infrequent.

Specifications for Respiratory Isolation:

1. Private room is indicated, door kept closed.
2. Masks are indicated for those who come close to the patient.
3. Gowns and gloves are not indicated.
4. Hands must be washed after touching the patient or potentially contaminated articles and before taking care of another patient.
5. Articles contaminated with infective material should be discarded or bagged and labeled before being sent for decontamination and reprocessing.

Diseases requiring Respiratory Isolation:

Epiglottitis, Haemophilus influenzae
Erythema infectiosum
Measles
Meningitis, Haemophilus influenzae or Meningococcal
Meningococcal pneumonia
Meningococccemia
Mumps
Pertussis (whooping cough)
Pneumonia, Haemophilus influenzae, in children

AFB Isolation (Tuberculosis)

Tuberculosis Isolation is an isolation category for patients with pulmonary TB who have a positive sputum smear or chest x-ray that strongly suggests current (active) TB. This category is called AFB (for acid-fast bacilli) Isolation to protect the patient's privacy.

Specifications for AFB Isolation:

1. Private room with special ventilation is indicated, door should be kept closed.
2. Masks are indicated only if the patient is coughing and

- does not reliably cover mouth.
3. Gowns are indicated only if needed to prevent gross contamination of clothing.
 4. Gloves are not indicated.
 5. Hands must be washed after touching the patient or potentially contaminated articles and before taking care of another patient.
 6. Articles are rarely involved in transmission of TB. However, articles should be thoroughly cleaned and disinfected, or discarded.

Enteric Precautions

Enteric Precautions are designed to prevent infections that are transmitted by direct or indirect contact with feces.

Specifications for Enteric Precautions:

1. Private room is indicated if patient hygiene is poor.
2. Masks are not indicated.
3. Gowns are indicated if soiling is likely.
4. Gloves are indicated if touching infective material.
5. Hands must be washed after touching the patient or potentially contaminated articles and before taking care of another patient.
6. Articles contaminated with infective material should be discarded or bagged and labeled before being sent for decontamination and reprocessing.

Diseases requiring Enteric Precautions:

Amebic Dysentery
Cholera
Coxsackievirus disease
Diarrhea, acute illness with suspected infectious etiology
Echovirus disease
Encephalitis
Enterocolitis caused by *Clostridium difficile* or *Staphylococcus aureus*
Enteroviral infection
Gastroenteritis caused by
 Campylobacter
 Cryptosporidium
 Dientamoeba fragilis
 Escherichia coli (enterotoxigenic, enteropathogenic, or enteroinvasive)

Giardia lamblia
Salmonella species
Shigella species
Vibrio parahaemolyticus
Viruses-including Norwalk agent and rotavirus
Yersinia enterocolitica
Hepatitis, viral, type A
Herpanginia
Meningitis, viral
Necrotizing enterocolitis
Pleurodynia
Poliomyelitis
Typhoid fever (Salmonella typhi)
Viral pericarditis, myocarditis, or meningitis (unless
known not to be caused by enteroviruses)

Drainage/Secretion Precautions

Drainage/Secretion Precautions are designed to prevent infections that are transmitted by direct or indirect contact with purulent material or drainage from an infected body site.

Specifications for Drainage/Secretion Precautions:

1. Private room is not indicated.
2. Masks are not indicated.
3. Gowns are indicated if soiling is likely.
4. Gloves are indicated for touching infective material.
5. Hands must be washed after touching the patient or potentially contaminated articles and before taking care of another patient.
6. Articles contaminated with infective material should be discarded or bagged and labeled before being sent for decontamination and reprocessing.

Diseases requiring Drainage/Secretion Precautions:

Abscess, minor or limited
Burn infection, minor or limited
Conjunctivitis
Decubitus ulcer, infected, minor or limited
Skin infection, minor or limited
Wound infection, minor or limited

Blood/Body Fluid Precautions

Blood/Body Fluid Precautions are designed to prevent infections that are transmitted by direct or indirect contact with infective blood or body fluids.

Specification for Blood/Body Fluid Precautions:

1. Private room is indicated if patient hygiene is poor.
2. Masks are not indicated.
3. Gowns are indicated if soiling of clothing with blood or body fluids is likely.
4. Gloves are indicated for touching blood or body fluids.
5. Hands must be washed immediately if they are potentially contaminated with blood or body fluids and before taking care of another patient.
6. Articles contaminated with blood or body fluids should be discarded or bagged and labeled before being sent for decontamination and reprocessing.
7. Care should be taken to avoid needlestick injuries. Used needles should not be recapped or bent; they should be placed in a prominently labeled, puncture-resistant container designated specifically for such disposal.
8. Blood spills should be cleaned up promptly with a solution of 5.25% sodium hypochlorite (bleach) diluted 1:10 with water.

Diseases requiring Blood/Body Fluid Precautions:

Acquired immunodeficiency syndrome (AIDS)
Arthropodborne viral fevers (dengue, yellow fever)
Babesiosis
Creutzfeldt-Jakob disease
Hepatitis B (including HBsAg carrier)
Hepatitis, non-A, non-B
Leptospirosis
Malaria
Rat-bite fever
Relapsing fever
Syphilis, primary and secondary with skin and mucous membrane lesion

Specific guidelines and recommendations (e.g., bagging of articles, linens, dishes, thermometers) are contained in

the CDC Isolation Techniques for Use in Hospitals available from the Government Printing Office, Public Documents Section, Superintendent of Documents, Washington, D.C. 20402. Other recommendations for employee exposures to infectious diseases may be found in the CDC Guideline for Infection Control in Hospital Personnel are available from the CDC, Hospital Infections Branch, Atlanta, Ga. 30333, phone number: (404) 329-3406.

In the event of an uncontrolled outbreak of an infectious disease within the facility that reflects a community concern, the State Health Department serves as the most competent source of epidemiologic advice and assistance. The epidemiologist working in the State Health Department may participate in the investigation of the outbreak and frequently acts as a liaison with other state or federal agencies whose knowledge and resources may be helpful in solving the problem. For example, the epidemiologist may obtain specialized laboratory services such as identification of unusual pathogens or serotyping of Salmonella organisms. In North Carolina, such assistance may be obtained by notifying:

State Department of Human Resources
Division of Health Services
225 N. McDowell St.
P.O. Box 2091
Raleigh, N. C. 27602
(919) 733-3421

Employee Health Concerns

Perhaps the most effective means of personal protection for laboratory technologists and those with direct patient contact is that provided by immunization. In the United States, these immunizations include diphtheria, pertussis, tetanus, mumps, and measles (rubella and rubeola). Other immunizations such as plague, cholera and typhoid may provide short-term or questionable immunity. Other immunizing antigens such as rabies and botulinum toxoid are used only in very special cases.

Recently, the Hepatitis B vaccine has become available for health care workers. The vaccine series of three shots

is approximately 95% efficient in antibody production. After an extensive evaluation, high risk areas at Duke Medical Center were designated and employees offered the vaccine. Nearly 50% opted to receive the vaccine. Interestingly, since the vaccine program began in fall, 1982, approximately 50% of employees with needlestick exposures reported to Employee Health had already received the Hepatitis B vaccine series and had been protected against development of Hepatitis B.

In addition to appropriate immunizations, a system of medical surveillance should be established for employees who acquire an illness or sustain an exposure while working in the laboratory or taking care of patients. Any exposures to infectious material or infected patients should be followed and preventive measures initiated. Base-line serum should be drawn at the time of exposure for serologic determination of immunity to the disease in question. For example, when an employee at Duke is exposed (i.e., needlestick, blood/body fluid in cuts or membranes) to a Hepatitis B patient, serum is drawn for antibody testing to Hepatitis B, whether or not that employee is a Hepatitis B vaccine recipient. If non-immune, Hepatitis B Immune Globulin is immediately given to aid in prevention of Hepatitis B infection. Other employee health activities include TB screening and treatment, if necessary, and prophylaxis for meningococcal meningitis exposures.

In the past two years, Duke has become involved in the CDC Prospective Surveillance of Employees who have been exposed to AIDS patients. Although no preventive measures are available for this disease after an exposure at this time, an extensive follow-up procedure in collaboration with the CDC is initiated. Hospitals may participate in this study by contacting Nancy Winslow of the Hospital Infections Program, CDC, phone number (404) 329-3406.

Of course, an ongoing personnel education program is imperative to augment an effective infection prevention program. Upon arrival, employees are evaluated and briefed on the specific risks for infections in their designated work areas. At Duke, the Division of Environmental Safety currently provides scheduled in-service educational programs on the following topics: Isolation Techniques, Handwashing, Hepatitis B, AIDS, Tuberculosis, Herpes Infections, and Biological Safety in Laboratories. Educational materials on these and other infections may be obtained from several sources listed in Appendix B.

In addition, daily consultation with employees is perhaps the most effective educational tool of the Infection Control division. Each infection problem presents with a unique setting depending on many factors: virulence of biological agent, isolation type, susceptibility of employees, length of exposures, types of procedures done, etc. It is therefore important that the Infection Control personnel become a visible source of information to provide proper prevention methods.

Decontamination and Sterilization

Methods of sterilization include autoclaving, dry heat, and use of chemical vapors. The most effective method of sterilization is by heat. Steam at 121 degrees Centigrade (C) under pressure in an autoclave is the most convenient method of rapidly achieving sterility. Dry heat at 160 to 170 degrees C for two to four hours is suitable for destruction of viable agents on impermeable nonorganic material.

Sterilization can also be achieved with formaldehyde and ethylene oxide vapors when employed in closed systems and under controlled conditions of temperature and humidity. Vapor and gas disinfectants are useful in sterilizing:

- 1) biological safety cabinets and their effluent air-handling systems and air filters,
- 2) bulky equipment that resists penetration by liquids,
- 3) instruments and optics that might be damaged by other sterilization methods, and
- 4) rooms and buildings.

Chemical liquid disinfectants at sufficient concentration may be used as sterilants for liquids. Generally, however, they are most practical as surface disinfectants. The degree of microbial inactivation may be altered by such factors as concentration of active ingredient, pH, duration of contact, temperature, humidity, and presence of organic matter.

Common disinfectants and their properties include:

1) Alcohol. Ethyl or isopropyl alcohol in a concentration of 70-85% by weight is often used. Alcohols denature proteins and are effective against lipid-containing viruses.

2) Formaldehyde. Formaldehyde in a concentration of 5% active ingredient is an effective liquid disinfectant. Its pungent, irritating odor requires that care be taken when using formaldehyde solutions in the laboratory.

3) Phenol. Phenolic compounds are found in many common disinfectants. Phenolics are effective against some viruses, rickettsiae, fungi, and vegetative bacteria, although ineffective against bacterial spores.

4) Quaternary ammonium compounds. These cationic detergents are effective surface cleaners, although are ineffective in the presence of proteins. In medium concentrations, they are bacteriocidal, fungicidal, and virucidal against lipophilic viruses.

5) Chlorine. Free, available chlorine is the active element in this halogen disinfectant. It is a strong oxidizing agent that is active against all microorganisms. However, chlorine can be corrosive to metallic equipment or surfaces.

6) Iodine. The characteristics of chlorine and iodine are similar. Use dilutions (25-75 ppm) of the commonly used iodophors are effective against microorganisms, but difficulties may arise if any protein is present. For use as a handwashing agent or as a sporicide, 1600 ppm of available iodine is recommended.

Recommendations for sterilization and decontamination of specific instruments, equipment, and patient care areas are found in Wenzel (1981) and Palmer (1984).

General Infectious Waste Management

In general, hospital or laboratory waste capable of producing injury or containing large numbers of infectious microorganisms should be handled in such a fashion that they will not cause any risk of disease during transport as well as at its final disposal site. Liquid waste (blood, feces, urine, other body fluids) may be flushed down the sewer. Solid wastes from rooms housing patients under isolation for communicable disease should be double-bagged at the point of generation and treated as "contaminated" or "infectious" waste according to hospital policy.

The North Carolina Solid and Hazardous Waste Management Branch has recently developed the first definitive rules (Statutory Authority G.S. 130A-294) relating to disposal of infectious waste in sanitary landfills. Types of waste designated as infectious are: microbiological waste, pathological waste, and blood products and sharps. Infectious waste that may pose a threat to the environment or public health is prohibited from disposal at a solid waste disposal site unless it has been treated and rendered non-infectious. The following are approved methods of treatment of infectious wastes prior to disposal in a sanitary landfill:

- microbiological waste - - steam sterilization or incineration;
- pathological waste - - incineration or steam sterilization followed by incineration;
- blood products - - incineration;
- sharps - - mutilation or incineration.

Hospital policy at Duke dictates that contaminated needles and sharp instruments should be placed immediately after use and without recapping into a rigid, puncture resistant container to prevent injury. These containers should be dealt with as "infectious" waste. At Duke, contaminated needle and sharp containers from patient areas are handled commercially (see Appendix C). The boxes are collected by the firm, emptied of contaminated instruments, needles rendered inoperable and contents autoclaved. The boxes undergo high level disinfection and are returned as

needed to patient areas. Although this system has only been in use for approximately six months, the number of needlesticks reported to Employee Health has already decreased since the previous year.

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BIOLOGICAL SAFETY CONFERENCE. Lexington, Ky.

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laboratory worker. JAMA 226 (10): 1219-1221.

APPENDIX A

Biosafety cabinets at Duke purchased from:

Baker Company
4003 Vista Dr.
Raleigh, N. C. 27612
(919) 779-6250

Certification of biosafety cabinets at Duke done by:

Bio Con
P.O. Box 52189
Raleigh, N. C. 27612
(919) 781-9777

Filtration Technology
5109 Hollyridge Rd.
Suite 203
Raleigh, N. C. 27612
(919) 787-3988

APPENDIX B

Educational materials may be obtained from the following sources:

Isolation Techniques - - CDC, Hospital Infections Program, Atlanta, Ga.

Hepatitis B - - Merck, Sharp, and Dohme, Rahway, N. J.

Herpes - - Burroughs-Wellcome, Research Triangle Park, N. C.

Biological Safety - - CDC, Atlanta, and National Institutes of Health, Division of Safety, Bethesda, Md.

Infections in general - - CDC Still Picture Collection, Atlanta, Ga., (404) 329-3631

APPENDIX C

Needle disposal contractor for Duke:

Stick Proof, Inc.
P.O. Box 40008
Raleigh, N. C. 27629
(919) 876-3521



RADIATION

Garris D. Parker, Jr.
Manager, Laboratory Compliance
Chemical Industry Institute of Toxicology
Research Triangle Park, North Carolina 27709

Daniel D. Sprau
Radiation Safety Officer
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East Carolina University
Greenville, North Carolina 27834

ABSTRACT

Radiation in various forms is regularly used in a biomedical environment. Low energy beta emitters such as tritium and carbon-14 are often employed in tracer techniques. Gamma emitting radioisotopes are used in both diagnostic (Tc-99m) and treatment (Co-60, I-131). Both diagnostic radiology and orthovoltage treatment are based on emission of x-rays.

Included in this chapter will be a discussion of the origin and use of different types of radiation, pertinent regulations and standards, protection, and disposal.

TYPES OF RADIATION AND THEIR ORIGINS

Even though there are several different types of radiation, they can be classified into two physical forms: those that may be characterized as small particles and those that are composed of waves, such as light. The term nuclear radiation offers an idea as to where the radiation originates- the nucleus of an atom.

When a nucleus of an atom, or for that matter, the entire atom, acquires more energy than normal, it is in an "excited" state. In order to return to normal or "resting" state, the atom or nucleus must release this excess energy. It does so by emitting radiation. Even though the release is purely spontaneous, the probability of its occurring can be predicted. The type of radiation emitted will depend upon several factors, including the size of the atom, the final product or "daughter" atom, and the amount of excess energy that the nucleus has acquired.

Equations describing radioactive decay follow the same basic format:



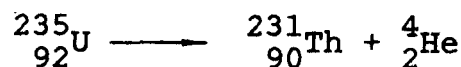
where A = atomic weight of element X
 Z = atomic number of element X
 A' = atomic weight of element Y
 Z' = atomic number of element Y
 R = radiation

Our study of radiation will be limited to the emissions that are most commonly used in a biomedical environment: alpha (α), beta (β), gamma (γ) and x-ray.

Particulate Emission

As in all equations, whether they be physical or mathematical, one side must equal the other. So it is with radioactive disintegration. Conservation of charge and mass, two basic laws in physics, state that the summation of atomic weights (A) on the left hand side of the arrow must equal the total atomic weights (A') on the right side. Likewise, the summations of the atomic numbers on opposite sides of the arrow must equal.

For example, an alpha particle (α) is characterized by a helium (He) nucleus, He. Uranium-235 decay by alpha emission can be written as:



Notice that the summation of the atomic weights on each side of the arrow is equal, 235 and 231+4. The same is true for the atomic numbers, 92 and 90+2.

The alpha particle, like other nuclear radiations, originates in the nucleus of an atom. It is a fairly large particle and, therefore, usually requires a large "parent" atom (the atom with which the decay begins). The range (distance that the radiation will travel) of an alpha particle is typically short. Due to its short range, detection of alphas require special instrumentation.

Beta (β) particles are symbolized by an electron, e . Beta decay of C-14, a radioisotope commonly used in biomedical research, can be symbolized as:



As with other nuclear radiations, betas originate from the nucleus of an atom. These particles are small when compared to alphas and, therefore, can be emitted from different sizes of parent atoms.

The energy of beta emission varies from approximately zero KeV (kiloelectron-volts) to the maximum energy for a particular decay, E_{MAX} . This type of energy spectrum is known as "continuous." E_{MAX} for several beta emitters used in a medical environment are:

<u>Particle</u>	<u>E-MAX</u>
H-3	18 KeV
C-14	158 KeV
S-35	167 KeV
P-32	1790 KeV
Sr-90	544 KeV
Y-90	2215 KeV
Mo-99	1215 KeV

Beta ranges vary from a few millimeters of air to several centimeters in air. Therefore, most have very good detectability.

All organic compounds incorporate specific numbers of hydrogen (H) and carbon (C) atoms. To assist the scientist in studying these compounds, H-13 or C-14, both β -emitters, can be substituted for a nonradioactive H or C. This substitution makes the compound radioactive, a process known as labeling. The compound can then be introduced into a cell culture or intact organism via injection, inhalation, gavage, painting, etc., and traced with appropriate radiation detectors. Tracing is one of the more prevalent applications of radioisotopes in the biomedical laboratory.

Photon Emission

Photons are discrete bundles of energy emitted as wave forms, somewhat like the light from a household bulb. Gamma (γ) rays are photons that are emitted from the nucleus of an atom. As with other nuclear radiations, it is a result of a decrease in energy of an "excited" atom to its normal resting state.

Gamma emission is characterized by the following equation:



Notice that ${}_{43}^{99m}\text{Tc}$ has A and Z numbers equal to zero. This results from the fact that photons have no mass and no charge. The small "m" in "99m" is an abbreviation for metastable, meaning that the atom is in an excited state.

In contrast with the continuous energies of beta emission, radiation is emitted at characteristic energies. This energy spectrum is analogous to a person's fingerprint in that it can be used to identify a particular radioisotope.

Gammas, like betas, find prevalent use in medical/research facilities as labeled chemicals (tracers) and as the basis for various treatment techniques. Due to the lack of charge and mass, their range and penetrating ability exceed those of the previously discussed emissions.

X-rays are photons that are emitted not from the nucleus, but from the electron cloud of the atom. Electrons are constantly "orbiting" an atom at specific energy levels. When one of these electrons is knocked from an inner orbit, another will try to fall into the vacancy. When this happens, a photon is emitted with an energy equal to the difference between the two energy levels.

X-rays are used as diagnostic tools via the x-ray machine. The x-rays penetrate the patient and are attenuated to varying degrees by the soft tissue and bone. This variance of the x-ray intensity leads to the different tones of gray on the developed film. Unlike the radiations discussed previously that are emitted continuously, x-rays are only produced when the machine is in operation.

RADIATION TERMS AND DEFINITIONS

The Roentgen (R) is the term describing exposure to photon emission and is physically equal to a specific electrical charge distributed in a unit volume of air, 1 esu/cm at standard temperature and pressure (STP). The amount of radiation energy that is actually absorbed in a unit mass of tissue is measured in terms of rads, 100 ergs/gram.

The dose equivalent, expressed in rem, can easily be calculated by factoring in the relative biological effectiveness of the type of radiation. This conversion unit, commonly known as the quality factor (QF), is a measure of the amount of radiation that is deposited along a unit length of the radiation's track. For most purposes, assumed values are: 1 for X-rays, gammas and medium to high betas and 20 for alpha particles (World Health Organization, 1983).

Radioactive isotopes are commonly used in biomedical research. The basic unit of radioactivity is the Curie (Ci), defined as 3.7×10^{10} disintegrations per second. This is a constant value and is, therefore, independent of the radionuclide. Half-life is defined as the time that is required for the activity of a particular radioisotope to decay to half of its initial value. Even though all radioisotopes decay as an exponential function, each does so at its own rate. The recently adopted international set of units are:

1 Becquerel (Bq)	=	1 disintegration per second
1 Gray (Gy)	=	100 rads
1 Sievert (Sv)	=	100 rem

RADIATION RISKS-HAZARDS

General

There has been a very large research effort over the last thirty years to determine the effects of radiation on humans. Probably more research has been done on the effects of radiation than on any other toxic or hazardous agent. All types of radiation--gamma, x-ray, beta and alpha--have been studied for both their internal and external hazards. Many groups of people with known exposures such as bomb survivors, radiation workers, and patients undergoing diagnostic x-ray exams and radiation therapy have been followed and their health status reviewed. From this we have a large amount of data covering radiation dose to humans. Unfortunately the effects and risks of very low doses are still very difficult to predict. It appears that no matter how small the dose of radiation there is always some small risk to human health.

Why then, if there is always some risk from being exposed to radiation sources should they be used in the biomedical environment? Certainly the only answer to this question is that the benefits obtained from using radiation sources outweigh the risks. Benefits such as an excellent diagnostic and treatment means for patients and medical personnel, and an excellent research tool for the scientific investigator. The use of radiation sources even provides employment for many biomedical workers. These benefits coupled with the fact that most doses to workers in the medical environment are very small make the use of radiation sources possible. Also, there are other physical, chemical, and biological hazards in the workplace that are accepted by workers and are much more hazardous when compared with the small radiation risks.

Even though the risks may be small, the goal of any radiation protection program is to keep doses as low as reasonably achievable and as close to background levels as possible. It is impossible to eliminate all exposure to radiation and there will always be a small dose to everyone from background sources. Approximate background radiation doses to the general population in the United States per year are as follows:

Source of Exposure	Approximate Exposure (mrem/year)
Cosmic Radiation	38-75
External Terrestrial	15-140
Radionuclides in Body	15-20
Medical and Dental Radiation	Approx 90
Fallout	5-8
Nuclear Energy	Approx 0.3
Consumer Products	Approx 0.03
Total	160-330
	(U of M, 1984)

Biological

Since radiation is a form of energy, a radiation dose comes from energy being deposited in our living cells. The chemical reactions and molecular changes that are caused by the addition of this energy in turn effect our bodies. Several factors determine how great this effect will be. Things such as the dose, dose rate, type of radiation, exposure to other hazardous material and our health and age all contribute to determine the effect. Some of these effects will not be seen until much later--possibly 20 to 30 years later. Effects that have generally been associated with high radiation exposure are cancer (leukemia), birth defects, cataracts, and shortening of life span.

Usually the higher the dose and dose rate the quicker results appear and the more noticeable the effect. Therefore, for those working in biomedical institutions, all doses should be kept as low as possible and it would be better to receive any exposure gradually over a long period of time rather than all at once. Fortunately, in biomedical institutions the doses are usually so small that it is not possible to notice any effect or the effects are masked by exposure to other hazardous materials.

The following table compares health risks and estimates of loss of life expectancy from occupational radiation dose and other hazards.

Estimated Loss of Life Expectancy from Health Risks

Health Risk	Estimates of Days of Life Expectancy Lost, Average
Smoking 20 cigarettes/day	2370 (6.5 years)
Overweight (by 20%)	985 (2.7 years)
All accidents combined	435 (1.2 years)
Auto accidents	200
Alcohol consumption (U.S. average)	130
Home accidents	95
Drowning	41
Natural background radiation, calculated	8
Medical diagnostic x-rays (U.S. average), calculated	6
All catastrophes (earthquake, etc.)	3.5
1 rem occupational radiation dose, calculated	1
1 rem/yr for 30 years, calculated	30

(U of M, 1984)

Biological effects of radiation can be classified into the following three categories.

- 1) Somatic Effects: Effects occurring in the exposed person that, in turn, may be divided into two classes:

Prompt effects that are observable soon after a large or acute dose (e.g., 100 rems or more to the whole body in a few hours), and

Delayed effects such as cancer that may occur years after exposure to radiation.

- 2) Genetic Effects: Abnormalities that may occur in the future children of exposed individuals and in subsequent generations.

- 3) Teratogenic Effects: Effects that may be observed in children who were exposed during the fetal and embryonic stages of development.

(U.S. NRC, 1981)

Somatic effects when they are from an acute dose-- a dose that is received all at one time--can be summarized as follows:

A Summary of Acute Dose-Response Effects in Humans

Dose (mrem)	Effect
10,000,000	Immediate prostration, coma, followed by death within 1 or 2 days from severe central nervous system damage.
1,000,000	Immediate nausea, vomiting, diarrhea. Death within 1 or 2 weeks from blistering of small intestine. Complications from depressed bone marrow activity.
100,000	No overt effects. Some depression of white cell count. Statistical increase in probability of radiogenic leukemia and life shortening (1 to 5 days/rem).
10,000	Effects are difficult to measure. In early embryo development defects are possible. Subtle abnormalities of brain structure and perhaps also function may occur above 10 rem.
1,000	No measurable effects except a statistical increase of tumor incidence before age of 10 in infants exposed in utero.

(Jacobson, 1980)

For total doses that are not acute and received over longer periods of time, the effects would be much less because of the bodies capacity for biological repair.

There are maximum legal dose limits for workers and visitors at biomedical institutions. All work must be conducted in the biomedical environment so that no member of the general public could receive a dose in excess of 500 millirem in one year. Also, work must be conducted so that the dose received by any radiation worker does not exceed 1,250 millirem in a calendar quarter to the whole body or 5,000 millirem in 1 year to the whole body. In addition there are higher limits set for non-blood forming organs such as the extremities and skin. Usually only 1% of the radiation workers in a biomedical environment receive more than 500 mRem/yr and over 60% of them receive no exposure at all. (U of M, 1984)

Internal exposures are limited by controlling the concentration of radioactive material in the air and water that is taken into the body. These Maximum Permissible Concentrations (MPC) are specified in state and federal regulations and are for continuous exposures during a 40 hour week. These limits are set so that if a worker is exposed to one of these maximum permissible concentrations during the whole year the worker will, under worst conditions receive a radiation dose equal to the Maximum Permissible Dose (MPD). If a worker is already receiving 5,000 rems per year from external exposure, then he should not be subjected to any internal exposure.

Some idea of the potential hazard of various radionuclides may be gained by knowing the Maximum Permissible Body Burden (MPBB) for the material. The MPBB along with the Critical Organ and Biological Half-life are listed by the National Council On Radiation Protection (NCRP). The Critical Organ may be the liver, spleen, thyroid, the total body, etc., and is simply that part of the body most likely to be damaged by the radiation from a given radionuclide. The Biological Half-life is a measure of how rapidly the material is excreted from the body. (NCRP, 1963)

The MPBB, MPC, and MPD are all directly related. The MPBB of a given radionuclide is that amount of the radionuclide which, if placed in the Critical Organ for a year, produces the Maximum Permissible Dose (MPD) to that organ. Exposure to the radionuclide at the Maximum Permissible Concentration (MPC) in air or water will cause one MPBB to be placed in the Critical Organ and then produce a MPD to that organ.

The International Commission on Radiation Protection (ICRP) has also published information on Annual Limits on Intake (ALI) and Derived Air Concentration (DAC). These may gradually replace the MPBB and the MPC since the ALI is more specific in that it gives limits on intake by ingestion or inhalation and several chemical forms for radionuclides. (ICRP, 1978)

Once ingested, radionuclides are incorporated into the body and there is generally no way they may be removed except by the normal body elimination and radioactive decay. The best protection then, is to prevent the material from entering the body.

Radiation Exposure During Pregnancy and to Children

Cells are more sensitive to radiation damage when they are dividing rapidly and when they are not very specialized in their function. Because of this, children are more sensitive to radiation than adults, and the unborn are more sensitive than children.

Sensitivity of the individual has always been a factor in the development of radiation exposure standards. Since the risks of harmful effects from radiation may be greater for young people, the Nuclear Regulatory Commission (NRC) places different limits on minors than on adult workers. Specifically, it limits anyone under 18 years of age to exposures to one-tenth of the limits for adult workers. This lower limit also applies to members of the general public. The biomedical institution must be conscious of the lower limits since there may be student and volunteer workers and members of the general public in the area of radiation sources.

When a woman is pregnant and exposed to either external or internal radiation sources, this could also involve exposure of her unborn baby. A number of scientific studies have shown that the unborn is more sensitive to radiation than the adult, particularly during the first 3 months after conception. During a large part of this critical period of pregnancy, a woman may not be aware that she is pregnant. Because of these factors, the National Council on Radiation Protection and Measurements (NCRP) and the International Commission on Radiological Protection (ICRP) recommend that special precautions be taken to limit exposure when an occupationally exposed woman could be pregnant. Both the NCRP and the ICRP have recommended that, during the entire pregnancy, the maximum permissible dose equivalent to the unborn from occupational radiation exposure of the expectant mother should not exceed 0.5 rem. (ICRP, 1977) (NCRP, 1977)

It is a women radiation worker's responsibility to decide whether the risks to her or to an unborn child are acceptable. The NRC recommends that she consider the following facts to help her make her decision:

1. The first 3 months of pregnancy are the most important, so she should make her decision early.
2. In most work situations, the actual dose received by an unborn child would be less than the mothers because her body would provide shielding for the fetus.
3. The dose to the unborn child can be reduced, where possible, (A) by decreasing the amount of time she spends in an area where she will be exposed to radiation, (B) by increasing the distance between her and the source of radiation, and (C) by shielding her abdominal area.

4. If she does become pregnant, she could ask her employer to reassign her to areas involving less exposure to radiation.
5. When her occupational exposure is below the 5 rems-per-year limit, the risk to an unborn child may be small in relation to other day-to-day risks to the unborn during pregnancy. Experts disagree on the exact amount.
6. There is no need to be concerned about sterility, i.e., loss of her ability to bear children. The radiation dose required to produce this effect is more than 100 times greater than the NRC's basic dose limits for adults of 5 rems/year or 1.25 rems/calendar quarter.
7. Even if she works in an area where she received only 0.5 rem per 3-month period, in 9 months she could receive 1.5 rems, and her unborn baby could receive more than 0.5 rem full-term limit recommended by the NCRP. Therefore, if she decided to restrict her unborn baby's radiation exposure as recommended by the NCRP, be aware that the 0.5 rem limit to the unborn applies to the full 9-month pregnancy. (U.S. NRC, 1975)

It is up to the pregnant worker in the biomedical environment to compare the benefits of her employment against the possible risks involving occupational radiation exposure to a known or potential unborn child.

REGULATIONS, STANDARDS, AND AGENCIES

Federal

The federal government is heavily involved in the control of radiation sources by regulations and standards. Unfortunately this control does not come from a single agency or a coordinated group of agencies. This makes it difficult for biomedical institution to know and comply with existing regulations. All of the agencies that control radiation, have their headquarters in Washington, D.C. and can be contacted directly for assistance. Below is a list of those agencies, their primary regulations (Code of Federal Regulations), and their principle function in radiation protection.

<u>Agency</u>	<u>Function</u>
<u>Nuclear Regulatory Commission</u> - All radioactive material licensing (NRC) 10 CFR 20 and Nuclear Power Plant operation standards and control	
<u>Center for Devices and Radiological</u> - Standards on electronic <u>Health/Food and Drug Administration</u> products emitting radiation (CDRH) 21 CFR 1000-1050	
<u>Department of Transportation</u> - Regulations on transportation of all (DOT) 49 CFR 171-179 hazardous materials including radio- active material	
<u>Environmental Protection Agency</u> - Standards on exposure limits and (EPA) 40 CFR releases of radioactive material to air, land, water	
<u>Occupational Safety and Health</u> - Standards on the exposure <u>Administration</u> of workers to radiation sources (OSHA) 29 CFR 1910	

State

In many instances state agencies parallel federal regulations and in some instances take over the role of federal agencies within their respective states. An example of this would be agreement state status under the Nuclear Regulatory Commission system. In North Carolina the State of North Carolina "agrees" to take over the regulatory role of the NRC (except in the case of Nuclear Power Plants) within the borders of the state. The principle agency and regulations involved in controlling radiation in North Carolina are:

North Carolina Radiation
Protection Section
Division of Facility Services
Department of Human Resources
Box 12200
Raleigh, NC 27605
(919)733-4283

North Carolina Regulations for
Protection Against Radiation Title
10, Chapter 3, Subchapter 3G
Radiation

The State of North Carolina Radiation Protection Section issues licenses for radioactive material, registrations for radiation producing machines and standards for the control of radiation. In addition state agencies controlling hazardous waste, air pollution, and occupational exposures (Department of Labor) are also involved in radiological health. The Radiation Protection Section also maintains a list of qualified experts that are registered with that state and available to biomedical institutions for radiation protection consultant services. (RPS, 1985)

Local

Almost no added regulations or restrictions are placed on working with radiation by local agencies and health departments. Most local health departments are ill-equipped to regulate radiation sources. However, some local governments have begun attempts to restrict shipments of hazardous material including radioactive material through their locality. Eventually jurisdiction will have to be settled between Federal, State, and Local regulations.

Voluntary Standards and Organization

There are a number of major organizations which publish voluntary reports, standards, and information concerning radiation protection. Some of them are:

NCRP - National Council on Radiation Protection

ANSI - American National Standards Institute

ICRP - International Commission on Radiation Protection

ICRU - International Commission on Radiation Units and Measurements

IAEA -International Atomic Energy Agency

In addition, the Health Physics Society is the primary professional organization concerned with radiation protection in the biomedical environment. The primary objective of the Society is the development of scientific knowledge and practical means for the protection of man and his environment from harmful effects of radiation. The Society publishes a journal, sponsors scientific meetings, and establishes local chapters. The national organization and local N.C. Chapter can be contacted for further information at the following addresses:

Health Physics Society
1340 Old Chain Bridge Road
Suite 300
McLean, Virginia 22101
(703) 790-1745

North Carolina Chapter
Health Physics Society
Box 13183
Research Triangle Park, NC 27709

PROTECTION AND DETECTION

Administrative Controls

Whenever a radiation source is being used in the biomedical environment, the administrative responsibility for that source is clearly defined by a Radioactive Material License or a Registration for a radiation producing device. This responsibility ultimately ends with the top management of the institution or with an individual licensed user. Most often in any large biomedical environment there is a radiation safety officer and radiation safety committee reporting to the administration that authorizes the use of radiation sources. In North Carolina the institutional responsibility is recorded by license and registration with the State Radiation Protection Section.

Training in any biomedical institution is very important when radiation sources are concerned. Personnel must receive the proper instruction before working with or around radiation sources. Even workers who are not working directly with radiation sources must learn how to protect themselves and know where sources are located. Radiation workers are required to have training in radiation fundamentals, measurement and control of exposure to radiation, the radiation protection program, biological effects of radiation, and preparations for emergencies. In a good radiation protection program the training is an ongoing process since it is easy to forget about the hazards of radiation because we have no physical senses for it. Those individuals in the biomedical setting who are not classified as radiation workers must also be trained about the meaning of warning signs and the hazards of restricted areas.

The security of radiation sources can be a problem. Sources such as x-ray equipment or radioactive material must be kept secure and away from improper use. No radiation source should be left in such a position that it can be used by an unauthorized or untrained person either knowingly or unknowingly.

Records are the first item that will be reviewed by any agency inspecting the biomedical institution's radioactive material license or registration of x-ray equipment. Adequate records must be maintained on personnel monitoring, radioactive material inventory, radiological health surveys (both radiation producing equipment and radioactive material), instrument calibration, and radioactive waste disposal. Some of these records such as personnel monitoring and waste disposal records must be kept indefinitely. In addition, radiation workers must have access to their own occupational exposure records.

General Protection

The body may be irradiated in two general ways: 1. Externally from radioactive material or radiation producing machines, 2. Internally from radioactive material inside the body:

1. External exposure can come from electronic equipment, gamma emitters, and high energy beta emitters. Low energy beta emitters and alpha emitters whose maximum range is small, are slight external hazards but may be a serious internal hazard. The degree of external exposure hazard depends on the following factors:
 - Amount - The external exposure hazard can depend on the amount of radioactive material that is being used. In order to reduce this exposure the smallest amount of activity needed to perform an experiment or procedure should be used.
 - Time - The total dose received from a radiation source will depend on the total time spent near the source. Therefore, the time spent near a source should be as short as possible and used as effectively as feasible.
 - Distance - A good way to reduce the exposure to external radiation is to use distance. Much of the time distance alone is enough to reduce the exposure rate from beta emitters to a background levels. X and gamma radiation are many times found as point sources and the radiation from such a point source will obey what is called the inverse square law. This law means that if the distance to a point source is doubled, the exposure rate is reduced by a factor of four.
 - Shielding - Shielding or absorbing material around the radiation source is needed when significant levels of gamma emitters and high energy beta emitters are used. The shielding material and thickness depends on the amount and type of radiation.
2. Internal exposure can come from any radioactive material, including the low energy beta and alpha emitters. These materials can be ingested in the body by:
 - Breathing radioactive vapor or dust.
 - Consuming radioactive material in food, water, from contaminated hands, or from smoking.
 - Entering through a wound.
 - Absorption through the skin.

The fundamental objectives of radiation protection measures are:

- To limit exposure to external radiation to as low a level as feasible and always within the set exposure limits.
- To limit entry of radionuclides into the human body by ingestion, inhalation, absorption, or through open wounds when unconfined radioactive material is handled, and always within the set limits.

An important secondary objective is to obtain reliable results from experiments and medical procedures. To accomplish these objectives, positive planning and following of procedures beyond the usual care taken in work with other materials is required. It is necessary to (1) analyze in advance the hazards of each job, (2) provide safeguards against foreseeable accidents, and (3) use protective devices and planned emergency procedures in accidents that do happen.

Guidelines for Using Radioactive Material

- Before starting any work with radioactive material, a full understanding should be reached between all laboratory and clinical personnel as to the work to be done and the safety precautions to be taken.
- The procedure for each project should be well outlined in writing for all laboratory personnel. Necessary equipment, waste containers, and survey instruments must be present.
- Characteristics of the radioactive material such as type of radiation, significant and typical amounts, ALI, MPBB, MPC, and chemical form should be known.
- In some cases, before the procedure is actually performed with radioactive material it should be given a "dry-run" so as to avoid any problems.
- Visitors and students to a laboratory or clinic that uses radioactive material should be supervised by a radiation worker.
- Radioactive material must not be left unattended in places where unauthorized persons may handle or remove it, particularly without realizing that it is radioactive.
- As a general practice, work with radioactive material should be confined to only the area necessary. This simplifies the problem of confinement and shielding, and aids in limiting the affected area in case of an accident.
- All work surfaces and storage areas (table top, hood, floor, etc.) should be properly covered. Some facilities, especially in older buildings are very difficult to decontaminate.

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- Absorbent mats or paper should be used. Protective absorbent, having a plastic back and absorbent paper front, is especially useful. If contaminated, it may simply be discarded in the radioactive waste container.
 - Plastic or metal trays (stainless steel washes easily) should be placed on the surface when liquids are to be used. The lip of the tray serves to confine a spill.
 - Experiments or medical procedures which might produce airborne contamination (volatile isotopes, dust, or gases) must be conducted in a hood, dry box, or other suitable closed system.
 - Practice good housekeeping. If an area is kept neat, clean and free from equipment and materials not required for the immediate procedure, the likelihood of accidental contamination or exposure is reduced.
 - Shipments of radioactive material must be opened and checked for contamination in a properly equipped laboratory.
 - Whenever feasible, radioactive material and particularly liquids should be kept in unbreakable containers or if glass is used a secondary container provided.
 - NEVER PIPETTE RADIOACTIVE SOLUTIONS BY MOUTH. Always use some type of pipette filling device.
 - Eating, drinking, or storing of food (refrigerators) is not allowed in laboratories or areas where work with unsealed radioactive sources is taking place or where contamination may exist.
 - Smoking is not permitted in areas where work with unsealed radioactive sources is in progress or where contamination may exist. Under no circumstances should cigarettes, cigars, or pipes be laid on tables or benches where radioactive work has been or is in progress.
 - Personnel working in areas containing radioactive material must wash their hands thoroughly before eating, smoking, or leaving work.
 - Gloves must be worn whenever hand contamination is likely and whenever unsealed sources are being used. Do not use the telephone, counting equipment, handle books, open cabinets or drawers, etc., with contaminated gloves. If there is a break in the skin on the hand, be sure to wear protective gloves.
 - Laboratory coats should be worn by all individuals handling radioactive material.
 - All reusable glassware and tools used with radioactive material should be thoroughly cleaned after use and kept separate from non-contaminated items. It is recommended that a marked storage cabinet or other marked container or area be provided for glassware and tools used in radioactive work.

Guidelines for Using Radiation Producing Machines

- In advance of working with any radiation producing machine adequately trained personnel should know exactly what work is to be done and the safety precautions to be taken.
- Written operating and safety procedures should be available to personnel before operating the machines.
- Visitors and students in areas where radiation producing machines are used should be supervised by the equipment operator.
- Radiation producing machines should not be left unattended in an operational mode.
- Structural shielding requirements for any new installation, or an existing one in which changes are to be made, should be reviewed by a qualified expert before the machine is used.
- If the safe use of the radiation producing machine depends on the mechanical set up of the unit or on technique factors, then these restrictions should be rigidly followed.
- Shutter mechanisms and interlocks should not be tampered with or defeated under any circumstances.
- All warning lights should be "fail safe".
- A manually reset cumulative timing device should be used which will either indicate elapsed time or turn off the machine when the total exposure reaches a certain previously determined limit.
- X-ray diffraction equipment can be particularly hazardous because of high exposure rates in the primary beam (e.g. in excess of 500,000 roentgens per minute at the x-ray tube part). (NIH, 1972)
- For larger irradiators and accelerators that may be separately licensed, detailed operating and emergency procedures should be posted and followed.
- All radiation producing equipment should be properly maintained. Attempts to "fix" equipment should only be made by properly trained technical staff.

Monitoring

Personnel

Any person working in or regularly entering areas where radiation producing machines or certain types of radioactive material are used should have some type of personnel monitoring. Personnel monitoring is required if

workers are likely to receive twenty-five percent of their maximum allowable dose. Since most biomedical workers receive no exposure at all only a small number of monitors are actually required at most institutions. However, the usual practice is to be extremely liberal in giving out personnel dosimeters. This is accomplished by giving badges to anyone who could possibly have any exposure and also to any one who wants one. This policy costs more but saves the institution from having to justify why workers are not monitored and also provides a record should any question of liability result.

In the biomedical environment, film badges or TLD (Thermoluminescent Dosimeters) badges are usually the type of monitors chosen to record whole body external exposure. These monitors are worn on the pocket or lapel of laboratory coats and are suitable dosimeters for x-rays, gamma-rays, and high energy beta particles. Alpha particles and low energy beta emission will not penetrate the film or TLD packet so the monitoring of radioactive material such as H-3 and C-14 with these types of devices is of no value.

Film and TLD badges are available through commercial suppliers. The names of the suppliers can be obtained through the N.C. Radiation Protection Section. Whole body monitors are usually supplied on a monthly or quarterly basis. Records of exposures must be kept indefinite and provided to workers on request. It should be remembered that these monitors record exposures "after the fact". They do nothing to shield workers from radiation and are to be used only to monitor total exposure and to prevent future exposures.

In diagnostic x-ray procedures where lead aprons are used it is a good idea to have one monitor under the apron and another above the apron on the collar. When handling significant amounts of certain radioactive material with the hands or when the hands will be placed in an x-ray field a ring TLD should be used. This is especially true for handling material such as P-32 which is high energy beta emitter. TLD rings should be worn under gloves and with the TLD in the ring facing inward on the palm side of the finger.

Pocket dosimeters of the self-reading type can be purchased and used with regular monitoring when immediate dose assessment is desired. This is rarely ever done in the biomedical environment and is hardly ever necessary except in working with sealed sources used in radiation therapy.

Internally ingested radioactive material can be monitored by bioassay techniques. Low energy beta emitters such as H-3, C-14, and S-35 when ingested are excreted gradually and almost exclusively in the urine. Because of this, collecting urine samples and counting a small amount in a liquid scintillation counter provides an effective monitoring method. This method can also be used for several other nuclides including P-32 and Ca-45. Urinalysis is required for workers handling 100mCi or more of unsealed tritiated water (H-3) or 25mCi or more of organically bound tritium. Bioassay is usually done within ten days after the radionuclide is handled.

Thyroid monitoring for the ingestion of radioactive iodine is another bioassay technique. Approximately twenty-five percent of ingested iodine

concentrates in the thyroid gland. If this iodine is radioactive it can cause a significant exposure. Workers handling as small as one mCi of I-125 or I-131 may be required to have routine thyroid monitoring monthly. Monitoring is accomplished by holding a sensitive detector to the thyroid gland (neck). This monitoring procedure should be carried out by a qualified expert using properly calibrated equipment.

Radioactive Material

Several methods for monitoring contamination are available which meet technical and legal requirements. The two main methods are either meter readings with a survey instrument, or liquid scintillation counting of filter papers which have been rubbed over suspected areas of contamination. The choice of either method is determined by the type of radiation emitted from the material being used and the sensitivity required. It should be remembered that there is no single survey meter that is adequate to monitor all types of radiation. Meters should be available when radioactive material is being used and should be matched to that material.

The survey meter is adequate for detecting higher energy radiations, such as either beta particles or gamma rays. Except in the case of tritium and certain low levels of other nuclides, laboratories using unsealed sources are required to have on hand and in operating condition sensitive survey instruments capable of detecting the presence of the radionuclide in use. A number of radionuclides that may be adequately monitored by use of a thin windowed Geiger-Muller (G-M) survey meter include:

P-32, I-131, Co-57, mTc-99, Cs-137, Sr-90, Cr-51, Na-22, I-125

Sometimes, however, even though the G-M survey meter may detect larger quantities of radioactive material, the method is not sensitive enough to detect smaller amounts of the material which may be encountered as unwanted contamination. For example, large amounts of C-14 may be detected by a thin window survey meter, but when the amount of activity is spread over a large area or there is a small quantity of the material in one spot, the survey meter will not detect the activity.

Radionuclides which may be detected by a survey meter, but which are more adequately measured in a liquid scintillation unit in order to obtain adequate sensitivity are:

C-14, S-35, Ca-45

Finally, there are some radionuclides which may only be detected by liquid scintillation counting methods:

H-3, Ni-63

In those cases where radiation may not be detected or adequately measured with a survey meter, or where it is necessary to evaluate the removability of contamination, the "Smear" counting technique is recommended. The smear technique basically consists of taking a piece of ordinary filter paper and rubbing it over areas of possible contamination and counting the paper in a liquid scintillation unit. Although a variety of counting methods, "cocktails", and liquid scintillation units may be used

the system must be able to detect whether or not radioactive material might be present in the area being surveyed.

Surveys of areas where radioactive material is used or stored should be conducted at least monthly by laboratory personnel and also upon completion and cleanup of each experiment or medical procedure. Results of these surveys must be maintained in an accurate and reliable form and be available for review.

In general, when a survey is conducted with a survey meter, any radiation in excess of background may be considered contamination. Background radiation is determined by reading the meter in a nonradiation area. However, readings in excess of normal background may also be the result of an external radiation source present in the room and would therefore represent no contamination hazard.

When radiation surveys are conducted by liquid scintillation counting of smear samples, results are generally considered indicative of contamination whenever the sample is greater than 3 times background. Background radiation is determined by counting a clean unused filter paper in the liquid scintillation unit under identical conditions as the smear samples and for all isotopes expected to be present within the area.

Radiation Producing Machines

All radiation producing machines should be monitored yearly and preferably every six months to see if they meet performance standards. Surveys should also be performed whenever major servicing is done on the unit or the equipment is moved.

Since x-ray equipment and other radiation producing machines can be very complicated devices only a qualified expert should perform any monitoring surveys. A shielding survey of each diagnostic x-ray room must be performed at the initial installation. Results of all surveys of servicing should be kept in a log book for each machine.

Monitoring of radiation producing machines can involve determining many things such as timer accuracy, reproducibility and linearity, exposure rate in the primary beam, scatter leakage, half value layer, shutter mechanisms, interlocks, KVp and mA settings, and light field alignment and warning lights. All of these tests would be part of a complete radiation producing machine survey. To perform this type of monitoring requires the use of properly calibrated test equipment by a qualified expert.

Signs and Labeling

State regulations require the posting of a "Notice To Employee" in all biomedical institutions using radiation sources. This notice which is available from the N.C. Radiation Protection Section serves to inform employees of their rights and responsibilities as a person working with radiation.

All areas where radiation sources are used and all radioactive material containers must have the proper signs, labels, and tags. All signs and labels must use the conventional radiation caution colors, of magenta or purple on a yellow background. The radiation symbol, the conventional three-bladed design, must also be present along with the appropriate wording. The required wording for signs and labels are listed below:

CAUTION RADIATION AREAS

A "radiation area" is defined as any area accessible to personnel in which there exists radiation at such levels that a major portion of the body or critical organ could receive in any one hour a dose in excess of 5 mrem.

CAUTION HIGH RADIATION AREA

A "high radiation area" means any area accessible to personnel in which there exists radiation at such levels that a major portion of the body or critical organ could receive in any one hour a dose in excess of 100 mrem.

CAUTION AIRBORNE RADIOACTIVITY AREA

An "airborne radioactivity area" as defined in any room, enclosure, or operating area in which airborne radioactive material exists in concentrations in excess of the amount specified in state and federal regulations.

CAUTION RADIOACTIVE MATERIAL

- Each area or room in which radioactive material is used or stored and which contains significant quantities of radioactive material should be posted with this sign.
- Each container which is transported, stored, used, or contaminated with radioactive material must have a durable and clearly visible label.

- Laboratory containers such as beakers, flasks and test tubes, used transiently in laboratory procedures, do not require labels when the user is present. If they are left unattended for long periods of time they should be labeled.
- Where containers are used for storage, the labels should state the quantities and kinds of radioactive materials in the containers and the date.
- All radioactive waste must be clearly labeled with the material, amount, and date.

CAUTION X-RAYS

Areas in which x-ray producing machines are located or are being used must be posted with the characteristic "Caution Radiation" or "Caution X-rays" sign to warn all personnel entering the radiation area. In addition, the equipment controls must have a sign stating "Caution Radiation--This equipment produces radiation when energized."

Radiation Incidents and Emergencies

Occasionally accidents or incidents involving radiation sources do occur in the biomedical environment. The important thing to remember in these situations is not to panic. Nearly all radiation emergencies can be handled without harm to anyone.

It is important to remember that most radiation emergencies result from or are associated with other factors such as fire explosion or broken glassware. These may result in contamination problems or physically injured persons. Because of this and in all emergencies in the biomedical environment injured personnel must be assisted with medical attention first without regard to delays because of radiation concerns.

Contamination in the laboratory is the most common form of incident when using radioactive material. Usually contamination levels are quite low but radioactive material can be spread quite rapidly. In the event of a spill of radioactive material the first priority is the care of contaminated personnel and then removal of any gross contamination. A high priority must be given to containing the spill and keeping it from spreading. This may involve turning off air handling systems and locking access doors. The following steps should be taken immediately to decontaminate personnel:

- Remove any clothing found to be contaminated before determining levels of skin contamination
- Specific spots of contamination should be located with a meter or a smear survey and should be cleaned first to prevent the spread of contamination
- Ordinary soap and lukewarm water will remove most of the contamination. Several washings may be needed but these

should be stopped before skin irritation or chapping occurs. Breaks in the skin should be covered.

- Do not use organic solvents

The following steps should be taken in decontamination of laboratory facilities:

- The general procedure is to confine the radioactive material as much as possible and prevent spread to other areas. The area should be marked and off limits to unnecessary personnel.
- Personnel preparation for decontamination should include putting on gloves, lab coat or surgical gown, and shoe covers, if the floor is contaminated.
- A survey instrument and/or counting equipment for smear surveys needs to be available. Without them contamination can not be located.
- First remove the gross contamination caused by the spill. Start at the edges of the contaminated area and work inward. If quantities of a gamma or high energy beta emitter have been spilled a quick pass with absorbent paper will significantly reduce hand exposure. Readings should be used to guide further procedures.
- After removing spilled liquids or other material, the next step is to scrub with soap and water.
- All waste material should be placed in a plastic bag or other container to prevent recontaminating the area. The waste must eventually be sealed in plastic bags for radioactive waste disposal.
- The laboratory personnel in the spill are responsible for the cleanup.
DO NOT CALL HOUSEKEEPING TO CLEANUP RADIOACTIVE SPILLS.

In the case of an accident or over exposure with a radiation producing machine, exposed persons should be given medical attention first. The power to the machine should also be turned completely off and secured. Personnel monitors should be evaluated, and a complete review of the incident should be done by a qualified expert. There is no danger of contamination.

All fires at a biomedical institution should be reported to the local fire department as soon as possible. Knowledgeable personnel should meet the firefighters and rescue workers at the scene and to tell them if radiation sources are involved. Normally with the small amounts of material used in laboratories, fires can be put out first without concern for radiation. Contamination can be controlled afterward. It is a good idea for all biomedical institutions to routinely review with their local department the general location of all radiation sources. This is especially true if multiple curie sources are used in irradiators.

All hospitals will have plans for handling radiation accident victims brought to the emergency room. Further information on handling these victims is available through other sources. (Ricks, 1984)

USES IN MEDICINE

General

With the ever increasing use of radiation sources at health care facilities, the potential for hazardous exposure to radiation also increases. In order to reduce these risks, management and administrative steps must be taken to limit any exposure of personnel and the general public to a level that is safe and reasonably achievable.

In health care facilities there are a wide range of workers that are classified as radiation workers and also workers that could potentially be exposed to radiation sources. All of these workers have varying degrees of knowledge and experience in handling radiation. Examples of workers that could get exposed as part of their jobs are as follows:

- Doctors
- Dentists
- Nurses, aides, orderlies
- X-ray technologists
- Nuclear medicine technologists
- Radiation therapy technologists
- Pathology laboratory technicians
- Shipping, receiving delivery personnel
- Secretaries and clerks
- Porters, messengers, and guards
- Janitors and maintenance men

These workers-although their backgrounds and training in radiation protection or wide ranging-have one thing in common. That one thing is that they have no physical senses (sight, feel, taste, smell) that will enable them to detect radiation. They must learn about the radiation sources they could come in contact with and how best to protect themselves and those around them. One of the most important items in radiation protection is to know the characteristics of the radiation source being used and the potential hazards of those sources.

Diagnostic Radiology

Radiographic

The largest use of radiation in the medical environment is in radiographic examinations. Since this type of diagnostic radiology procedure is such an effective tool in medicine and dentistry and so widely used, adequate controls to limit worker exposure must be provided.

Before any radiographic x-ray equipment is put into use or anytime a structure containing an x-ray room is changed, a complete radiation safety survey and evaluation should be performed by a qualified expert. These surveys should be conducted to make sure that shielding of the x-ray room is adequate and that all equipment is operating properly. Shielding checks

should include areas adjacent to the x-ray room and occupied areas above and below. This would cover patient waiting areas, offices, exam rooms, corridors, storage areas, control booths, and work stations. There are specific exposure limits for controlled areas—areas occupied by radiation workers and not open to the general public—and noncontrolled areas. The x-ray equipment should also be regularly checked for such items as scatter radiation, timer accuracy, adequate beam filtration, light field alignment, and exposure levels.

During radiographic procedures the only person that should normally be in the x-ray room outside of the shielded control area is the patient. The technologist should always remain in the control booth. Occasionally someone will need to hold and restrain a patient such as a child or uncooperative adult during an exposure. This should be avoided if possible. The person doing the holding should not be a person employed for that purpose and preferably it should be a member of the patient's family. Anyone holding a patient should be given a lead apron and gloves and kept out of the primary x-ray beam. A few exposures of this type are of little concern, but employees at the radiographic facility should not be required to routinely hold patients in this manner.

Generally one of the best ways for a biomedical institution to control worker exposure in diagnostic radiology is to hire qualified x-ray technologists. Technologists should be hired who are members of the American Registry of Radiologic Technologists (AART). This will assure that they have undergone educational training, practical experience, and have passed a qualifying examination.

Using good radiographic techniques is another way to control worker exposure and reduce the number of retake radiographs required. The fewer number of films taken, then the less exposure to the patient and the less likely workers will be exposed.

Mobile x-ray machines create more of a possibility for unnecessary exposure than stationary systems. These systems are used out in the hospital or clinic area without the benefit of fixed shielding. The operation of such systems should only be for patients who are not capable of being moved to a regular x-ray room. The operator of a mobile x-ray system must wear a protective apron and have an exposure switch that can be located at least six feet away from the machine. The area should be cleared of all unnecessary individuals and those remaining should be provided with protective clothing. It should be noted that the principle exposure to personnel during this type of procedure will be from radiation scattered by the patient's body.

Special Procedures-Fluoroscopy

Personnel involved in fluoroscopy, angiography, cardiac catheterization, and other forms of special procedures normally have the greatest radiation exposure of anyone in the biomedical environment. These procedures often require long periods of fluoroscopy and many radiographs to be taken while workers are in the room near the patient. All personnel must be aware during these types of exams of the basic radiation protection procedures to be taken and have the necessary equipment to protect themselves. In

addition to their monitors, personnel should have available such things as protective clothing (aprons, gloves, glasses, and collars) lead drapes, movable leaded shields, bucky slot covers and specially designed protection. Also anyone who is not required to be close to the procedure should stand back as far as possible.

Nuclear Medicine

There are two types of diagnostic procedures in nuclear medicine. One type consists of invitro analysis of samples after a dose of radioactive material has been administered. Samples may be such things as blood, urine, feces, or expired air. The other type is making a direct measurement of the amount or distribution of a radionuclide tracer within the patient. (NCRP, 1976) Usually the activity of the radionuclide used in these types of diagnostic procedures is small and the half-life quite short. Because of this, these examinations present little hazard to both the patient and personnel.

Qualified doctors and technologists who are radiation workers should be the only ones to perform this type of procedure. Normal radionuclide handling techniques using the protection of time, distance, and shielding should be consistently used. Hand exposure of the technologist from stock solutions can be significant so precautions such as shielded syringes should be available. Personnel monitors must be provided and gloves and lab coats used.

Special attention should be paid to the control of contamination both for workers protection and clinical accuracy. Cleanliness in the nuclear medicine laboratory is essential. Absorbent paper on counter tops and trays should be used. Ways to control radioactive gases such as xenon-133 should be provided. The only way to maintain control of contamination is to perform routine radiological health surveys using appropriate instrumentation. A complete record of these surveys must be maintained along with a complete inventory of all radioactive material and doses administered.

Urine from a patient can contain significant amounts of radioactive material so precaution should be taken. Nursing and support staff must be notified when patients are returned to wards.

Radiation Therapy

Radiation Therapy procedures can also be divided into two categories. External beam therapy where the patient is treated by a radiation producing machine and internal therapy where radionuclides are placed in the body. Internal therapy can come from oral and ingested doses of radioactive material and sealed sources that are implanted.

External beam therapy is commonly done with large x-ray units, accelerators, or cobalt equipment. Written operating and protection procedures for all these machines should be available and strictly followed by the operator along with the specific treatment plan for the patient.

General safety guides for all radiation machines should be followed. A complete survey of the shielding in a radiation therapy room and a calibration on the machine must be done by a qualified expert before the facility can be put into operation.

Under no circumstances should anyone be in the room except the patient while treatment is in progress. Emergency off switches are always located in each room and at the controls along with beam-on monitors. Also a means for viewing the patient must be provided. Interlocks should never be defeated and a survey meter must always be available to personnel.

The patient in external beam therapy does not become radioactive so there are no radiation concerns after the machine has been turned off (except for a stuck source in a cobalt unit). However there are some physical hazards such as moving gantries, treatment tables, and heavy doors that must be considered.

Internal therapy sources are more of a problem for medical workers than external beam therapy. This is primarily because the source remains in the patient during their treatment and stay in the hospital. When patients are undergoing this type of therapy, proper signs must be placed on the patients door and patient care personnel must be properly trained and provided with an appropriate survey instrument. Radiation surveys should be done regularly and recorded. When surveys are performed with a survey meter the audible signal should be turned off so as not to frighten the patient.

Patients receiving gamma-emitter radionuclides should be placed in a room by themselves which is preferable on an outside wall and as far from the nurses station as possible. Measurements of exposure levels around patients and "stay times" for staff and visitors should be calculated. However, consideration should be given to family members who may wish to remain with a patient even though exposure levels are higher than desired. In critical care instances, efforts should be made to allow family members to stay as long as they desire.

When unsealed sources such as I-131 are given as therapeutic doses special precautions must be taken. Workers should always wear disposable gloves, wash hands thoroughly, and monitor themselves with the survey instrument provided. Personnel monitoring is not normally required for nurses but can be provided to those workers who desire it. Depending on the therapy procedure, patient excreta may have to be saved and disposed of as radioactive waste. Patient linen and personal items must also be treated as being contaminated and kept in the room until they can be monitored. Whenever possible paper plates and disposable utensils should be used during food service. Anything that leaves the patient's room should be checked for contamination.

There is a wide variety of procedures using sealed sources. Implants may be seeds or needles and made of such things as iodine, iridium, cobalt, radium, or cesium and be permanent or temporary. Almost any part of the body can be irradiated using a variety of methods, so the radiation precautions for each patient should be evaluated separately. The number one problem in using sealed sources is that the source may fall out of the patient and get lost in the bed linens or other material. Thorough surveys of anything removed from the vicinity of the patient's room should be made

until all sources are accounted for or the conclusion of the treatment. There is no contamination problem with these sources but the external exposure levels can be high. Many times bedside shielding can be provided to reduce exposure levels and increase the time visitors and staff members can stay in the room.

Miscellaneous Sources

There are other radiation sources in the biomedical environment that need to be considered. Radiography and fluoroscopy in the operating room and emergency medicine department can present unavoidable problems. Examinations in these areas require personnel to be near the patient and a wide variety of beam directions are used. Personnel in these areas must be trained in radiation protection procedures and monitored for personnel exposure just as they are in the radiology department.

Pathology departments use a number of invitro diagnostic test kits containing very small amounts of radioactive material. Very little hazards are associated with these sources, but outlined procedures for personnel must be followed and inventories must be kept. Small irradiators containing curie sources are also used by many departments for irradiating whole blood. These systems are self contained and quite safe from a radiation stand point as long as they are not tampered with or taken apart.

Research laboratories using radiation techniques must conform to all proper procedures in handling radioactive material. This includes planning and record keeping.

A large number of medical research projects use radiation on experimental animals. Radiation hazards exist in these projects since x-ray sources and radioactive material are used. The same high standards in radiation protection that are used by personnel in patient care should be utilized in animal research. Special care must be given to the cleaning of contaminated cages and the disposal of radioactive carcasses.

On rare occasions a patient who has received a therapeutic dose of a radionuclide will die in the hospital. If there are sealed sources involved, they should be removed before the body is released. The biomedical institution must give personnel detailed instructions for handling, tagging, transporting, and performing autopsy procedures as well as specific instructions to morticians regarding such patients.

DISPOSAL

Radioactive Material

There has been great concern on the part of workers and the general public about the disposal of hazardous radioactive waste. Although most of this concern has been centered around high level radioactive waste from nuclear power plants some of this concern has spilled over onto the low level waste generated by biomedical institutions. There have been difficulties in proceeding and getting public acceptance of plans for high level waste disposal, but there are many technically acceptable ways to dispose of low level radioactive waste. These ways do not add significant amounts of activity to the already existing and naturally occurring radioactive material in the environment and do not measurably increase the health hazard to the public beyond background levels.

Recently there has been a lot of work in forming "compacts" between bordering groups of states with the purpose of solving their low level radioactive waste disposal problems collectively. It is hoped that these required compacts if approved by Congress will help alternate some of the problems biomedical institutions have had in disposing of their radioactive waste in recent years.

Although there are many ways to dispose of waste there is no single way that is most effective for the disposal for all types of radioactive material coming from biomedical institutions. Radioactive waste comes in many forms such as solids, liquids, biological material, scintillation vials, and in some instances gases. Just as there are many types of instruments needed to detect the variety of radiations, there are also many choices in the disposal of radioactive material. However, a biomedical institution must limit their disposal methods--whether it be decay, incineration, burial or sewer dumping--to those methods that are allowed by their radioactive material license.

Not all of the choices that are made on ways to dispose of radioactive waste are made because of the radiological considerations. There are also other hazards that quite often accompany the radioactive waste such as biological, chemical, and physical factors. Examples of these hazards are infectious biological material, chemical carcinogens, and physical hazards such as uncapped syringes and broken glass. Much of the time these other hazards that are mixed in with the radioactive waste pose much more of a risk than the radioactive portion.

The time for a biomedical institution to plan for radioactive waste disposal is before the material is purchased and arrives. Institutions should try to purchase and use the minimum amount necessary to complete the research experiment or medical procedure. Researchers and clinicians should also plan to use the material as soon as possible and dispose of it right after they are finished with it using proper procedures.

As a good rule of thumb biomedical institutions can figure on spending as much for waste disposal as they paid for the original radioactive material. This can be a costly item for any institution so it should be planned for in the budgeting process or in any grant requests.

Adequate and secure waste disposal containers must be provided in all laboratories. Where necessary these containers should be shielded and/or placed in fume hoods. Containers should be properly labeled and marked so housekeeping staff will not remove the waste as normal trash.

Decay

The easiest, cheapest, and preferred way to dispose of radioactive material with a short half life is to decay the activity away. Usually if the half life of the material is less than about sixty days, such as I-125, the material can be reasonably held in a safe storage area until it has decayed away to insignificant quantities. Ten to twelve half lives of decay is enough provided the initial activity is less than about five mCi.

Storage for decay should be done in a storage area away from the laboratory and clinical areas. Material should be properly packaged, labelled and shielded so external radiation levels are low and no contamination is present. Liquid containers should be strong enough to hold the material for a long period of time and provisions made so that biological waste can be kept frozen. After a sufficient decay time all radioactive material labels should be removed. If allowed by license the waste can then be treated as nonradioactive and go to the landfill, incinerator, or sewer depending on other associated hazards.

Decay can be a highly effective means of disposal provided that small amounts of material are being used, the material has a short life, and adequate storage space is available.

Incineration and Atmospheric Release

Incineration has recently become the chosen method to dispose of much of the very low level radioactive waste of isotopes such as tritium H-3 and carbon C-14 coming from biomedical institutions. Unfortunately because of the costly equipment, operating costs, public opinion, and strict licensing requirements it has not been as widely used as it could be. Incineration has the advantages as a disposal method in that it reduces the volume of waste and gets rid of problems such as biological and chemical hazards. Incineration does not effect the activity of the material but rather relies on dilution in air. It is a good method for small quantities of tritium and carbon mainly because these isotopes are naturally occurring in the atmosphere in large quantities. Occasionally, depending on an institution's license, some radioactive waste gases can be released to the atmosphere through a fume hood. Activities must be kept at a small percentage of the maximum concentrations allowable in air by the regulations for both incineration and the release of waste gases to the atmosphere.

Shipping for Burial

The most costly of all forms of radioactive waste disposal is shipment to one of the available burial sites for radioactive waste disposal. The sites that are currently accepting waste are Barnwell, South Carolina; Hanford, Washington; and Beatty, Nevada. Procedures for packaging, labelling, and shipping radioactive waste in drums for burial are complex. The procedures are also difficult to keep up with since they are always rapidly changing. Unless knowledgeable personnel are available at the biomedical institution to package waste it is usually advisable and more cost effective to hire a commercial broker. Broker's can package the waste, obtain permits, fill out shipping papers, label the drums, and transport them for burial. Without consistently keeping up with all of the regulations problems could arise that might cause a shipment of waste to be returned to the institution and future shipments banned by the disposal site!

Sewer Disposal

Sewer disposal is the least desirable method to get rid of radioactive waste. Even though some institutions are allowed to put up to one curie of soluble radioactive material down the drain there are some problems with this. Although dilution will reduce the activity levels to almost insignificant levels, chemical hazards and biological hazards may also remain with the material. Activities must be kept at a small percentage of the concentrations allowable in water by regulations. Ideally the only radioactive material to be put down the sewer is wash water from contaminated glassware. Specific conditions for waste disposal by sewage are listed in the institutions radioactive material license.

X-Ray Equipment

All used x-ray equipment may not be sold or transferred to another individual or institution without meeting specific requirements. These requirements depend on the registration of the individual or institution receiving the equipment and if the equipment components have been certified to meet federal x-ray equipment performance standards. If the equipment is being sold for surplus, the x-ray tube must be removed so the equipment is inoperable. Specific details for removing or trading x-ray equipment must be worked out with a registered equipment dealer. It is advisable for biomedical institutions to contact the N.C. Radiation Protection Section to obtain specific information on disposal of used x-ray equipment.

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LASER SAFETY

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ABSTRACT

Lasers are being used in many sectors of our society. Among those uses, an increasing array of medical surgical applications are proving highly beneficial. There are, however, some risks to health care providers and to patients if the laser is not used properly. This chapter introduces the reader to some of the risks associated with laser use and suggests safety precautions that should be taken to minimize the adverse affects of this new medical tool.

LASER SAFETY

The carbon dioxide gas laser uses a mixture of gases within a tube which radiates at 10,600 nm in the far infrared portion of the electromagnetic spectrum. From the standpoint of medical applications, the carbon dioxide laser offers both high power and high efficiency at a far infrared wavelength.

The term "LASER" is an acronym for "Light Amplification by Stimulated Emissions of Radiation." Thus the laser is a device which produces and amplifies light. Lasers or laser systems emit intense, coherent electromagnetic radiation that has many applications in surgical procedures, but also has the potential for damaging the skin and eyes. The radiation from this type of laser can cause irreparable damage to the cornea of the human eye; therefore it is recommended that everyone in an operating room where a laser is being used, should wear either ordinary prescription eyeglasses appropriate glass safety glasses. The eyelids of the patient under anesthesia should be taped shut and completely covered with gauze soaked in water.

The carbon dioxide laser, which is used for a wide variety of surgical procedures, is the only common type of surgical laser which operates outside of the retinal hazard region. Hence, carbon dioxide laser reflections from specular metal surfaces (mirror-like) commonly found in the operating room do not produce reflected hazards to the human retina as would occur from the argon or Nd:YAG Lasers. Reflections by specular metal surfaces from all three types can, however, be a fire hazard. Lasers should never be used in the presence of flammable liquids or vapors, such as ethyl ether, alcohol, acetone, propane, etc.

It should also be stressed that some respiratory hazards are associated with toxic chemicals from laser induced fumes and vapors. When a laser is used to mold or vaporize methyl metha-

crylate, the vapors released are toxic and noxious and must be evacuated from the breathing space of the workers. The recommended guideline is that 99.97% of all particulate matter must be removed from the field. Additionally, there are hazards associated with the electrical power supplies and from the noise generated by the operation of the laser.

Laser radiation can have an adverse affect on the skin. The large surface area makes this organ readily accessible to both acute and chronic exposures to all forms of optical radiation.

Several recent incidences that have occurred during laser surgery have suggested a need for more comprehensive understanding and utilization of recommended safety procedures. New detailed recommendations for laser safety were published in 1980 by the American National Standards Institute (ANSI) in the publication entitled, "For the Safe Use of Lasers" ANSI Z 136.1. Existing Federal and New Proposed Model State Legislation are based upon these recommendations. All appropriate personnel must be thoroughly trained to follow these procedures. The responsibility for compliance and for establishing an adequate training and safety program have been delegated to the user organizations and to their laser safety operators.

Attachment #1 entitled, "Suggested Laser Safety Check List," from the ANSI Z 136.1 standard is included to promote the safe use of lasers in all medical situations.

SUMMARY

In laser applications, as with all new technologies, it takes some time to develop a thorough understanding of the technology's potential benefits and of its potential risks. Once we know about the potential risks, we must develop and utilize administrative policies, employee education and certification, and engineered safety and maintenance procedures. These are all designed to help ensure that patients will benefit from the new technology while they and the workers are protected from the hazards associated with its use. This brief chapter introduces these concerns and suggests some direction to be followed. Much remains to be done in this developing field.

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APPENDIX

Date _____

Technician _____

SUGGESTED LASER SAFETY CHECK LIST

Yes	No	<u>Preoperative</u>
()	()	1. Move laser vacuum cart into room (all supplies are in drawers in the cart).
()	()	2. Obtain bucket of water.
()	()	3. Hang "Laser in Use" sign on door.
()	()	4. If laser is not in room and is to be moved: a. Before laser is moved, check to be sure that the articulating arm is secured in holder on the side of the main cabinet. b. Before moving through the doorway, remove articulating arm from its holder and hold parallel to floor. (Most doorways are not high enough to permit the laser to pass through with the arm in the secured state.) c. When through the doorway, re-secure articulating arm in its holder. d. Move laser slowly to room - do not bump other objects.
()	()	5. Check cords for torn areas or exposed wires, check plug for cracks or loose prongs.
()	()	6. Plug into wall outlet.
()	()	7. Check tubing on laser medium tank, (NOS); make sure that laser medium tank is attached to the laser gas outlet and that the nitrogen tubing is attached to the nitrogen outlet at the back of the laser.
()	()	8. Open valves on the laser medium tank and the nitrogen tank by using a T-handle.
()	()	9. Put key in slot.
()	()	10. Turn key to "on" position.
()	()	11. Test lights by pushing red test button on left side of panel.
()	()	12. If all test lights functioning, push red "off" button on right side of panel.
()	()	13. If all test lights are not functioning, notify clinical engineer at _____.
()	()	14. Adjust dials on tanks until the arrow of the dial on the CO ₂ tank is positioned at _____ psi and the arrow of the dial on the nitrogen tank is positioned at _____ psi. Nitrogen dial cannot be adjusted down unless the laser is in operation, so adjust dial upward slowly.

()	()	15. Attach 125mm lens to articulating arm.
()	()	16. Attach nitrogen tubing to nipple on lens.
()	()	17. Screw on 125mm hand piece.
()	()	18. Attach focusing tip.
()	()	19. Push green stand-by button on right side of panel.
()	()	20. Adjust vacuum pressure dial on top of machine to _____ psi.
()	()	21. Set wattage at 10 watts.
()	()	22. Open manual shutter for He Ne beam.
()	()	23. Set mode for single pulse.
()	()	24. Test fire laser at 15 watts by aiming laser beam at a wet (saline) tongue blade and depressing foot pedal.
()	()	25. Continue to test fire laser in repeat pulse, continuous pulse and super pulse. Listen for discharge of Nitrogen when laser is fired. Nitrogen should be discharged only when the foot pedal is depressed.
()	()	26. If laser does not fire, call clinical engineering.
()	()	27. If laser functional, continue with check-off list.
()	()	28. Attach appropriate lens or microslad if different from 125mm lens. The lens in the microscope should correspond to the lens in the microslad which the surgeon will use.
()	()	29. Attach nitrogen tubing to nipple on lens or microslad.
()	()	30. Flash sterilize metal hand piece and focusing tip. Do not sterilize 125mm lens, 50mm lens or microslad.
()	()	31. Make glasses available to staff and to patient if patient under spinal or local anesthesia.

Intra-Operative

()	()	1. Position laser near patient.
()	()	2. Position foot pedal near surgeons foot.
()	()	3. Drape appropriately with sterile drape. (see draping procedure)
()	()	4. If surgeon requests power less than 50 watts, switch power toggle switch to 0-50. If he requests power greater than 50, switch toggle switch to 50-100. Power (watts) is read on the top scale.
()	()	5. Dial in the wattage desired by turning the black knob clockwise while pressing the yellow meter button until the desired wattage is attained.
()	()	6. After surgery begins, check the gas pressure dials and the vacuum pressure dial periodically.

- () () 7. While in operation, gas conservation dial should be on.

Post-Operative

- () () 1. Push red "off" button.
- () () 2. Move laser away from patient. Either hold articulating arm or place in holder.
- () () 3. Turn power key off.
- () () 4. Remove key.
- () () 5. Move unit to allow patient's bed to be moved in.
- () () 6. Unplug electrical plugs and secure.
- () () 7. Turn off both tanks.
- () () 8. Bleed tanks by removing hoses by means of the snap assembly.
- () () 9. Collect glasses and return to drawer in suction cart.
- () () 10. Remove hand piece and wash. Decontaminate and return to proper box.
- () () 11. Remove lens or microslad and return to box - do not wash lenses. The gimbaled mirror on the microslad may be wiped with alcohol.
- () () 12. Cover end of articulating arm with plastic or other suitable cover to keep mirrors clean.
- () () 13. Wipe off laser unit with damp cloth and return to storage.
- () () 14. Record procedure in the case book that is stored with the laser unit. Record should contain:
- a. Patient's name and address
 - b. Procedure done
 - c. Power (watts) used
 - d. Lens used
 - e. Surgeon performing case

If the laser is not functioning before or during case, an incident report is to be filed and a copy sent to the Laser Safety Officer.

CLINICAL AND RESEARCH LABORATORY SAFETY

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ABSTRACT

Safety is an integral part of all clinical and research laboratory activities. Effective communication between environmental safety specialists and laboratory personnel enhances the awareness for improved laboratory safety.

Laboratory audits provide an opportunity for environmental safety personnel to meet with laboratory personnel on a one to one basis to discuss various aspects of safety. The topics discussed range from general laboratory safety to the management of hazardous wastes within the laboratory. The audit program is two-fold providing the opportunity to collect information regarding laboratory safety practices, as well as distribute pertinent, up to date safety information.

General laboratory safety, including the appropriate use of refrigerators and freezers and the safe management of compressed gases will be discussed. Chemical safety and chemical waste management practices will also be discussed.

THE LABORATORY AUDIT

Introduction

Communication is essential to a successful environmental safety program. Problems in communication arise in medical institutions and research facilities where laboratory personnel are isolated and unaware of the availability of resources and services provided by an environmental safety program. One solution to this communication problem has been the development and implementation of a laboratory audit program. Recognizing that effective communication is critical to the development of a comprehensive safety program, laboratory audits are utilized to open this line of communication. The audit program can be divided into two components - the collection of information and the distribution of information. The audits provide an effective mechanism for the exchange of ideas between environmental safety specialists and laboratory personnel. The audits create an informal atmosphere for discussion of various aspects of safety between these two groups.

Collection of Information

The information collected (see Appendix I) includes the following - laboratory safety practices, containment devices, chemical handling and storage practices, hazardous waste management, handling and storage of biological materials and identification and disposal of imminent hazards.

The following information is collected with regards to laboratory safety practices. The presence of safety equipment in the laboratory or nearby is recorded. Safety equipment includes eye washes and safety showers, protective clothing for laboratory personnel including safety glasses and appropriate gloves, chemical spill kits, first aid kits and fire extinguishers. Management practices of compressed gas cylinders - including cylinders in storage, and in use, are noted. The contents of refrigerators and freezers are

checked to insure that they are utilized in an appropriate manner. Two common problems are encountered with regards to the safe use of refrigerators and freezers. Flammables, such as ether have been found stored in refrigerators and freezers which are not suitable for the storage of flammable material. Also, it is common to find food stored in refrigerators along side specimens and chemicals. Recalls of ultracentrifuges occur on a periodic basis. Because of this, the collection of information regarding ultracentrifuges, including make, model and serial number are collected. Having this information allows quicker response to recalls.

Fume hoods and biological safety cabinets can provide a false sense of security to laboratory personnel if not properly maintained. Information is collected on the current certification status of both biological safety cabinets and fume hoods. If flammable storage cabinets are present in the laboratory, the contents are checked to insure they are being utilized in an appropriate manner.

An inventory of chemicals commonly used is a primary element of the audit program. Special attention is given to storage practices with regards to appropriate segregation of hazard classes as well as selection of storage locations. In addition, attention is given to the appropriate labeling of containers. The use of Occupational Safety and Health Administration (OSHA) regulated carcinogens is noted, as well as compliance with applicable standards.

Chemicals are then evaluated in terms of hazardous waste management practices. Those chemicals routinely used, as well as the end products or chemical waste streams generated from specific laboratory processes, are identified. Finally, disposal methods for these waste streams are evaluated. Through the audit, it is possible to identify ahead of time, chemicals in the laboratory which will require special handling at their time of disposal.

Situations have been encountered in which chemicals have been left in a laboratory from a previous occupant, or just pushed to the back of the shelf and forgotten about for several years. Problems arise with these chemicals if they

are deemed to be imminent hazards. These chemicals include picric acid, short chain aliphatic ethers, organic peroxides, pyrophoric materials and water reactive compounds. The presence of chemicals which pose an imminent hazard are noted, and safe disposal arranged.

Biological materials or agents used in the laboratory are identified. The infectious risk of the material is evaluated. It is determined whether the biological materials or agents are involved in any procedures which have the potential to create aerosols - such as centrifugation or sonication. Decontamination methods and sterilization practices are evaluated. Syringe and needle disposal methods are verified for the safety of the laboratory workers as well as housekeeping personnel.

Distribution of Information

Information distributed to the laboratories includes the following - a laboratory safety manual, guidelines for handling and disposal of chemical wastes, an incompatible chemicals chart, emergency phone number cards and miscellaneous information.

Emergency phone number cards are posted in all clinical and research laboratories. In addition to emergency phone numbers, the card provides information numbers for all available safety resources at Duke University Medical Center (figure 1).

The audit provides an excellent opportunity for the distribution of new information on specific topics, which needs to reach the researcher.

Information Management

In order to effectively manage the information collected, it must be stored in a structured manner. The audits are documented using a personal computer and a commercial software package. Several factors were considered in choosing a software package - cost, flexibility and ease of use. For these reasons, LOTUS was

MEDICAL CENTER

EMERGENCIES

FIRE - 911 - POLICE

CHEMICAL SPILL - 911

CARDIAC - 115

POISON - 113

EMERGENCY ROOM

684-2413

INFORMATION

FIRE & BUILDING SAFETY 684-5697

ENVIRONMENTAL SAFETY 684-2794

RADIATION SAFETY 684-2194

POISON CONTROL 684-2498

EMPLOYEE OCCUPATIONAL HEALTH 684-3225

Figure 1. Duke University Medical Center Emergency Telephone Number Card

chosen, which provides a spreadsheet data-base format. The software has been upgraded to SYMPHONY, which is a more integrated system.

Audits are recorded by building and room number. The worksheet format allows sorting and extractions of relevant information (figure 2). Due to flexibility of the software, modification of the data-base is a simple task.

In addition to the softwares' ability to store information, it is also useful in generating reports back to the laboratories. A macro, or program within a program has been written so that reports can be computer generated, but at the same time not appear as a form letter (figure 3). The reports outline problems or questions that were identified in the laboratory during the audit. Specific solutions to these problems are also provided.

Summary

The audit program has helped to assure compliance with applicable guidelines and federal, state and local regulations.

The audit information will eventually be integrated into a data-base useful in emergency response situations. By querying the data-base, information on a specific room or building could be retrieved quickly, and relayed by phone to the emergency site.

The factual data collected has helped to identify program strengths and weaknesses. This has enabled the prioritization of goals allowing a more directed approach towards safety management.

By opening the lines of communication, laboratory personnel have been made more aware of the safety resources available. But more importantly, the audit program has increased the personnel awareness as to their responsibilities within the safety management program.

BUILDING/ROOM	FUME HOOD	BSC	FSC	REFRIGERATORS	FREEZERS
JONES 330	none	(2) 2/83	none	(1) R/F combo, not ep biologicals	(1) biologicals not ep
JONES 327	none	(3) 7/83	none	none	none
JONES 328	none	none	none	(1) combo, radact tissue culture, not ep	(2) tissue culture not ep
JONES 326	none	none	none	(1) combo R/F, tissue culture media not ep	(1) See left
JONES 311	none	needs	none	R/F combo samples	see left
JONES 311	none	certif		& reagents not ep	
JONES 309	none	none	none	R/F combo, biological not ep	(1) see left (1) biological not ep

Figure 2. Data-base excerpt from laboratory audit data-base

MEMORANDUM

TO: John Q. Investigator
FROM: Rosanne Feild, Environmental Safety Specialist
SUBJECT: Laboratory Audit
DATE: April 15, 1984

On April 1, 1984 an audit of Jones building--room 000 was conducted by the Division of Medical Center Environmental Safety.

In general, good laboratory work practices were observed; however, there are certain conditions which will require your attention:

Unsupported pressurized cylinders

Pressurized cylinders were not secured in the prescribed manner. It is Medical Center Safety Policy that cylinders, full or empty, shall be secured by OSHA approved methods or devices during storage and transport". OSHA approved methods for securing cylinders include chains or secured straps. Engineering and Operations personnel can assist you in complying with this policy.

If you have any questions, please feel free to contact me. I can be reached at 684-3096 or 684-2794.

cc: Jane Q. Administrator

Figure 3. Sample report outlining problems or questions identified during a laboratory audit

GENERAL LABORATORY SAFETY
(CAP, 1984)

Smoking is prohibited in technical work areas. Smoke is annoying to some, the burning cigarette is an ignition source to flammable solvents, and the handling of cigarettes from bench to mouth is a route of exposure for both bacteria, virus (eg. hepatitis), and certain toxic materials, such as mercury.

Eating and Drinking are also prohibited in technical work areas. It is poor laboratory practice, a source of contamination, and specimens (blood, urine, feces, sputum) containing a variety of pathogens are handled daily in the technical work area and stored in the lab refrigerators.

Food is excluded from storage in technical refrigerators. Refrigerators reserved exclusively for food storage may be located in areas where eating and drinking are permitted. A policy should be established to assure the proper housekeeping of the refrigerator.

Application of cosmetics in the technical work area is prohibited.

Contact lenses, especially soft lenses, will absorb solvents and also constitute a hazard in splashes or spills. They offer no protection from a splash and may concentrate caustic material against the cornea or prevent tears from washing a chemical away. You are strongly advised not to wear contact lenses in the laboratory or to wear suitable eye protection with the contact lenses.

Face shields or eye protectors must be worn when handling corrosive materials.

Clothing. Do not wear clothing or uniforms with a high percentage of acetate or other highly flammable material. Laboratory coats should be either worn in the laboratory and removed when out of the laboratory or worn over the uniform when out of the laboratory and removed when working. (Policies may vary. The intent of the rule is to reduce the transfer of microorganisms from the laboratory to other persons and vice versa.)

Shoes should be comfortable, rubber or crepe soled, and cover the entire foot (lace or loafer type). Shoes with

open toes or negative heels are not recommended.

Hair should be secured back and off the shoulders in such a manner as to prevent it from coming in contact with contaminated materials or surfaces and also to prevent shedding of organisms into the work area. This is especially true in bacteriology. It is also important to keep hair out of moving equipment such as a centrifuge. Certain pieces of jewelery that can become caught in equipment or hang into infective material should be avoided.

Men with beards must observe the same precautions as above. Long beards are a danger in regard to moving equipment and all beards may be a source of bacterial contamination.

Handwashing. Hands should be washed frequently during the day, before leaving the laboratory, before and after contact with patients, and before eating or smoking.

Eye wash stations should be conveniently located where acids, caustics and other hazardous chemicals are in use. These eye wash stations may be of an approved and elaborate design or may be a simple spray type device attached to the water supply by a flexible hose. The eye wash station must be capable of delivering at least fifteen minutes of continuous water flow.

Emergency showers should be available convenient to the location where corrosive chemicals are used. These devices should be tested periodically for proper function. The number of such emergency showers depends on the complexity and extent of the laboratory. If floor drains are provided in proximity to such emergency showers, a regular program should be established to assure that the traps in such drains remain filled with water.

Mouth pipetting of specimens is prohibited. There are pipetting aids available for every task.

Isolation procedures. The same isolation procedures as adopted by the hospital should be used. If available, consultation with the infection control practitioner may be productive.

Good housekeeping

a. Rags and/or flammable solvents should be disposed of in

- self-closing safety containers.
- b. Do not hang clothing on or near radiators, steam pipes, heating instruments or open flames.
 - c. Do not allow trash to accumulate in any area. Trash should be disposed of daily.
 - d. Trash containers into which ash trays have been emptied should be inspected for fire at the end of each day.
 - e. Festive decorations should be limited to designs on glass outside of laboratory work areas. Hanging decorations and wax candles should be prohibited. Decorations on lights and instruments should be prohibited.

Glassware

- a. Do not use broken or chipped glassware. Discard it and order new.
- b. Do not leave pipettes sticking out of bottles, flasks or beakers.
- c. Do not attempt to remove stoppers on glass tubing by forcing. If they are stuck, cut them off.
- d. Glass blowing and other artistic endeavors by inexperienced personnel should be prohibited.
- e. Decontaminate glass exposed to samples by heat.
- f. Dispose of broken or discarded pieces in a specially marked separate container. (Disposal of broken glass along with paper and trash is a hazard to the housekeeping staff).
- g. Hot glass or heated containers should be handled with heat retardant gloves.

Centrifuges

- a. Do not operate centrifuges unless the covers are closed (including serofuges). Keep hair, beard, neck ties, hair ribbons, or other frilly or dangling items out of the way.
- b. Do not centrifuge uncovered tubes of specimens (blood, urine, sputum) or flammable liquids. Centrifugation creates a vacuum and volatilizes liquids. (Contaminated items become aerosols, flammable liquids become bombs, etc.). Use caps, stoppers or parafilm. Screwed on rotor covers are an acceptable method of closure.

Autoclaves

- a. Personnel should not operate autoclaves until they have been checked out on the proper autoclave operation.
- b. Do not open until both temperature and pressure have returned to normal.
- c. Be sure intake steam valve is off before opening.
- d. Use heat retardant gloves when putting items into or removing items from the autoclave. The sides and door may be hot in addition to the material being autoclaved. Note: Beware of steam which may permeate heat retardant gloves.
- e. Loosen caps of any containers to allow equalization of pressures inside containers. This prevents explosions, boilovers, and implosions.
- f. Do not place cellulose nitrate tubes in an autoclave.
- g. Do not overpack autoclaves as the central part of the load may not reach temperatures necessary to sterilize.
- h. A program should be developed to use biological and heat indicators to assure proper functioning of autoclaves.

Appropriate Use of Refrigerators and Freezers

Food and drink shall not be stored in any refrigerator or freezer designated for the storage of chemicals or biological materials or patient specimens.

At no time shall flammable materials be stored in refrigerators or freezers which are not designated for this specific use. A notice stating "This refrigerator/freezer is not suitable for storage of flammables" shall be clearly posted where applicable.

The following are features of an internally explosion safe refrigerator (USDHHS, 1982).

1. Exterior label
2. Self closing door, magnetic catch
3. No interior light, switch or thermostat control
4. Non-combustible interior
5. Threshold capable of retaining a one liter spill
6. No unsealed penetrations of compartment liner
7. Thermostat controls hermetically sealed between inner and outer shells
8. Compressor located at upper rear of refrigerator

Existing refrigerators can be modified to accomodate flammable storage by (NRC, 1981):

1. Removing any interior light activated by a switch mounted on the door frame.
2. Moving the contacts of the thermostat controlling the temperature to a position outside the refrigerated compartment.
3. Moving the contacts for any thermostat present to control fans within the refrigerated compartment to the outside of the refrigerated compartment.

Compressed Gases (CAP, 1984)

General Standards

- a. Cylinders must be secured at all times so they cannot fall.
- b. Valve safety covers should be left on until pressure regulators are attached.
- c. Containers must be marked clearly with the name of the contents. Tanks with wired on tags or color code only, should not be accepted.
- d. Hand trucks with safety straps must be used in moving cylinders. Do not roll or drag cylinders.
- e. The use of oil, grease or lubricants on valves, regulators or fittings is prohibited.
- f. Do not attempt to repair damaged cylinders or to force frozen cylinder valves.

Flammable Gases

- a. Gas cylinders connected to laboratory apparatus should be either a minimally sized container of the gas, or should not exceed the needs of two working days.
- b. Gas container storage for a laboratory should be in a separate room or enclosure reserved exclusively for that purpose.
- c. Manifolding of compressed gas cylinders is permitted. Such manifolded systems being located either in a separate room having a fire resistance classification of at least one hour and ventilated in accordance with NFPA 56A, or be located outside of the building and connected by a permanently installed piping system.
- d. Valves on all gas cylinders should be shut off when the laboratory is unattended.

Pressure Regulators and Needle Valves

Needle valves and regulators are designed specifically for different families of gases. Use only the properly designated fittings.

- a. Threads and surfaces must be clean and tightly

- fitted. Do not lubricate.
- b. Tighten regulators and valves firmly with the proper sized wrench. (Do not use adjustable wrenches or pliers. They damage the nuts.) Do not force tight fits.
 - c. Open valves slowly. Do not stand directly in front of gauges (the gauge face may blow out). Do not force valves that stick.
 - d. Check for leaks at connections. Leaks are usually due to damaged faces at connections or improper fittings. Do not attempt to force an improper fit.
 - e. Valve handles must be left attached to the cylinders.
 - f. The maximum rate of flow should be set by the high pressure valve on the cylinder. Fine tuning of flow should be regulated by the needle valve.
 - g. Shut off cylinders when not in use.

Leak testing

Cylinders and connections should be tested by "Snoop" or a soap solution. First test the cylinders before regulators are attached and test again after the regulators or gauges are attached.

Empty cylinders

- a. Must be marked empty.
- b. Empty or unused cylinders must be returned promptly.
- c. Replace valve safety caps before transporting.
- d. Store empty cylinders separate from full cylinders.

The Compressed Gas Association, Inc. publishes pamphlets regarding the safe handling of various types of compressed gases. These pamphlets are found referenced in 29 CFR 1910 - Occupational Safety and Health Standards for General Industry. The following pamphlets are of interest to medical and research facilities.

CGA P-1 - 1984
Safe Handling of Compressed Gases in Containers

Pamphlet C-6
Standards for Visual Inspection of Compressed
Gas Cylinders

CGA Pamphlet S-1.1
Pressure Relief Device Standards Part 1 - Cylinders
for Compressed Gases

Pamphlet C-8
Standard for Requalification of DOT-3HT Cylinders

CGA Pamphlet P-2
Characteristics and Safe Handling of Medical Gases

CGA G-1 - 1972 (R1980)
Acetylene

CGA Pamphlet G-1.3
Acetylene Transmission for Chemical Synthesis

Information regarding these publications as well as other Compressed Gas Association publications can be obtained by writing or calling:

Compressed Gas Association, Inc.
1235 Jefferson Davis Highway
Arlington, VA 22202
(703)979-0900

CHEMICAL SAFETY

Labeling

All containers of chemicals shall be labeled. A manufacturer's label is generally sufficient. If material is transferred from its original container, to a new or cleaned used container, a new label shall be generated. This label should contain the chemical name (preferably not a trade name), the date in which material was placed in the container, and the hazard class of the material. Chemicals should never be transferred to a container previously used for storing another chemical, without thoroughly cleaning the container. Problems arise when incompatible chemicals are mixed together. Violent reactions can occur, possibly causing a fire or an explosion.

Many commercial laboratory chemicals are being packaged using a new labeling system (figure 4). These new labels provide a wealth of information that should be utilized by laboratories. The labels are color coded to aid in the safe storage of the chemicals. Each color refers to a specific hazard class, i.e. flammable, poison, corrosive, etc.. The labels provide information on appropriate protective clothing for the user, as well as suggested protective equipment, i.e. fume hood or fire extinguishers. Individual manufacturers provide additional health and safety information as well.

Storage

Chemicals should be segregated and stored according to compatibility classes (figure 5). In general, chemicals should be stored off the floor, out of the main flow of traffic. When possible, enclosed cabinets, located close to the floor should be utilized for chemical storage. The storage of chemicals underneath sinks should be avoided due to the reactivity of many chemicals with water.

Toxic substances

Toxic substances should be segregated from other substances and stored in a well defined or identified area that is cool, well ventilated, and away from light, heat, acids, oxidizing agents, moisture, and such (NRC, 1981).

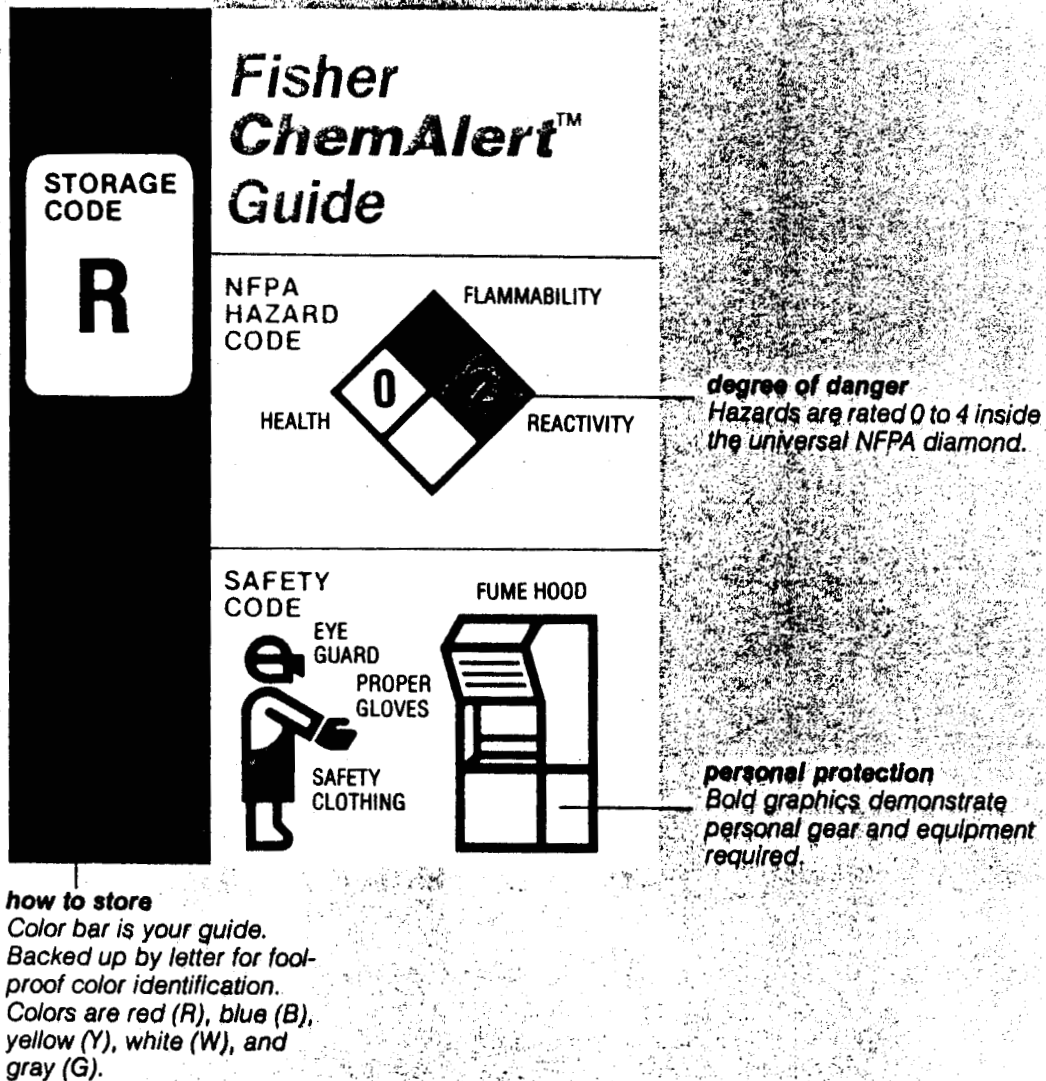


Figure 4. Fisher Scientific ChemAlert labeling system

Chemical Compatibility*

Chemical Class																	
1	Inorganic Acids	1															
2	Organic Acids	X	2														
3	Caustics	X	X	3													
4	Amines & Alkanolamines	X	X		4												
5	Halogenated Compounds	X		X	X	5											
6	Alcohols, Glycols & Glycol Ethers	X					6										
7	Aldehydes	X	X	X	X		X	7									
8	Ketones	X		X	X			X	8								
9	Saturated Hydrocarbons									9							
10	Aromatic Hydrocarbons	X									10						
11	Olefins	X				X							11				
12	Esters	X		X	X									12			
13	Halogens			X			X	X	X	X	X	X	X	X	13		
14	Ethers	X														14	
15	Acid Anhydrides	X		X	X		X	X							X	15	
16	Oxidizers	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	16

X = Unsafe Combinations

Note: Identify class to which a specific compound belongs, read unsafe combinations with other classes both horizontally and vertically.

X = Unsafe Combinations

Figure 5. *U.S. Department of Health and Human Services, National Institutes of Health, Division of Safety (1982)

Flammable materials

Ideally, flammable materials should be stored in an approved flammable storage cabinet. When this is not possible, material should be stored in a well ventilated area. Other considerations in the storage of flammable liquids in the laboratory include ensuring that aisles and exits are not blocked in the event of fire; that accidental contact with strong oxidizing agents such as chromic acid, permanganates, chlorates, perchlorates, and peroxides is not possible; and that sources of ignition are excluded (NRC, 1981).

Water reactive materials

Storage facilities for water-sensitive chemicals should be constructed to prevent their accidental contact with water. This is best accomplished by eliminating all sources of water in the storage area. Storage facilities for such chemicals should be of fire-resistant construction, and other combustible materials should not be stored in the same area (NRC, 1981).

Special Considerations

Potential peroxide forming chemicals

Potential peroxide forming chemicals (figure 6) should be labeled as to the date the container is opened. Contents should be periodically checked for peroxide formation, and disposed immediately if evidence of peroxides is found. The following are various test methods for peroxide detection.

Ferrous thiocyanate is reported to be a very sensitive method of detecting hydroperoxides. The ferrous thiocyanate test is as follows (Steere, N.V., 1971):

A fresh solution of 5 cc of 1% ferrous ammonium sulfate, 0.5 cc of 1N sulfuric acid and 0.5 cc of 0.1N ammonium thiocyanate are mixed (and if necessary, decolorized with a trace of zinc dust) and shaken with equal quantity of the solvent to be tested; if peroxides are present, a red color will develop.

Examples of Peroxide Forming Compounds^{*}

Ethers (e.g., Isopropyl, Diethyl,
Tert-butyl)

Vinylidene Chloride

Divinyl Acetylene

Sodium Amide

Discard Within
3-6 Months After
Opening

Tetrahydrofuran

Dioxane

Methyl Isobutyl Ketone

Cyclohexene

Cumene (Isopropyl Benzene)

Decalin

Discard Within
6-12 Months
After Opening

Note: Test for peroxides before distilling
or evaporating any of the above materials.

Figure 6. *U.S. Department of Health and Human Services,
National Institutes of Health, Division of
Safety (1982)

The potassium iodide method for testing for peroxides in ethyl ether is as follows (Steere, N.V., 1971):

Add 1 cc of a freshly-prepared 10% solution of potassium iodide to 10 cc of ethyl ether in a 25 cc glass-stoppered cylinder of colorless glass protected from light; when viewed transversely against a white background, no color is seen in either liquid.

A quantitative test for peroxide in tetrahydrofuran and dioxane is described as follows (Steere, N.V., 1971):

To 50 ml of the ether add 6 ml of glacial acetic acid, 4 ml of chloroform, and 1 g of potassium iodide; titrate with 0.1N thiosulfate to find the percent of peroxide, equal to

$$\frac{\text{ml of Na}_2\text{S}_2\text{O}_3 \times \text{Normality} \times 1.7}{\text{Weight of Sample}}$$

If the reaction is carried out in acetic acid (Davies, A.G., 1961), air must be excluded by an inert gas or by the vapor of the boiling solvent to prevent autoxidation of the iodide; or acetic anhydride or hot isopropyl alcohol can be used as the reaction medium. (Avoid ignition of the flammable vapors of acetic acid, acetic anhydride and isopropyl alcohol).

Perchloric Acid - Acid Handling (Steere, N.V., 1971)

73% PERCHLORIC ACID OR LESS

1. Use goggles for eye protection whenever the acid is handled.
2. Always transfer acid over a sink in order to catch any spills and afford a ready means of disposal.
3. In wet combustions with perchloric acid, treat the sample first with nitric acid to destroy easily oxidizable matter.
4. Any procedure involving heating of the perchloric acid must be conducted in a ventilated hood.
5. No organic material should be stored in the perchloric acid hood.
6. Do not allow perchloric acid to come in contact with strong dehydrating agents (concentrated sulfuric acid, anhydrous phosphorus pentoxide, etc.).

7. Perchloric acid should be used only in standard analytical procedures from well recognized analytical texts. (This does not apply to analytical research workers.)

73% TO 85% PERCHLORIC ACID

1. Same precautions as above.

ANHYDROUS PERCHLORIC ACID (GREATER THAN 85%)

1. Only experienced research workers should handle anhydrous perchloric acid. These workers must be thoroughly familiar with the literature on the acid.

2. A safety shield must be used to protect against a possible explosion, and the acid must be used in an appropriate hood with a minimum of equipment present. No extraneous chemicals should be present in the hood.

3. A second person should be informed of the intended use of anhydrous acid and be in the same room with the research worker using this extremely strong oxidizer.

4. Safety goggles, face shield, thick gauntlets, and rubber apron must be worn.

5. Only acid freshly prepared should be used.

6. Dispose of the unused anhydrous acid at the end of each day.

7. Do not make any more anhydrous perchloric acid than is required for a single day's work.

8. Contact of the anhydrous acid with organic materials will usually result in an explosion.

9. Any discoloration of the anhydrous acid requires immediate disposal.

CHEMICAL WASTE MANAGEMENT

General Guidelines

Each principal investigator who generates waste chemicals shall contact the appropriate office to make an appointment for pick-up during the routine waste pick-up for their area.

Each container of waste must have a chemical waste label before it will be removed from the laboratory. The label must contain the following information:

- a) chemical name
- b) quantity of chemical
- c) solvent (if applicable)

- d) person responsible for chemical
- e) date of chemical placement into container
 - 1. for safety cans record date each time chemical is added to the can.
 - 2. for new containers, record date container opened, for chemicals transferred to another container record transfer date.
- f) building name
- g) laboratory room number

All hazardous materials must be handled through the appropriate waste disposal system rather than discarding them in the sewer or solid trash.

If the principal investigator needs assistance in determining how a chemical should be handled for disposal, he should contact the appropriate office. He should try to provide the following information:

- a) chemical name
- b) chemical abstract service number
- c) quantity
- d) physical state
- e) chemical supplier/manufacturer
- f) age of chemical
- g) known hazardous properties
- h) investigator's name
- i) phone number
- j) location of chemical

Chemical wastes should be rendered non-hazardous in the laboratory if possible. The waste can only be "treated" if the method is written into the standard laboratory operating or experimental procedure with documentation that this method is reliable in completely changing the hazardous nature of the compound without damaging equipment or endangering the investigator. In an effort to maintain a current resource file, the appropriate office should be notified before a laboratory initiates such a procedure.

Cracked or leaking containers, or containers without secure caps will not be removed from the laboratory.

Incompatible chemical wastes must be stored separately.

The wastes must not decompose, react with or ignite the container they are stored in.

Deliberate or careless mislabeling or treatment of waste chemicals may result in severe legal or personnel health penalties. Therefore, each principal investigator is accountable for proper chemical waste disposal in his laboratory.

The following is an excellent reference for the treatment of hazardous waste from laboratories.

NRC Committee on Hazardous Substances in the Laboratory, Prudent Practices for the Disposal of Chemicals from Laboratories, National Academy Press, Washington, D.C., 1983

Waste Handling by Chemical Classification

Halogenated and non-halogenated solvents

Halogenated and non-halogenated solvents are segregated and collected in 5-gallon safety cans. As materials are added, the investigator updates the log for each container.

Aqueous solutions

Each investigator should place an appropriate screw capped container in his hood to collect waste aqueous solutions, and the first rinse of the glassware containing these compounds. As the investigator adds each compound to the container, he/she updates the label and reseals the container. Incompatible materials must not be mixed in the same container.

EP toxic compounds

All solutions containing EP toxic compounds (including heavy metals) should be labeled and stored in appropriate containers for removal. See Appendix II for an explanation of EP toxicity.

Corrosive materials

Waste corrosives should be stored in properly labeled approved containers. The original containers should be suitable for this purpose.

Reactive compounds

To further expand on EPA's definition of reactive chemicals, a compound will be considered reactive if:

1. A chemical has a "4" rating for reactivity in the NFPA handbook of Hazardous Materials;
Examples: picric acid, nitromethane.
2. Is listed in Sax's Dangerous Properties of Industrial Materials having an explosion hazard of "high" or "severe";
Example: dinitrophenylhydrazine.
3. In the presence of organic material may cause a fire;
Example: perchloric acid.
4. May cause an explosion in the presence of air;
Example: methyl lithium.
5. After a period of aging forms a product which is unstable;
Examples: ether, dioxane.

If the reactive chemical does not constitute an immediate fire or safety hazard, contact the appropriate office to arrange a special pick-up. The information to be supplied to the office is the name and phone number of the person responsible for the reactive chemical, the room, location of the chemical, the physical state of the chemical and the type container holding the chemical.

Metallic mercury

When possible, waste metallic mercury should be collected, and recycled. Bethlehem Apparatus will either buy dirty metallic mercury outright, or will triple redistill dirty metallic mercury, and return it in 6 pound plastic containers. Information regarding mercury recycling can be obtained from:

Bethlehem Apparatus
890 Front Street
Hellertown, PA 18055
(215) 838-7034

APPENDIX I

DUKE UNIVERSITY MEDICAL CENTER
DIVISION OF ENVIRONMENTAL SAFETY
LABORATORY AUDIT

BUILDING _____ ROOM NUMBER _____

PRINCIPAL INVESTIGATOR _____

DEPARTMENT _____ PHONE NUMBER _____

DATE OF AUDIT _____

PRIMARY FUNCTION OF ROOM

- ☐ RESEARCH LAB
- ☐ TEACHING LAB
- ☐ PREPARATION ROOM
- ☐ STORAGE
- ☐ OFFICE
- ☐ MAINTENANCE/HOUSEKEEPING
- ☐ OTHER (SPECIFY) _____

LABORATORY SAFETY - CHECK IF PRESENT

- ☐ SAFETY GLASSES
- ☐ APRONS/LAB COATS
- ☐ GLOVES
- ☐ SAFETY SHOWER
- ☐ EYE WASH
- ☐ CHEMICAL SPILL KITS - SPECIFY TYPES

- ☐ FIRST AID KIT
- ☐ SAFETY CAN
- ☐ FIRE EXTINGUISHERS - SPECIFY TYPES

- ☐ FIRE BLANKET
- ☐ OTHER - SPECIFY

DOES THE LABORATORY CONTAIN:

☐ FUME HOOD(S)

	LAST TEST DATE	LOCATION IN LAB
1.	_____	_____
2.	_____	_____
3.	_____	_____

☐ BIOLOGICAL SAFETY CABINET(S)

	LAST CERTIFICATION DATE	SERIAL NUMBER
1.	_____	_____
2.	_____	_____
3.	_____	_____

☐ FLAMMABLE STORAGE CABINET(S) IS IT VENTED ☐ YES ☐ NO☐ REFRIGERATOR(S)

	BRIEF DESCRIPTION	PRIMARY USE	EXPLOSION PROOF?
1.			
2.			
3.			

☐ FREEZER(S)

	BRIEF DESCRIPTION	PRIMARY USE	EXPLOSION PROOF?
1.			
2.			
3.			

☐ ULTRACENTRIFUGE(S)

	MAKE	MODEL	SERIAL NUMBER	DUKE TAG #
1.				
2.				
3.				

☐ ROTORS

	MAKE	MODEL	SERIAL NUMBER	DUKE TAG #
1.				
2.				
3.				

GAS CYLINDERSIN STORAGE

ARE FULL CYLINDERS SEGREGATED FROM EMPTIES ()YES ()NO

ARE FULL CYLINDERS SEGREGATED BY HAZARD CLASS ()YES ()NO

ARE THE CYLINDERS SUPPORTED TO PREVENT ROLLING OR TIPPING ()YES ()NO

ARE THE CYLINDERS CAPPED ()YES ()NO

ARE THE CYLINDERS PLACED AWAY FROM HEAT SOURCES AND OPEN FLAMES ()YES ()NO

IN USE

ARE THE CYLINDERS SUPPORTED TO PREVENT ROLLING OR TIPPING ()YES ()NO

ARE THE CYLINDERS PLACED AWAY FROM HEAT SOURCES AND OPEN FLAMES ()YES ()NO

ARE THE SYSTEMS PERIODICALLY LEAK TESTED ()YES ()NO

LECTURE CYLINDERS

ARE LECTURE CYLINDERS CURRENTLY BEING STORED IN THE LABORATORY ()YES ()NO

IF YES, LIST CHEMICALS AND NUMBER OF CYLINDERS

RADIOACTIVE ISOTOPES

ARE RADIOACTIVE ISOTOPES USED IN THE LAB ()YES ()NO
IF YES, PLEASE LIST:

FOOD AND DRINK

IS FOOD AND/OR DRINK STORED/CONSUMED IN THE LABORATORY ()YES ()NO

CHEMICAL HANDLING AND STORAGE PRACTICES

ARE CHEMICALS STORED:

() UNDER THE HOOD (SPECIFY CLASS (ES) OF CHEMICALS)

() IN THE HOOD

() UNDER SINKS

() ABOVE COUNTERS - ON OPEN SHELVES

() ABOVE COUNTERS - ON CLOSED SHELVES

() OTHER AREAS (PLEASE SPECIFY)

ARE ALL CONTAINERS OF CHEMICALS CLEARLY () YES () NO
LABELED WITH CHEMICAL NAME(S)

IF NOT, HOW MANY UNIDENTIFIED BOTTLES ARE IN THE LAB _____

WHAT ARE THE MAJOR CHEMICAL WASTE STREAMS GENERATED IN THE LAB (LIST USING CHEMICAL NAMES)

WHAT METHOD OF CHEMICAL WASTE DISPOSAL DOES THE LABORATORY USE

CARCINOGEN USE

ARE ANY OF THE FOLLOWING CARCINOGENS USED IN THE LABORATORY:

☐ ASBESTOS	☐ 4-AMINODIPHENYL
☐ 4-NITROBIPHENYL	☐ ETHYLENEIMINE
☐ MEHTYL CHLOROMETHYL ETHER	☐ beta PROPIOLACTONE
☐ 3,3'-DICHLOROBENZIDINE	☐ 2-ACETYLAMINOFLUORENE
☐ alpha NAPHTHYLAMINE	☐ 4-DIMETHYLAMINOAZOBENZENE
☐ bis-CHLOROMETHYL ETHER	☐ N-NITROSODIMETHYLAMINE
☐ beta NAPHTHYLAMINE	☐ VINYL CHLORIDE
☐ BENZIDINE	☐ BENZENE

IF ANY OF THE ABOVE CARCINOGENS ARE USED IN THE LABORATORY, IS THE FOLLOWING INFORMATION IN CLEAR SIGHT UPON ENTERING THE LAB: ☐ YES ☐ NO

CANCER-SUSPECT AGENT

AUTHORIZED PERSONNEL ONLY

ARE CONTAINERS OF THE ABOVE CARCINOGENS PROPERLY LABELED WITH "CANCER-SUSPECT AGENT" ☐ YES ☐ NO

BIOLOGICAL MATERIALS/AGENTS HANDLING PRACTICES

ARE BIOLOGICAL MATERIALS/AGENTS ()YES ()NO
USED IN THE LABORATORY

IF YES, PLEASE SPECIFY:

ARE BIOLOGICAL MATERIALS/AGENTS INVOLVED IN ANY OF THE
FOLLOWING PROCEDURES:

- () CENTRIFUGATION
- () SONICATION
- () BLENDING
- () LARGE BATCH PRODUCTION/FERMENTOR

HOW ARE BIOLOGICAL MATERIALS/AGENTS DECONTAMINATED
(SPECIFY METHOD)

WHERE IS THE NEAREST AUTOCLAVE BUILDING _____
ROOM _____

IS IT USED FOR ROUTINE STERILIZATION ()YES ()NO

WHAT DISINFECTANT IS USED FOR ROUTINE CLEANING OF THE LAB
(PLEASE SPECIFY)

WHAT METHOD OF NEEDLE DISPOSAL IS USED _____

ARE NEEDLES CLIPPED ()YES ()NO

ARE ANIMALS HOUSED IN THE LABORATORY ()YES ()NO

PLEASE CHECK IF THE FOLLOWING COMPOUNDS ARE PRESENT IN THE LAB:

- ☐ PICRIC ACID
☐ SHORT CHAIN ALIPHATIC ETHERS (SPECIFY)

- ☐ CYANIDE COMPOUNDS (SPECIFY)

- ☐ ORGANIC PEROXIDES (SPECIFY)

- ☐ PYROPHORIC MATERIALS (SPECIFY)

- ☐ ACROLEIN
☐ CARBON DISULFIDE
☐ DIISOPROPYLFLUOROPHOSPHATE
☐ NICOTINE AND SALTS
☐ OSMIUM TETROXIDE
☐ SODIUM AZIDE
☐ DINITROPHENOL
☐ DINITROPHENYL HYDRAZINE
☐ HYDRAZINE

HEAVY METAL COMPOUNDS

- ☐ ARSENIC COMPOUNDS
☐ BARIUM COMPOUNDS
☐ BERYLLIUM DUST
☐ CADMIUM COMPOUNDS
☐ CHROMIUM COMPOUNDS
☐ LEAD COMPOUNDS
☐ MERCURY COMPOUNDS
☐ SELENIUM COMPOUNDS
☐ SILVER COMPOUNDS
☐ THALLIUM COMPOUNDS

SOLVENTS

- ☐ NON-HALOGENATED SOLVENTS (SPECIFY)

- ☐ HALOGENATED SOLVENTS (SPECIFY)

() ALUMINUM HYDRIDE
() ALUMINUM, METALLIC, POWDER
() ALUMINUM PHOSPHIDE
() CALCIUM CARBIDE
() CALCIUM HYDRIDE
() CALCIUM METAL
() CALCIUM PHOSPHIDE
() CESIUM METAL
() LITHIUM ALUMINUM HYDRIDE
() LITHIUM AMIDE
() LITHIUM BOROHYDRIDE
() LITHIUM FERROSILICON
() LITHIUM HYDRIDE
() LITHIUM METAL
() LITHIUM NITRIDE
() LITHIUM SILICON
() MAGNESIUM ALUMINUM PHOSPHIDE
() MAGNESIUM METAL
() PHENYL LITHIUM
() PHOSPHORUS PENTASULFIDE
() PHOSPHORUS SESQUISULFIDE
() POTASSIUM HYDRIDE
() POTASSIUM METAL
() RUBIDIUM METAL
() SODIUM ALUMINUM HYDRIDE
() SODIUM AMIDE
() SODIUM HYDRIDE
() SODIUM METAL
() SODIUM METHYLATE
() SODIUM PHOSPHIDE
() SODIUM-POTASSIUM ALLOY
() STANNIC PHOSPHIDE
() ZINC PHOSPHIDE
() ZIRCONIUM HYDRIDE

() ALUMINUM CHLORIDE
() ACETYL BROMIDE
() ACETYL IODIDE
() ALLYL TRICHLOROSILANE
() ALUMINUM BROMIDE, ANHYDROUS
() AMMONIUM HYDROGEN FLUORIDE
() AMYL TRICHLOROSILANE
() ANISOYL CHLORIDE
() ANTIMONY PENTACHLORIDE
() ANTIMONY PENTAFLUORIDE
() ANTIMONY TRIBROMIDE

() ANTIMONY TRICHLORIDE
() ANTIMONY TRIFLUORIDE
() BENZOTRICHLORIDE
() BENZOYL CHLORIDE
() BENZYL CHLORIDE/BROMIDE
() BENZYL CHLOROFORMATE
() BUTYL TRICHLOROSILANE
() CHLOROACETYL CHLORIDE
() CHLOROPHENYL TRICHLOROSILANE
() CHLOROSULFONIC ACID
() CHROMIUM OXYCHLORIDE
() CHROMYL CHLORIDE
() CYCLOHEXENYL TRICHLOROSILANE
() CYCLOHEXYL TRICHLOROSILANE
() DICHLOROACETYL CHLORIDE
() DICHLOROPHENYL TRICHLOROSILANE
() DODECYL TRICHLOROSILANE
() FLUOROSULFONIC ACID
() FUMARYL CHLORIDE
() HEXADECYL TRICHLOROSILANE
() HEXYL TRICHLOROSILANE
() IODINE MONOCHLORIDE
() MONOFLUOROPHOSPHORIC ACID
() NONYL TRICHLOROSILANE
() OCTADECYL TRICHLOROSILANE
() OCTYL TRICHLOROSILANE
() PHENYL TRICHLOROSILANE
() PHOSPHORIC ANHYDRIDE (PHOSPHORUS PENTOXIDE)
() PHOSPHORUS OXYBROMIDE
() PHOSPHORUS PENTACHLORIDE
() PHOSPHORUS TRIBROMIDE
() PHOSPHORUS TRICHLORIDE
() PHOSPHORUS TRIIODIDE
() PROPIONIC ANHYDRIDE
() PROPYL ANHYDRIDE
() PROPYL TRICHLOROSILANE
() PYROSULFURYL CHLORIDE
() SELENIC ACID, LIQUID
() SILICON CHLORIDE
() SILICON TETRACHLORIDE
() SODIUM MONOXIDE, SOLID
() SULFUR MONOCHLORIDE
() SULFUR DICHLORIDE
() SULFUR TRIOXIDE
() SULFURYL CHLORIDE
() THIONYL CHLORIDE
() THIOPHOSPHORYL CHLORIDE

- () TIN TETRACHLORIDE (STANNIC CHLORIDE)
- () TITANIUM TETRACHLORIDE
- () TRIS-(1-AZIRIDINYL) PHOSPHINE OXIDE

APPENDIX II

40 CFR 261.24 Characteristic of EP toxicity (U.S. CFR, 1984)

(a) A solid waste exhibits the characteristic of EP toxicity if, using the test methods described in 40 CFR 261 Appendix II or equivalent methods approved by the Administrator under the procedures set forth in sections 260.20 and 260.21, the extract from a representative sample of the waste contains any of the contaminants listed in Table I at a concentration equal to or greater than the respective value given in that Table. Where the waste contains less than 0.5 percent filterable solids, the waste itself, after filtering, is considered to be the extract for the purposes of this section.

(b) A solid waste that exhibits the characteristic of EP toxicity, but is not listed as a hazardous waste in Subpart D, has the EPA Hazardous Waste Number specified in Table I which corresponds to the toxic contaminant causing it to be hazardous.

Table I - Maximum Concentration of Contaminants for Characteristic of EP Toxicity

EPA hazardous waste number	Contaminant	Maximum concentra- tion (milligrams per liter)
D004	Arsenic	5.0
D005	Barium	100.0
D006	Cadmium	1.0
D007	Chromium	5.0
D008	Lead	5.0
D009	Mercury	0.2
D010	Selenium	1.0
D011	Silver	5.0
D012	Endrin	0.02
D013	Lindane	0.4
D014	Methoxychlor	10.0
D015	Toxaphene	0.5
D016	2,4-D	10.0
D017	2,4,5-TP Silvex	1.0

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SECTION V: Special Topics

THE SAFE USE OF CLEANING COMPOUNDS IN THE HEALTH CARE FACILITY

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ABSTRACT

The primary goal of an Environmental Services or Housekeeping Department in any health care facility is to create a safe, clean environment conducive to proper patient care. The particular aspect of creating this atmosphere to be examined in this brief article deals with the usage of cleaning compounds.

RULES FOR SAFE USE OF CLEANING COMPOUNDS

It is vital, when using chemicals for cleaning in the health care setting, to realize that each cleaning compound is designed with a specific usage in mind. In every case the cleaning compound should be equipped with a label giving the following information: product name, chemical dilution rate, safety precautions, areas of use, and EPA or OSHA listing number. Therefore, first and foremost in the "safe" use of cleaning compounds, proper labeling should be followed consistently. This one section will remedy nearly all of the safety problems encountered when using chemicals in the health care facility. Remember the proper label will tell you what the chemical is, where you may use it, how to mix it, and it will also tell you of any precautions to take while using it to ensure your personal safety and that of others in the vicinity. The second factor is that the precautions and directions for use of these substances must be followed precisely.

One factor which seems to be a consistent problem in most health care facilities involves the proper mixing and usage of cleaning compounds. The label on the chemical compound will give instructions on how to mix or dilute the compound for effective use. Some custodial personnel have the impression that if one ounce of a compound to one gallon of water is the proper dilution ratio, then why not double or triple it since that will surely add strength to the cleaner and do a better job of cleaning. Unfortunately this is highly incorrect! More is not necessarily better and, in fact, is quite often harmful to the areas to be cleaned and the personnel present in the vicinity of the area being cleaned. Follow the directions. If one ounce is called for on the directions, then one ounce is all that is needed to do the job properly. Another problem in mixing cleaning compounds lies in the area of mixing solids and liquids. Always bear in mind that, to get the proper mixture, one must add the solid to the liquid to ensure a proper solution. If this is done in the

reverse order, congealing of the solid will almost always occur and an incomplete solution will result.

When custodial personnel prepare to clean areas involving any type of patient residence, several items to ensure the safety of both the patient and themselves should be observed. First, always have the cleaning solutions pre-mixed prior to entering the areas to be cleaned. Also, before entering patient care areas, cleaning compounds should be kept in such a way that accidental spilling or consumption by the patients is rendered virtually impossible. After ensuring the first step has been accomplished, custodial personnel should be aware of the types of patient care occurring in the area they are cleaning. If, for example, the area to be cleaned involves respiratory cases, the custodian should spray the cleaning compounds on the cleaning utensils prior to entering the room to ensure the patient does not breathe the mist or fumes from the cleaner. Usually the proper use of common sense and following your facility's cleaning procedure manual will assist in the proper usage and applications of cleaning compounds throughout the entire health care facility.

SUMMARY

In recapping the points discussed, the safe use of cleaning compounds involves three basic issues; proper labeling, correct dilution of compounds and proper usage and application of cleaners. If correct labeling is used, cleaners are mixed properly and the cleaners are used as they are intended, the creation and maintenance of a safe, clean environment within the health care facility for both patients and personnel should be ensured.

PEST MANAGEMENT

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ABSTRACT

Pest management plays a crucial role in allowing health care facilities to provide an essentially germ-free and sanitary environment because many pests are disease vectors. Integrated pest management (IPM) involves a combination of control methods which include sanitation, mechanical controls and pesticide application. Because of the sensitive environment of health care facilities, emphasis is placed on sanitation and mechanical control. Since integrated pest management expertise is usually outside the expertise of health care personnel, the selection process of a pest control firm is explored and three phases of an IPM are program presented. The nature of pesticides, how they work and factors affecting their activity are given. Pesticide safety includes a selection process, application techniques, ability to read the label and the material safety data sheets, and the keeping of records. The applicator and application of pesticides are regulated by federal and state laws.

INTRODUCTION

Pest management plays a crucial role in allowing health care facilities to provide an essentially germ-free and sanitary environment for the diagnosis, treatment, recovery and rehabilitation of ill or injured persons. In the developed nations, during the past 75 years, mankind has added 25 years to his lifespan. Ecologists attribute this increase to three key factors, sanitation practices, pest control and the development of pharmaceuticals.

NECESSITY OF PEST MANAGEMENT

There are many pests of public health significance. Such pests either cause health problems directly, like bee stings, or are known carriers or vectors of disease organisms, such as cockroaches transmitting salmonellosis. Below is a partial list of pest groups by common name, followed by their public health significance.

1. Ant: bite, sting; strongly implicated in mechanical disease transmission.
2. Bat: transmit rabies; associated with histoplasmosis, etc.
3. Bed Bug: cause dermatitis; not known to transmit diseases.

4. Bee, Hornet, Wasp: sting.
5. Beetle: infest stored food; infest human intestine; cause dermatitis.
6. Bird: associated with histoplasmosis, ornithosis, cryptococcosis, toxoplasmosis, etc.; carry mites.
7. Caterpillar: stinging hairs; infest intestinal track; infest stored food.
8. Centipede: venomous bite; infest nasal, intestinal and urinary tracts.
9. Cockroach: transmit enteric diseases.
10. Flea: cause dermatitis; transmit plague, murine typhus, tapeworm.
11. Fly: some bite; some larvae infest human flesh; transmit internal human parasites including bacteria, protozoa, virus, etc.
12. Kissing Bug: transmit chagas disease.
13. Millipede: exude vesicating venom; infest human digestive and urinary tract; intermediate host of tapeworms.
14. Mite, Chigger: cause dermatitis; infest human intestine, transmit scrub typhus, rickettsial pox, epidemic hemorrhagic fever, infest stored food.
15. Mosquito: transmit malaria, encephalitis, yellow fever, dengue, filariasis.
16. Moth or Butterfly: infest stored food; infest human intestine; some have stinging hairs.
17. Rodent: transmit leptospirosis, lymphocytic choriomeningitis, salmonellosis, trichinosis, carry mites.
18. Scorpion: sting.
19. Silverfish, Firebrat: infest stored food, transmit enteric diseases.
20. Spider: venomous bite.
21. Sucking Louse: cause dermatitis; transmit epidemic typhus, trench fever, relapsing fever.
22. Thrip: occasionally bite.
23. Tick: cause dermatitis, tick paralysis; transmit Rocky Mountain Spotted Fever, relapsing fever, tularema, Colorado tick fever, Q fever, etc.

Of those pests listed above, the ones most commonly found in health care facilities include: cockroaches (especially the German and American cockroach), ants (especially the Pharaoh ant), silverfish and rodents (especially rats and mice). Those which are of occasional importance include: flies, stored food infestors (beetles, caterpillars, moths and mites), spiders, fleas, mites and birds. In addition, there are pests which can cause structural damage such as termites and carpenter ants. Realize that the presence of any pest, not just those listed above, is in itself of public health importance if it causes annoyance. Any particular pest at any given time can be the most important pest problem in a health care facility.

INTEGRATED PEST MANAGEMENT

The basic principles of integrated pest management consist of a series of steps which must be done in order to solve a pest problem. These steps are summarized below.

Evaluation Steps

1. Identify the pest.
2. Know or research control methods possible.
3. Evaluate the risks and benefits of each method or combination of methods.
4. Choose the methods which are most effective but which also present the greatest safety to the applicator, the patients, the health care workers and to the environment.
5. Know and utilize the correct use of each method.
6. Know the local, state and federal regulations that apply to the situation at hand.

The key to pest management is pest identification. The correct name is the key to the literature and hence, knowledge of the pest's biology and habits. The correct name is also the key to control methods, both from literature and the labels of various pesticides.

Sanitation

Sanitation is the cornerstone of any pest management program. Sanitation practices must emphasize the elimination of all potential food and water sources for pests and the elimination of harborage sites such as litter or debris. Cockroach, rodent and fly control is often impossible unless the food and filth they feed on is removed. Good sanitation is the responsibility of the health care facility's staff. The pest control technician should make note of any observed problems on the service report and corrective recommendations should be included in the periodic inspection report done by the pest control firm's technical/quality control director. The complete cooperation of the health care facility's administration is imperative to incorporate good sanitation practices into the pest management program.

Mechanical/Physical Control

Mechanical or physical controls are also vital to the success of any pest management program. These controls emphasize the elimination of pest entry routes into the structure, and the

elimination of harborage sites for pests. For example, gaps of one-quarter inch or more at the bottom of outside doors provide easy access for rodents. Cracks and crevices in concrete wall tiles provide passageways throughout the structure for pests. All of these problems can be corrected by the maintenance or engineering department personnel. The pest control technician should make note of any observed problems on the service report and recommendations should be included in the periodic inspection report done by the pest control firm's technical/quality control director. Once again, cooperation from the health care facility's administration is essential in the area of implementing or correcting deficiencies in mechanical controls.

Legal Controls

Legal controls consist of federal, state or local laws and regulations. They include periodic inspections by accreditation and/or licensing officials.

Pesticides

Pesticides must often be used in pest management programs when other methods cannot reduce pest populations to acceptable levels. Pesticides should be used where they are needed and where they can be used safely. Those selected should work well with the other control methods being used. Rarely will pesticide application alone solve a pest problem. Typically, successful control requires a combination of methods, thus the concept of "integrated pest management."

SELECTION OF A PEST CONTROL FIRM

With this basic knowledge of the workings of integrated pest management in mind, what should the health care facility administrator look for in the selection of a pest control firm?

Professionalism

Professionalism of the pest control operator (PCO) is probably the overall trait that is most important. The first impression of professionalism comes from the appearance or dress, the knowledge demonstrated of not only pest control but of health care facilities, and the confidentiality with which business is conducted.

Initial Conference

There should be an initial conference between the PCO and the individual having the overall responsibility for the facility which may be the administrator/director of building services, housekeeping, environmental services or maintenance. Its purpose is to discuss past and present pest problems and problem areas. This should include an examination of the health care facility's service request or pest complaint log for the past few months.

Facility Survey

Next, the PCO should conduct a thorough survey of the interior of the building and its outside perimeter. Both a set of floor plans and a person from maintenance or engineering should accompany the PCO on the survey. The survey's purpose is to acquaint the PCO with the layout of the facility and to find or observe problem situations or areas with regard to sanitation, mechanical exclusion and pests. Such a survey typically requires between one-half and one full day, or possibly longer, depending on the size of the facility.

Review Conference

Following the survey, there should be a review conference with the individual who has overall responsibility for the facility and with engineering or maintenance personnel to answer any procedural or structural questions. Depending on what is found, the PCO may request that the head of nursing, surgery, etc. be present so that tentative scheduling of initial service can be discussed and any procedural and timing problems resolved. A day and time should be scheduled for the presentation of the pest management proposal.

Pest Management Proposal

The final preparation step is the presentation of the pest management proposal. The individual who has overall responsibility for the facility must be present. In addition, the directors of environmental services or housekeeping, maintenance, surgery, nursing and the infection control center should also be present. The pest management proposal must be in written form but it should also be presented orally. The proposal should include the following:

1. Introduction
2. Company Background
3. Integrated Pest Management Concept

-
4. Survey Report and Recommendations
 5. Proposed Pest Management Program
 - a. Scope of work
 - b. Materials
 - c. Schedule
 - d. Periodic reports
 6. Confidentiality Statement
 7. Pest Control Agreement or Contract
 8. References

Cost Considerations

The statement that "you get what you pay for" must be kept in mind when making the final decision. A comprehensive Integrated Pest Management Program is more expensive because it involves more expertise and labor than a program that consists of routine pesticide treatment of food handling areas and additional service/treatments on a "complaint" basis. The health care facility administrator should be looking for quality, professional pest management which involves the minimal use of pesticides for effective pest control.

INTEGRATED PEST MANAGEMENT

An Integrated Pest Management Program can be divided into three phases. The program is an integrated system which combines all of the most up-to-date methods of pest management.

Phase I: Initial Survey

Phase I consists of the initial health care facility survey. The purpose of this survey is to locate where the pest problems are and to identify what pests are involved. Treatment recommendations are then made for the entire facility and especially for any specific problem areas. When the survey phase is completed and the report submitted, the health care facility should have a thorough understanding of its pest problems and of what will be required to correct them.

Phase II: Implementation of Program

Phase II consists of implementation of the integrated pest management program in the facility. Pest management is divided into the two general areas of Pesticide Controls and Non-Pesticide Controls.

Pesticide Controls

Pesticide Controls involve three different kinds of pesticide treatments which are incorporated into the pest management program. These consist of preventative treatment, corrective treatment and special treatment.

1. Preventative Treatment involves a regularly scheduled inspection-treatment service to all areas in the facility most likely to harbor insect and/or rodent infestations. These include: all food service areas, all receiving areas, garbage and trash collection areas, lobbies, janitor closets, basement and boiler room areas. Preventative treatment is designed to bring pest populations within these areas down to acceptable levels and to prevent major pest infestations from developing. An example of this schedule form is at the end of this chapter.
2. Corrective treatment is designed to provide pest management services to highly sensitive areas. It is not performed on a regular basis but instead on a "call-only" basis as pest problems develop in these areas. These highly sensitive areas include: patient rooms, operating and recovery rooms, intensive care areas, OB wards, burn wards and other sensitive treatment areas. In all of these areas, people are present who could be highly sensitive to pesticides. Therefore, pesticide treatments in these areas should be restricted to applications only as pest problems actually occur and should involve only the minimum amount of pesticide in the environment. Patients should be removed before the pesticide is applied.
3. Special treatment involves the pest management of pests which are not included in the typical pest control contract. They are not typically included because their management/control requires special expertise, equipment, pesticides and a concentrated increase in labor. Such pest problems involve termite infestations, bird problems, Pharoah ant infestations, special insect/mite infestations in the laboratory or outside lawn and turf problems. Pest management services for these additional pest problems are usually available from the larger pest control companies on a special contract basis.

Non-Pesticide Controls

Non-pesticide controls play a key role in modern integrated pest management programs. They are of paramount importance in the sensitive environments of health care facilities. The indiscriminate application of pesticides as a "cure-all" to pest problems cannot be tolerated in health care facilities. For the most part, these controls are made in the form of recommendations to the facility's administration on the PCO Service Report which

is left each time service is performed and on the periodic inspection reports done by the pest control firm's technical or quality control director. Non-pesticide controls are grouped under the categories of sanitation and mechanical controls. For a discussion of these, see the section on the basic principles of integrated pest management above. To summarize:

1. Sanitation involves the elimination of all potential food and water sources for pests and the elimination of harborage sites for pests.
2. Mechanical control involves the elimination of pest entry routes into the structure, the elimination of pest passage-ways within the system and the elimination of harborage sites for pests.

Phase III: Continual Evaluation

Phase III consists of the continual evaluation of the integrated pest management program. The major purpose of this phase is to provide continual evaluation of and feedback on the effectiveness of the program, so any necessary adjustments can be made for continued success. Three kinds of surveys are conducted to achieve this goal; the pest management log, the PCO service report and the periodic inspection report.

Pest Management Log

The daily Pest Management Log records by date and time all pest problems reported by staff with respect to the specific area involved and the kind of pest problems observed. This log should be maintained by the secretary of the department responsible for the facility's pest control, be it environmental services, housekeeping, etc. This log must be religiously maintained and therefore, it will be the quickest method of evaluation of the pest control program. Each time the PCO comes to service the facility, a copy of the new entries is given to the PCO who then responds to these requests for service. Before leaving, the PCO records in the log any action taken to solve each pest problem entry. Repeated entries for the same pest in the same location indicate the need for reevaluation of the control techniques being utilized. An example of a "Pest Management Log" is at the end of the chapter.

PCO Service Report

The PCO Service Report should include a section on sanitation and mechanical control observations. All deficiencies noted should be corrected immediately. This report should also

indicate any pest infestations found, their identification, and their location. Finally, this report should indicate all pesticides applied, their percent of active ingredients, and the amount used of each, as well as the PCO firm and its address, the date and the technician's signature. An example of this form entitled, "Pest Control Operator's Service Report," is at the end of this chapter.

Periodic Inspection

The Periodic Inspection is made by the pest control firm's management, usually by the technical or quality control director. Typically, this is on an annual basis but if conditions warrant, two or more of these inspections may be done each year. The major purpose of such inspections is to provide the health care facility administration with an in-depth evaluation of their integrated pest management program. This will be the continuing main source of in-depth sanitation and mechanical control evaluation, coupled with the recommendations for the correction of any deficiencies found. Remember, it is the responsibility of the health care facility to correct sanitation and mechanical control deficiencies. Corrective action must have the total support of the administration and must be implemented immediately. This report, along with the Pest Management Log, will indicate to the administration how well the program is meeting the goals of the original program proposal. It can serve both as a decision tool in the contract renewal and as a basis for developing recommendations for pest management practices in the coming year.

PESTICIDES

Nature of Pesticides

Definition of Pesticides

Pesticides are chemicals which are used to kill, prevent or control pests. They also include chemicals used to attract or repel pests and chemicals used to regulate pest growth processes. Here are the major kinds of pesticides and their uses.

1. Acaricide: controls mites, ticks, spiders.
2. Attractant: lures pests.
3. Avicide: controls birds.
4. Bactericide: controls bacteria.
5. Desiccant: dries up insects and related pests, such as ticks and spiders
6. Fungicide: controls fungi.
7. Herbicide: controls weeds.

8. Insecticide: controls insects and related pests, such as ticks and spiders.
9. Insect Growth Regulator: stops, speeds up, or otherwise changes normal insect processes.
10. Miticide: controls mites.
11. Molluscicide: controls mollusks, such as snails and slugs.
12. Nematicide: controls nematodes.
13. Predacide: controls vertebrate pests.
14. Repellent: keeps pests away.
15. Rodenticide: controls rodents.

Pesticide Groups

Pesticides are commonly categorized into four groups based on their chemical nature. These groups are:

1. Inorganic Pesticides: These pesticides are made from minerals. The minerals most often used are arsenic, boron, copper, lead, mercury, sulfur, tin and zinc. Examples include boric acid powder and silica aerogel.
2. Synthetic Organic Pesticides: These are man-made pesticides containing carbon, hydrogen and one or more other elements such as chlorine, phosphorous and nitrogen. Examples are 2,4-D, Dursban, Baygon and Resmethrin.
3. Plant-Derived Organic Pesticides: These chemicals are made from plants or plant parts. Examples include nicotine, pyrethrins, rotenone and strychnine.
4. Living Micro-organisms: These are bacteria, fungi and viruses.

How Pesticides Work

What They Do

Pesticides can also be categorized according to what they do. Many synthetic organic pesticides work in more than one way. The major modes of activity are:

1. Anticoagulants: These prevent normal clotting of blood.
2. Contacts: These kill simply by contact with the pests.
3. Desiccant: These cause excessive water loss, resulting in death.
4. Fumigants: These are gases which kill when inhaled or otherwise absorbed by the pest.
5. Sterilants: These make pests unable to reproduce.
6. Stomach Poison: These kill when swallowed.
7. Residual: These are applied to leave a film/crystalline layer which is later absorbed by pests resting/walking on it.

Mode of Action

Almost all of the commonly used insecticides today are synthetic organics. This group is subdivided into the organophosphate insecticides (Diazinon, Dursban, Malathion, Orthene, Safrotin, etc.), the carbamate insecticides (Baygon, Ficam, etc.). Both organophosphates and carbamate pesticides kill by lowering the level of the enzyme choline-esterase whereas, the pyrethroid mode of action varies greatly with the different compounds. Choline-esterase is vital to the transmission of nerve impulses between nerve endings.

When the human body is exposed to a choline-esterase inhibitor, it immediately metabolizes/detoxifies as much as possible as fast as possible and its breakdown products are rapidly excreted primarily via urine and feces. At the same time, any excess is temporarily stored until it can be metabolized and the body is also busy replacing the choline-esterase which has been destroyed by the pesticide. This usually all takes place in a matter of hours, maybe up to a few days. Because of this, there are known long-term affects resulting from even the typical daily exposure of a PCO to these insecticides. However, extreme caution should be exercised around infants and small children who naturally have a lower choline-esterase level than adults.

Pyrethrins are one of the plant-derived organic insecticides. Pyrethrins are typically used as a flusher during inspections or as an ULV (Ultra Low Volume) material for the control of flying insects. Most pyrethrin formulations have synergized chemicals added to increase their insecticidal activity.

Pyrethrins are rapidly detoxified by hydrolysis and rapidly excreted in the urine. Neither pyrethrins nor their breakdown metabolites are known to be stored in the body. There are no long-term affects known. However, pyrethrins with the synergist piperonyl butoxide should not be used around patients on medication because piperonyl butoxide also has a synergistic affect with some medications.

Boric acid is the most commonly used of the inorganic pesticides. It acts as both a desiccant and stomach poison on insects. As a desiccant, it either absorbs or removes the outer waxy layer of the insect's exoskeleton (outer shell) causing excessive/lethal water loss. As a stomach poison for both insects and man, the mechanism of toxic action of boron is unknown. Boric acid is excreted unchanged in the urine. However, the toxicity of boric acid is approximately the same as that of common table salt.

The safest and most commonly used rodenticides are the anticoagulant kind. This means they retard/prevent clotting of the blood and hence, an animal which eats a lethal dose bleeds to death internally. Because these compounds are not absorbed through the skin, exposure is minimal. The antidote is vitamin K which is naturally produced by the human body. All these anticoagulant chemicals attack the enzyme responsible for the production of vitamin K. When the human body is exposed to these chemicals, the body fights back with its stored 3-day supply of vitamin K. The body excretes the damaged enzyme. Since the damaged enzyme is readily replaced, there are no long-term affects.

Factors Affecting Pesticide Activity

Pesticide activity and therefore, effectiveness can be greatly affected by environmental factors. Those of greatest importance are:

1. Architectural design and construction
2. Environmental sanitation
3. Human knowledge
4. Pest identification
5. Pest population density
6. Pesticide application technique
7. Pesticide degradation
8. Pesticide dosage
9. Pesticide repellency
10. Pesticide resistance
11. Pesticide selection
12. Temperature effecting activity

The synthetic organic pesticides (primarily organophosphate and carbamate insecticides) by design retain their potency for up to about 30 days in the environment. This is to help prevent the build up of pesticides in the environment. Pyrethrins last for up to about two or three hours in the environment when exposed to light. In contrast, the inorganics boric acid and silica aerogel last for years if not mechanically removed. All the various kinds of pesticides can have the length of their potent/activity period greatly reduced by any one or combination of the above environmental factors.

Commonly Used Pesticide Formulations

Pesticide Formulations

One of the major factors affecting the performance of pesticides is the way in which they are formulated. Active ingredients are the chemicals in a pesticide that do the work but they can rarely be used in the form in which they were made. Inert ingredients are usually added to make them easier to handle, to make them safe and easy to apply, and to ensure the accuracy of application. This mixture of active and inert ingredients is called a pesticide formulation. Some formulations are ready-to-use while others must be diluted, usually with water, before application. The pesticide label's directions give the correct method for that particular pesticide formulation.

Commonly Used Formulations

The most common kinds of pesticide formulations are listed below. The abbreviations are given since many labels refer to the formulations in this manner.

1. Aerosols (A)

These formulations contain an active ingredient in solution in a solvent. Most aerosol formulations have a low percentage of active ingredients. When applied to a surface or void, the end product may vary from a crystalline to a dust layer. Other aerosols are designed to be used as mist generators or for ULV (Ultra Low Volume) applications for flying or exposed insects and related pests.

2. Baits (B)

A bait formulation has a pesticide mixed with an edible and/or attractive substance. The bait attracts the pests and the pesticide kills them when they eat the formulation. Baits are commonly used to kill rodents, but others are designed for some insects or birds. They can be used both in buildings and outside. The amount of active ingredient in most bait formulations is quite low, from 0.005 to 5.0 percent.

3. Dusts (D)

Most dust formulations are ready-to-use and contain an active ingredient, plus a very fine or powdered inert substance such as clay or talc. The amount of active ingredient usually varies from 1.0 to 10.0 percent, but boric acid formulations may be as high as 99.0 percent boric acid. All ingredients are ground into fine, uniform particles. Inert ingredients such as drying agents are often added to improve storage and ease of application. Dusts must be used dry which means they can drift into non-target areas if not carefully applied.

-
4. **Emulsifiable Concentrate (EC or E)**
Emulsified concentrates allow active ingredients which cannot be dissolved in water to be suspended in water for application. An emulsified concentrate is mixed with water to form the desired strength of finished spray, typically 0.25 to 2.0 percent.
 5. **Fumigants**
Some fumigants are gases which become liquid when placed under pressure. This kind of formulation is stored under pressure in steel cylinders. They are applied by releasing them under tarps or into a sealed steel structure. Some other fumigants are formulated as solids, usually in the pellet or tablet form. In the presence of moisture, a reaction takes place and the gas is liberated/generated. This kind is stored in air-tight flasks.
 6. **Granules (G)**
Granular formulations are dry and must be applied dry. Most are made by applying active ingredients in a liquid formulation to coarse particles (granules) of some porous material such as corn cobs or clay. The pesticide is either absorbed into the granule or coats the outside of it, or both. Inert ingredients may be added to improve handling. The amount of active ingredient ranges from 2.0 to 40.0 percent. Because granules are much larger than dust particles, there is no drift problem. An external or environmental source of moisture is required for release of the active ingredient or pesticidal activity. Granules are typically used as soil treatments.
 7. **Solutions (S)**
Solutions are formulations containing the active ingredient dissolved in an organic solvent and diluted with oil, usually deodorized kerosenes. Ultra Low Volume (ULV) concentrates are designed to be used without dilution. The high concentration of organic solvent increases the pesticidal efficacy because penetration of the body is increased.
 8. **Soluble Powders (SP)**
Soluble powders are also dry formulations but must be added to water for application. When added to water, they form true solutions. Initial agitation is needed to get them to dissolve but after that, no more is required. The amount of active ingredient in a SP is usually above 50 percent.
 9. **Wettable Powders (WP or W)**
These are dry, finely ground pesticide formulations which look like dusts. In contrast to dust however, wettable powders are made to be mixed with water for application. They are a mixture of pesticide, inert powder, and a wetting agent which allows the powder to be suspended in water. The amount of active ingredient ranges from 15 to 95 percent, but is usually over 50 percent. Good agitation is required to maintain the suspension in water. Although abrasive to pumps and nozzles, their advantage is that most of the active

ingredient stays on the surface available to pests. This is in contrast to EC's where a good portion of the pesticide soaks into a porous surface and is unavailable to kill pests.

PESTICIDE SAFETY

Pesticides are toxic and can cause injury if misused. Manufacturers determine how toxic a pesticide is by testing it on animals. The pesticide hazard, or danger that injury will occur to man, depends both on the toxicity of the active ingredient and the exposure to the pesticide during use. All pesticides must be registered with the Environmental Protection Agency (EPA) and before registration is granted, it must be determined that "when used in accordance with widespread and commonly accepted practice it will not cause unreasonable adverse affects on the environment." In other words, if a pesticide is used according to label directions, it is safe and is not a hazard to man or his environment. For additional discussion, see the sections pertaining to pesticide labels and material safety data sheets.

Pesticide Selection

The first step in selection of a pesticide is the correct identification of the pest causing the problem. The pest's name is the key to the literature about its biology and habits. In order to legally use a pesticide, the pest must be listed on the label. In most states, it is still legal to treat even if the specific pest is not listed on the label providing that the specific site where it is reasonable to expect the pest to infest based on its biology and habits, is listed and that all other label instruction are followed. Next, based on this specific pest, the available pesticides must be evaluated with respect to repellency and possible pest resisitance.

The remainder of the selection process depends on an evaluation of the conditions under which the pesticide is to be applied and function. Some of these conditions are: physical construction of area, level of sanitation, humidity or wetness, temperature and the porosity of surface involved. Based on personal experience, the label, and these considerations, the best pesticide formulation will be selected and the proper application technique chosen.

Application Techniques

In commercial structures, pesticide application is restric-

ted to crack and crevice, spot, space and/or void treatment. The label will say which may be used for that particular pesticide.

Crack and Crevice Treatment

Crack and crevice treatment means that the pesticide is applied to a crack or crevice while the tip of the applicator is within the crack or crevice. Hence, the environmental exposure is kept to a bare minimum when this method is utilized. This is the usual treatment for cockroaches and most pesticides are labeled for this type of treatment.

Spot Treatment

Spot treatment is defined to be the treatment of an area not to exceed two square feet. Very few pesticides permit spot treatment. There is a much greater environmental exposure with this method but with some pests, it is necessary for successful control.

Space Treatment

Space treatment utilizes micro-fine particles put into a confined space. It is typically an ULV application. This technique is used primarily to kill small flying insects or the exposed stages of small insects or related pests. The application rate is usually given as either a few seconds per 1000 cubic feet for an aerosol generated ULV or one or more ounces per minute per 1000 cubic feet for a machine generated ULV. Synergized pyrethrins are the usual active ingredients and they usually degrade within two to three hours.

Void Treatment

If the infestation is located in a void, this must be treated. This may involve wall voids, ceiling voids, pipe chases, equipment voids, etc. If there is no access, a small hole must be drilled to permit application. Depending on the type of void, dusts and/or ULV material are typically utilized.

Treatment for Rodents

Rodenticide bait must be placed in tamper-resistant bait stations. Each bait station should be labeled with the name and address of the pest control firm, date, active ingredient and percentage of active ingredient, with a skull and cross-bones

symbol, and with the word "poison." The number and placement of bait stations depends on which rodent is involved, where the entry point is and the location of the infestation.

Also available are a number of mechanical devices. These include glue boards, automatic, self-setting mouse traps and snap traps. These can be used in areas where baits are illegal, baiting is impractical/undesirable, or in addition to bait stations. The number and placement again depends on which rodent, the entry point and the location of the infestation.

Pesticide Labels and Labeling

Labeling vs. Label

Labeling is all the information received from the manufacturing company or its agent about the pesticide. Labeling includes such things as the label on the product, brochures, flyers, material safety data sheets (MSDS's) and the information made available by the dealer. An example of labeling is the specimen label for Dursban L.O. located at the end of this chapter.

The label is the information printed on or attached to the pesticide container. A sample label of Orkinban Granules is at the end of this chapter. This label serves several purposes:

1. To the manufacturer, the label is a "licence to sell."
2. To the State or Federal Government, the label is a way to control the distribution, sale, storage, use and disposal of pesticides.
3. To the buyer or user, the label is the main source of facts/directions on how to use the pesticide correctly and legally.
4. The label is a way to tell users about any special safety measures needed.

How to Read a Pesticide Label

Each pesticide label is required to provide certain information by the EPA. The health care facility should have on file a specimen label for each pesticide which it has on its property. These should be kept with the MSDS's (see below) and should be readily available at all times. Below, the parts of a label are given and briefly discussed.

1. Brand Name

Each company has brand names for its products. The brand name is the one used in ads. The brand name shows up plainly on the front panel of the label. It is the most

identifiable name for the product.

2. Type of Formulation

Different kinds of pesticide formulations (such as liquids, wettable powders, and dusts) require different methods of handling. The label tells what kind of formulation the package contains. The same pesticide may be available in more than one formulation.

3. Common Name

Many pesticides have complex chemical names. Some have been given another name to make them easier to identify. These are called common names. For instance, Diazinon is the common name for 0,0-diethyl 0 - (2-isopropyl-4-methyl-6-pyrimidyl) phosphorothionate. A chemical made by more than one company will be sold under several brand names, but you may find the same common name or chemical name on all of them.

4. Ingredient Statement

Every pesticide label must list what is in the product. The list is written so that the active ingredient is quickly recognizable. The amount of each active ingredient is given as a percentage by weight or pounds per gallon of concentrate. It can be listed by either the chemical name or the common name. The inert ingredients need not be named, but the label must show what percent of the contents they comprise.

5. Net Contents

The net contents number tells how much is in the container. This can be expressed in gallons, pints, pounds, quarts, or other units of measure.

6. Name and Address of Manufacturer

The law requires the maker or distributor of a product to put their name and address on the label.

7. Registration and Establishment Numbers

A registration number must be on every pesticide label. It shows that the product has been registered with the Federal Government. It usually is found on the front panel of the label and will be written as "EPA Registration No. 0000." The establishment number tells what factory made the chemical. This number does not have to be on the label, but will be somewhere on each container.

8. Signal Words and Symbols

To do their job, most pesticides must control the target pest. By their nature, they are toxic. Therefore, some may be hazardous to people. The toxicity of a product is indicated by the signal word and the symbol on the label.

a. Signal words

The signal words that follow are set by law. Each manufacturer must use the correct one on every label:

<u>Signal Word</u>	<u>Toxicity</u>	<u>Approximate Fatal Dose</u>
DANGER	Highly toxic	A taste to a teaspoonful
WARNING	Moderately toxic	A teaspoonful to a tablespoonful
CAUTION	Low Toxicity	An ounce to more than a pint

All products must bear the statement, "Keep out of Reach of Children."

b. Symbol

One of the best ways to catch a person's eye is with symbols. This is why a skull and crossbones symbol is used on all highly toxic materials along with the signal word DANGER and the word POISON.

9. Precautionary Statement

a. Hazards to Humans (and Domestic Animals)

This section will tell you ways in which the product may be poisonous to man and animals. It also will tell you of any special steps that should be taken to avoid poisoning, such as the kind of protective equipment needed. If the product is highly toxic, this section will inform physicians of the proper treatment for poisoning.

b. Environmental Hazards

Pesticides are useful tools but wrong or careless use could cause undesirable affects. To help avoid this, the label contains environmental precautions that should be read and followed. Here are some examples.

- "This product is highly toxic to bees exposed to direct treatment or to residues on crops."

- "Do not contaminate water when cleaning equipment or when disposing of wastes."

- "Do not apply where runoff is likely to occur."

Labels may also contain broader warnings against harming birds, fish or wildlife.

c. Physical and Chemical Hazards

This section will tell of any special fire, explosion or chemical hazard that the product may pose.

10. Statement of Practical Treatment

If swallowing or inhaling the product or getting the product in the eyes or on the skin would be harmful, the label gives the emergency first aid measures. It also tells what types of exposure requires medical attention. The pesticide label is the most important information that can be taken to the physician when someone has been poisoned.

11. Statement of Use Classification

Every pesticide label must show whether the contents are for general or restricted use. EPA puts every product use into one of these two classes. The classification is based on the hazard of poisoning, the way the pesticide is used and its general affect on the environment.

a. General Use

If a pesticide will harm the applicator or the environment very little or not at all when used exactly as directed, it will be labeled a general use pesticide. The label on these products will say: "General Classification."

b. Restricted Use

A restricted use pesticide is one which could cause some human injury or environmental damage even when used as directed. The label on these products will say:

"Restricted use pesticide for retail sale to and application only by certified applicators or persons under their direct supervision."

The restricted use statement must be at the top of the front panel of the label.

12. Directions for Use

The instructions on how to use the pesticide are an important part of the label. This is the best way to find out the correct method of applying the product. The use instructions tell:

- a. The pests the product is registered to control (labels use common names for pests).
- b. The animal, crop or other item the product can be used on.
- c. Whether the product is for general or restricted use.
- d. In what form the product should be applied.
- e. How much of the product to use.
- f. Where the material should be applied.
- g. When the product should be applied.

The types of statements are:

a. Misuse Statement

This section reminds the user that it is a violation of Federal law to use a product in a manner inconsistent with labeling. Do not use a product for a pest not listed on the label unless the "site provision" is applicable. Do not use at more than the recommended rate. Before the product could be registered, EPA required the manufacturer to conduct many tests to be certain the label instructions were correct. Follow them. By following them exactly, the user will get the best results the product can give and will avoid breaking the law.

b. Reentry Statement

If required for the product, this section will tell how much time must pass before a pesticide-treated area is safe for entry by a person without protective clothing. Consult local authorities for special rules that may apply.

c. Category of Applicator

If required for the product, this section will limit the use of certain categories of commercial applicators.

d. Storage and Disposal Directions

Every pesticide should be stored and disposed of correctly. This section tells how to store and dispose of the product and empty containers.

Material Safety Data Sheet

The material safety data sheet (MSDS) is an example of labeling; a sample MSDS for Whitmire PT 260 is at the end of this chapter. The U.S. Department of Labor's Occupational Safety and Health Administration (OSHA) requires manufacturers to make this completed OSHA-20 form available upon request. It contains some information about a pesticide not normally found on a product label. The MSDS is divided into nine sections as follows:

1. Section I. This includes the manufacturer's name, address and telephone number, the chemical and trade names and the formula.
2. Section II-Hazardous Ingredients. This includes some Threshold Limit Values (TLV's). A TLV is defined as the amount of material that a human being can be exposed to in the work place for 8 hours per day, 5 days per week, with no ill affect.
3. Section III- Physical Data. This includes solubility in water, appearance and odor.
4. Section IV- Fire and Explosion Hazard Data. These data are often requested by local fire departments.
5. Section V- Health Hazard Data. This gives the TLV, affects

- of overexposure and emergency first aid procedures.
6. Section VI-Reactivity Data. This includes stability data and conditions to avoid.
 7. Section VII- Spill or Leak Procedures. The corrective steps and waste disposal method are given in this section.
 8. Section VIII- Special Protection Information. This includes requirements for respiratory, skin and eye protection.
 9. Section IX- Special Precautions. The storage and handling precautions and any other precautions are given here.

The health care facility should have on file a MSDS for each pesticide utilized at their facility. These should be kept with the specimen labels and should be readily available at all times.

Record Keeping

The EPA mandates that the pest control technician leave a record of the pesticide applications with the customer. This is the EPA service ticket or sometimes the pest control operator's service report. This ticket or report must include the name and address of the pest control firm; for each pesticide used, the pesticide name, percent of active ingredients and amount used must be given; and it must be signed by the pesticide applicator. These EPA or service tickets/reports should be kept by the health care facility for at least six months.

Pesticide Residue Management

Should an accidental spill occur or there is an accidental application in an undesired area, the pesticide should first be contained so as not to increase the size of the problem area. Then it should be cleaned up and this followed by proper disposal of the clean-up materials.

Spills of Liquids

1. Absorb spills immediately with some absorbent material such as rags or kitty litter. The absorbent material should be placed in a plastic container for later disposal.
2. Wash the affected area with the minimal amount of detergent solution so as not to increase the affected area. Remove the solution with absorbent material.
3. Rinse with a minimal amount of water and remove the water with an absorbent material.
4. Repeat steps 2 and 3.
5. It may be desirable to make a final rinse utilizing a 50% chlorox solution; this is particularly effective with Dursban. Remove the rinse solution with absorbent material.

6. Dispose of the absorbent material as mandated by state regulations.

Spills of Dusts

1. Physically remove as much as possible using two pieces of heavy cardboard. The dust may be returned to the container and the cardboard should be disposed of in the same manner as the used liquid absorbent materials.
2. Remove the remaining material dust with a slightly dampened paper towel. Dispose of these in the same manner as the absorbent material.

CAUTION- DO NOT use a vacuum cleaner because it will put the dust particles into the air. Extensive clean-up procedures will be required if one is used.

Accidental Application

1. Liquids located on the floor or other flat surface should be handled following the steps outlined above for spills.
2. Aerosols or liquids on vertical surfaces should be handled as outlined above but care must be exercised by using the bare minimum amount of solution for clean-up.
3. Dusts should be removed as outlined above under dust spills.

LAWS AND REGULATIONS

Without pesticides, man would not have the food, fiber, shelter and landscape plants needed for survival. However, because pesticides can be dangerous, Congress has passed laws affecting pesticide use. These laws attempt to balance the need for pesticides against the need to protect people and the environment from their misuse.

FIFRA and EPA

The original Federal Insecticide, Fungicide, Rodenticide Act (FIFRA) was passed in 1947. It was basically a consumer protection law and emphasized truth in labeling. In 1970, the EPA was created as the enforcement agency for the FIFRA. In 1972, FIFRA was amended and these amendments changed FIFRA from a consumer protection to a regulatory law. FIFRA was again amended in 1978. This amended version is the law that presently regulates the sale, use and disposal of pesticides.

The important parts of FIFRA which are of concern to the applicator are:

1. Classification of Pesticides

Manufacturers must register every pesticide with the EPA. By regulation, when each pesticide is registered, all its uses must be classified. EPA must decide whether each use is a general or a restricted use.

2. Certification of Applicators

Certification is proof that the applicator knows the safe and correct way to carry out restricted uses. The EPA has set minimum standards of competency for all private and commercial applicators. Each state has developed and administers a program for certification of competency that meets the minimum federal standards.

3. Prohibited Actions

The law names many things an applicator cannot do. The two of most concern are:

- a. A pesticide may not be used other than as the label or labeling directs, except when special regulations allow use at a lower rate than the label recommends.
- b. The disposal of any pesticide or its container can be done only as the label or labeling directs. States have the right to further restrict pesticide usage, but they cannot have laws less restrictive than the federal laws.

4. Penalties

A violator of FIFRA is subject to civil penalties. They can be as much as \$5,000.00 for each offense. Before EPA can assess a fine, the applicator has the right to request a hearing in their own city or county. Violations of the law may also subject the applicator to criminal penalties. They can be as much as \$25,000.00 or one year in prison, or both.

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APPENDIX
PEST MANAGEMENT PREVENTIVE TREATMENT
SERVICE SCHEDULE

Area to be Treated	Treatment Schedule	Treatment Method	Time Required
Dietary (Food Preparation)			
Cafeteria (Food Services)			
Basements & Boiler Rooms			
Lobbies			
Garbage, Refuse Areas			
Receiving Docks			
Laundry Janitor Closets			
Other (Specify)			

[illegible]



PEST CONTROL
World's Largest

**PEST CONTROL OPERATOR'S
SERVICE REPORT**

TYPE SERVICE

- ☐ Regular
☐ Follow-up
☐ Complaint

Date _____ Time In _____ Time Out _____ Route No. _____ Service Day Code _____

Chain
Location Name
Address

Chain #
Chain Dist. #
Location #
Branch #

City & State

1. Lot clean, free of harborages/burrows.
2. Bldg. free of holes, harborages, etc.
3. Doors rodent-proof, windows screened.
4. Storage 1 ft. or more from walls.
5. Storage area clean, free of spillage.
6. Did you discuss Nos. 1-5 with manager?

PCO	MGR.
Yes	No

7. Rodent bait stations inspected/served.
8. Orkin/Aires cleaned/served. No. of units. _____
9. Interior of premises inspected/served.
10. Exterior of premises inspected/served.
11. Location free of dead insects.
12. Location free of dead rodents/droppings.

PCO	MGR.
Yes	No

13. Explain all "no" answers to Questions 1-12 _____

CHEMICALS	MFG. NAME	CONCENTRATION	QTY.
BAYGON (Orkinrol)	DETTEL BACH	1.0%	
BAYGON BAIT (Pellets)	CHEMAGRO	2.0%	
BAYGON BAIT (Jelly)	LETHELIN PRODUCTS	1.0%	
BORIC ACID	SANIT	99.0%	
DIAZINON SPRAY (Orkin-Aid)	DETTEL BACH	☐ 0.5% ☐ 1.0%	
DURSBAN (Orkinban)	DETTEL BACH	☐ 0.25% ☐ 0.5%	
DURSBAN L. O.	DOW	☐ 0.25% ☐ 0.5%	
DURSBAN-DICHLORVOS COMB. (Orkinban Plus)	DETTEL BACH	Dursban 0.5% - Dichlorvos 0.25% ☐ Dursban 0.25% - Dichlorvos 0.125%	
KILLMASTER	POSITIVE FORMULATORS	Dursban 2.0%	
DURSBAN GRANULES (Orkinban)	DETTEL BACH	0.5%	
SAFROTHIN	SANDOZ	0.5%	
WHITMIRE # 230	WHITMIRE	Silica Gel 4.0% Pyrethrins 0.3% Piperonyl Butoxide 3.0%	
WHITMIRE # 240	WHITMIRE	Boric Acid 20.0%	
WHITMIRE # 250	WHITMIRE	Baygon 1.0%	
WHITMIRE # 270	WHITMIRE	Dursban 0.5%	
WHITMIRE # 565	WHITMIRE	Pyrethrins 0.5%	
WHITMIRE 3-6-10	WHITMIRE	Pyrethrins 1.0%	
FICAM W	NORAM	☐ 0.125% ☐ 0.25% ☐ 0.5%	
FICAM DUST	NORAM	1.0%	
MALATHION	DETTEL BACH	2.0%	
PYRETHRUM-DIAZINON COMB. (RD-98)	DETTEL BACH	Pyrethrum 0.33% Diazinon 1.38%	
SYNERGIZED PYRETHRUM	DETTEL BACH	Pyrethrum 1.2% Piperonyl Butoxide 2.4%	
CHLOROPICRIN	INDUSTRIAL FUMIGANT	96.5%	
FUMATOXIN	PESTCON SYSTEMS	Aluminum Phosphide 55.0%	
PIVALYN	MOTOMCO	0.025%	
P. M. P. TRACKING POWDER	MOTOMCO	2.18%	
ZINC-PHOSPHIDE TRACKING POWDER	BELL LAB	10.0%	
BAIT BLOCKS	DETTEL BACH	Diphacinone 0.005%	
BAIT PELLETS	DETTEL BACH	Diphacinone 0.005%	
ORKINIDE RODENT BAIT # 6	DETTEL BACH	Diphacinone 0.005%	
RAMIK-PRO	VELISCOL	Diphacinone 0.005%	
TALON	ICI	Brodifacoum 0.005%	
ZINC PHOSPHIDE BAIT	BELL LAB	2.0%	
OTHER (SPECIFY)			
OTHER (SPECIFY)			

- ☐ No infestation found. Preventive treatment rendered
☐ Infestation found. Treatment Rendered.

Location of Infestation	
☐ RATS	
☐ MICE	
☐ GERMAN ROACHES	
☐ AMERICAN ROACHES	
☐ ORIENTAL ROACHES	
☐ ANTS	
☐ OTHER (SPECIFY)	
☐ OTHER (SPECIFY)	
DATE OF SCHEDULED FOLLOW-UP	If infestation found: Schedule, service and submit PCOSR within 7 days until infestation controlled. Route PCOSR as for regular visit.

INVENTORY					
RODENT TRAPS, BAIT STATIONS & ORKIN/AIRES					
	(1)	(2)	(3)	(4)	(5)
# PREVIOUSLY INSTALLED +					
# ADDED +					
# PICKED UP -					
# CURRENTLY INSTALLED					
# LOST OR BROKEN (Chargeable)					
(1) Ketch Alls @ \$10.00 (2) Rat Traps @ \$7.5 (3) Rodent Cafeterias @ \$10.00 (4) Bait Stations @ \$1.50 (5) Orkin/Aires @ \$35.00 Total Replacement Charge \$ _____					

IS ACTION LINE PLAQUE CURRENTLY DISPLAYED? ☐ Yes ☐ No

I AM SATISFIED WITH THIS MONTH'S SERVICE ☐ Yes ☐ No

SIGNATURE: Location Manager _____

SIGNATURE: Technician _____

BR. MGR. APPROVAL _____

DISTRICT APPROVAL _____

LOCATION STAMP: _____

(52-130-3)

Specimen Label

Dursban* L.O. Insecticide

Controls Numerous Pests In and Around Households

To Be Applied Only by or Under the Supervision of Commercial Applicators Responsible for Insect Control Programs. Not Intended for Use by Homeowners.

Active Ingredient(s):

Chlorpyrifos [O,O-diethyl O-(3,5,6-trichloro-2-pyridyl) phosphorothioate]	41.5%
Xylene Range Aromatic Solvent	11.5%
Inert Ingredients	47.0%

Contains 4 pounds of chlorpyrifos per gallon

E.P.A. Registration No. 464-571

E.P.A. Est. 11715-TN-1

KEEP OUT OF REACH OF CHILDREN

WARNING

AVISO:

PRECAUCION AL USUARIO:

Si usted no lee inglés, no use este producto hasta que la etiqueta le haya sido explicada ampliamente.

PRECAUTIONARY STATEMENTS

Hazards to Humans and Domestic Animals

HARMFUL IF SWALLOWED • HARMFUL IF ABSORBED THROUGH SKIN • CAUSES EYE AND SKIN IRRITATION

Avoid Contact With Eyes, Skin, Or Clothing • Wash Thoroughly After Handling • Remove Contaminated Clothing and Wash Before Reuse • Avoid Breathing Vapors and Spray Mist • Avoid Spraying Food Crops • Keep Container Closed • Handle Concentrate in a Ventilated Area

STATEMENT OF PRACTICAL TREATMENT: IF

Swallowed: Do not induce vomiting. Contains aromatic petroleum solvent. Call a physician immediately. **If On Skin:** Immediately remove contaminated clothing and wash with plenty of soap and water. Get medical attention if irritation persists. **If In Eyes:** Flush eyes with plenty of water for 15 minutes. Call a physician.

NOTE TO PHYSICIAN: Chlorpyrifos is a cholinesterase inhibitor. Treat symptomatically. If exposed, plasma and red blood cell cholinesterase tests may indicate degree of exposure (baseline data are useful). Atropine, only by

injection, is the preferable antidote. Oximes, such as 2-PAM/protopam, may be therapeutic if used early; however, use only in conjunction with atropine. In case of severe acute poisoning, use antidotes immediately after establishing an open airway and respiration.

Physical or Chemical Hazards

COMBUSTIBLE • Do Not Use or Store Near Heat or Open Flame.

Environmental Hazards

This product is toxic to fish, wildlife and birds. Do not apply directly to lakes, streams, ponds or public waters. Do not contaminate water by cleaning of equipment or disposal of wastes. Do not apply directly to water.

NOTICE

Read the entire label. Use only according to label directions.

Before buying or using this product, read "WARRANTY LIMITATIONS AND DISCLAIMER" elsewhere on this label. If terms are not acceptable, return **unopened** package at once to seller for full refund of purchase price paid. Otherwise, use by the buyer or any other user constitutes acceptance of the terms under the Limit of Warranty and Liability.

IN CASE OF AN EMERGENCY

endangering life or property involving this product, call collect 517-636-4400

AGRICULTURAL CHEMICAL

Do Not Ship or Store with Food, Feeds, Drugs, or Clothing

Dursban* L.O.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

Do not tank mix this product with dichlorvos (DDVP) containing products. Can be tank-mixed with methoprene or pyrethrin-containing products.

PESTS INDOORS

General Information: Use DURSBAN L.O. insecticide to control the pests indicated in areas listed below by application as a 0.25% or 0.5% chlorpyrifos spray. Use the 0.25% spray to control light infestations and the 0.5% spray to quickly reduce heavy infestations or as directed. To prepare the spray, dilute DURSBAN L.O. with water as shown in the following SPRAY DILUTION CHART. Repeat the treatment as needed.

SPRAY DILUTION CHART

Gallons of Spray Mixture Desired	Amount of DURSBAN L.O. to Use			
	0.25% spray		0.50% spray	
Water-base spray	fl oz	ml	fl oz	ml
1	2/3	20	1-1/3	40
2	1-1/3	40	2-2/3	80
3	2	60	4	120

* Note: 1 fluid ounce = 2 tablespoonsful = 6 teaspoonfuls

Application Within Food Handling Establishments (Places Other Than Private Residences in Which Food is Held, Processed, Prepared or Served) Including, But Not Limited to, Restaurants, Grocery Stores, Bakeries, Bottling Plants, Canneries, and Grain Mills: Use as a spot treatment in and around both food and nonfood areas to control cockroaches (including strains resistant to certain other insecticides), ants, crickets, firebrats, silverfish, spiders, and stored product insects such as confused flour beetles, saw-toothed grain beetles, Indian meal moths, rice weevils, Mediterranean flour moths, and red flour beetles. Apply as a coarse, low pressure (20 psi or less) spray to localized areas. Do not introduce the spray into the air or allow the spray to contact food or food-contacting surfaces. Areas treated may include dark corners of rooms and closets; along and behind baseboards; beneath and behind stoves, refrigeration units and similar food preparation areas and equipment; floor drains; and around plumbing and other utility installations. For ants apply to ant trails and wherever these pests may find entrance.

Spot treatment may include crack and crevice treatment by applying small amounts of material directly into openings leading to voids and hollow spaces in walls and on and around equipment legs and bases of equipment. Equipment capable of delivering a pin stream of insecticide should be used. Repeat treatment as needed but not more often than once every 7 days in restaurants and similar food service establishments or more often than once every 14 days in other types of food handling establishments. In case of emergency (call back) DURSBAN L.O. may be applied after 2 days from the last treatment, but emergency use should be limited to once per month.

APPLICATION OF THIS PRODUCT IN FOOD HANDLING ESTABLISHMENTS OTHER THAN AS A SPOT AND/OR CRACK AND CREVICE TREATMENT ARE NOT PERMITTED.

Application Within Residential Buildings Including Homes and Apartment Buildings and Within Nonfood Areas of Industrial, Institutional, and Commercial Buildings Including Hospitals, Stores, Manufacturing Plants and Warehouses: For Spot Treatment Only - Apply as a

coarse spray or with a paint brush to localized areas where cockroaches, (including strains resistant to certain other insecticides), ants, clover mites, crickets, firebrats, silverfish, and spiders are found or normally occur including dark corners of rooms and closets; cracks and crevices in walls; along and behind baseboards; beneath and behind sinks, stoves, refrigerators, and cabinets; around plumbing and other utility installations. For ants apply to ant trails also around doors and windows and wherever else these pests may find entrance. For clover mites use a 0.5% spray only. Note: A period of 4 to 7 days is normally required for maximum effect on cockroaches.

For control of carpet beetles, thoroughly apply a 0.5% spray as a spot treatment along baseboards and edges of carpeting, under carpeting, rugs and furniture, in closets and on shelving, and wherever else these insects are seen or suspected.

For control of brown dog ticks, thoroughly apply a 0.5% spray as a spot treatment to infested areas such as pet beds and resting quarters; nearby cracks and crevices; along and behind baseboards, window and door frames and localized areas of floor and floor covering where these pests may be present. Old bedding of pets should be removed and replaced with clean, fresh bedding after treatment of pet areas. Additionally, treat pets with a product registered for use on pets. **DO NOT TREAT PETS WITH THIS PRODUCT.**

For control of fleas, thoroughly apply a fine-particle broadcast spray of 0.25% to infested rugs, carpets, pet beds and pet resting areas. A 0.5% dilution can be used to control heavy infestations or for extended residual control. **Use one gallon of diluted spray per 1600 square feet.** Cover aquaria and fish bowls and remove birds such as canaries from area prior to treating. Other than applicator, treated areas should be vacated during application. **DO NOT PERMIT HUMANS OR PETS TO CONTACT TREATED SURFACES UNTIL THE SPRAY HAS DRIED.** Old pet bedding should be replaced with fresh, clean bedding after treatment. Do not treat pets with this product. To control the source of flea infestation, pets inhabiting the treated premises should be treated with a product registered for application to animals.

WOOD INFESTING INSECTS

General Information: Wear suitable protective clothing when using or handling this product to help avoid exposure to eyes and skin. As a minimum, chemical worker's goggles, protective head covering, neoprene or natural rubber gloves and footwear, a long-sleeved shirt and long-legged pants or coveralls are recommended. To avoid breathing spray mist during application in confined areas, wear a mask or respirator of a type recommended by NIOSH for filtering spray mists and organic vapors. When spraying overhead interior areas of homes, apartment buildings, etc. to the point of runoff, cover all surfaces below the area being sprayed with plastic sheeting or other material which could be disposed of by placing in trash if contamination from dripping occurs.

Do not permit humans or pets to contact treated surfaces until spray has dried.

Dosage and Mixing Instructions: To prepare a 0.5% aqueous emulsion containing 0.5% chlorpyrifos, add 1 1/3 fl oz (40 ml) of DURSBAN L.O. insecticide to every gallon of final spray mixture desired. To prepare a 1% emulsion add 2 2/3 fl oz (80 ml) of product per gallon of spray.

For control of wood-infesting beetles of the families Lyctidae, Bostrichidae, Anobiidae and Cerambycidae in homes and other structures, apply an emulsion containing 0.5% to 1% chlorpyrifos. For treatment of small areas, apply by brushing the emulsion evenly on wood surfaces. For

large or overhead areas, apply as a coarse spray to the point of run-off.

For control of carpenter ants in homes and other structures, apply a solution containing 0.5% chlorpyrifos around doors and windows and other places where carpenter ants enter the premises and where they crawl and hide. Also spray into cracks and crevices or through openings or small newly drilled holes into wall voids where these ants or their nests are present. Use a sufficient amount of coarse spray to cover the area to the point of run-off.

For control of termites (localized areas in structures), apply a 0.5% solution to voids and channels in damaged wood and in spaces between wooden members of a structure and between wood and foundations where infestation is likely to occur. Application may be made to inaccessible areas by drilling and then injecting the solution. Use a sufficient amount of coarse spray to cover the area to the point of run-off. Treatment of localized areas is intended to kill workers and winged reproductive forms of termites in the treated areas and to prevent infestations for a temporary period. This type of application is not intended to be a substitute for soil treatment or mechanical alteration to control subterranean termites.

ATTENTION (Pests Indoors): Do not apply waterbase sprays of this product in conduits, motor housings, junction and switch boxes or other electrical equipment because of possible shock hazard. Do not use in poultry houses or other animal buildings. Thoroughly wash dishes and food handling utensils with soap and water if they become contaminated by application of this product. Do not allow children or pets to contact treated surfaces until spray has dried. Remove pets and cover fish bowls (tanks) before spraying.

PESTS OUT-OF-DOORS

General Information: Use DURSBN L.O. for control of certain pests on outside surfaces of buildings and for perimeter treatment. Consult the following directions for dosage and application details to control the pests listed.

Perimeter Treatment and Pests on Outside Surfaces of Buildings: Use DURSBN L.O. at the rate of 4 fluid ounces per 3 gallons of water (0.5% chlorpyrifos emulsion) to control ants, clover mites, cockroaches, crickets, earwigs, fleas, flies, millipedes, mosquitoes, sowbugs (pillbugs), spiders, and ticks by application as a residual spray or with a paint brush to outside surfaces of buildings, including porches, screens, window frames, eaves, patios, garages, refuse dumps and other areas where these pests congregate or have been seen. Do not treat or allow the spray to contact flowering plants because of possible injury. Repeat treatment as needed to maintain effectiveness.

NOTE: To help prevent infestation of buildings by ants, crickets, earwigs, millipedes, and sowbugs (pillbugs), treat a band of soil 6 to 10 feet wide around and adjacent to buildings, also the building foundation to a height of 2 to 3 feet, where pests are active and may find entrance. Use 8 ounces of DURSBN L.O. per 100 gallons of water and apply as a coarse spray at the rate of about 10 gallons spray mixture per 1000 sq. ft. to thoroughly and uniformly wet the band area.

STORAGE AND DISPOSAL

Do not contaminate water, food or feed by storage or disposal.

STORAGE: Store Above Freezing (32°F). Crystals may form in this product if stored below freezing (32°F). If crystals are present, warm to above 55°F and shake occasionally until crystals disappear.

PESTICIDE DISPOSAL: Pesticide wastes are toxic. Improper disposal of excess pesticide, spray mixture, or rinsate is a violation of Federal Law. If these wastes cannot be disposed of by use according to label instructions, contact your State Pesticide or Environmental Control Agency, or the Hazardous Waste representative at the nearest EPA Regional Office for guidance.

CONTAINER DISPOSAL: Triple rinse (or equivalent). Then dispose of in a sanitary landfill or by other approved State and local procedures.

WARRANTY LIMITATIONS AND DISCLAIMER

The Dow Chemical Company warrants that this product conforms to the chemical description on the label and is reasonably fit for the purposes stated on the label when used in strict accordance with the directions therein under normal conditions of use. THIS IS THE ONLY WARRANTY MADE ON THIS PRODUCT. NO OTHER EXPRESS AND NO IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE IS MADE OUTSIDE OF THIS LABEL. Therefore, neither this warranty nor any other warranty of merchantability or fitness for a particular purpose, express or implied, extends to the use of this product contrary to label instructions (including conditions noted on the label, such as unfavorable temperatures, soil conditions, etc.), under abnormal conditions (such as excessive rainfall, drought, tornadoes, hurricanes, etc.) or under conditions not reasonably foreseeable to or beyond the control of seller.

When buyer or user suffers losses or damages resulting from the use or handling of this product (including claims based on contract, negligence, strict liability, or other legal theories), buyer or user must promptly notify in writing The Dow Chemical Company of any claims to be eligible to receive either remedy given below. The EXCLUSIVE REMEDY OF THE BUYER OR USER and the LIMIT OF LIABILITY of The Dow Chemical Company or any other seller will be one of the following, at the election of The Dow Chemical Company:

- (1) Refund of purchase price paid by buyer or user for product bought, or
- (2) Replacement of amount of product used.

The seller will not be liable for consequential or incidental damages or losses.

The terms of this Limit of Warranty and Liability cannot be varied by any written or verbal statements or agreements. Any employee or sales agent of the seller is not authorized to vary or exceed the terms of this Warranty Limitations And Disclaimer in any manner.

**RQ/INSECTICIDE LIQUID N.O.S.
(Chlorpyrifos)
NA1993**

* Trademark of THE DOW CHEMICAL COMPANY

26066-L4

1084



THE DOW CHEMICAL COMPANY
Midland, Michigan 48640 U.S.A.

PRECAUTIONARY STATEMENTS**HAZARDS TO HUMANS
AND DOMESTIC ANIMALS****CAUTION**

Harmful if swallowed. Do not take internally. Avoid eye contact. Wash thoroughly after handling. Wash contaminated clothing before re-use. Keep away from food, feedstuffs and domestic water supplies. Keep children and pets off treated areas until this material is washed into the soil and grass is dry.

ENVIRONMENTAL HAZARDS

This product is toxic to fish, birds and other wildlife. Do not apply directly to water. Do not apply where runoff is likely to occur. Do not contaminate water by cleaning of equipment or disposal of wastes.

DIRECTIONS FOR USE

It is a violation of Federal Law to use this product in a manner inconsistent with its labeling.

Apply this product only as specified on this label.

STORAGE AND DISPOSAL

Do not contaminate water, food or feed by storage or disposal. Open dumping is prohibited.

STORAGE: If container is damaged: Stop any leaks by repositioning the container or by patching or otherwise repairing the leaks. Take care to avoid contact with pesticide and wear protective gear. On cleanup, wear protective equipment as required to prevent contact with the product. Sweep onto a shovel and put the sweepings into a salvage drum. Dispose of wastes as below.

PESTICIDE DISPOSAL: Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility.

CONTAINER DISPOSAL: Completely empty liner by shaking and tapping sides and bottom to loosen clinging particles. Empty residue into application equipment, then dispose of liner in a sanitary landfill or by incineration if allowed by State and local authorities. If carton is contaminated and cannot be re-used, dispose of in same manner.

PROFESSIONAL ORKINBAN GRANULES

FOR PROFESSIONAL EXTERMINATOR USE ONLY

Contains DURSBAN® Insecticide

*Dursban® Trademark The Dow Chemical Company—U. S. Patent #3,244,586

ACTIVE INGREDIENT:

Chlorpyrifos (O,O-diethyl O-(3,5,6-trichloro-2-pyridyl)

phosphorothioate) ----- 0.5%

INERT INGREDIENTS ----- 99.5%

TOTAL ----- 100.0%

KEEP OUT OF REACH OF CHILDREN**CAUTION****STATEMENT OF PRACTICAL TREATMENT**

If swallowed—Drink 2 glasses of water and induce vomiting by touching back of throat with finger. Do not induce vomiting or give anything by mouth to an unconscious person. Get medical attention. If on skin—In case of contact, remove contaminated clothing and immediately wash skin with soap and water. If in eyes—Flush eyes with plenty of water and get prompt medical attention.

NOTE TO PHYSICIAN—Active ingredient is a cholinesterase inhibitor. Treat symptomatically. Atropine only by injection is an antidote.

AGRICULTURAL CHEMICAL—DO NOT SHIP OR STORE WITH FOOD, FEED, DRUGS OR CLOTHING.

DIRECTIONS FOR USE

Pests of Lawns and other Ornamental and Recreational Turf Grass Areas:

Ants, brown dog ticks, chinch bugs, crickets, cutworms, earwigs, grasshoppers and sod webworms (lawn moths):

Apply as a broadcast application at the rate of 5-7 lbs. per 1000 sq. ft. or 200-300 lbs. per acre. Water after application. (Use setting #5 on Model B Cyclone Spreader.)

CAUTION—Keep children and pets off treated areas until lawn is dry. Fish may be killed if their water is contaminated with this product.

Ants, Crickets, Earwigs and Ticks Outside of Dwellings:

Barrier Application: Apply as a band or barrier application 12-18" wide at the rate of 1 lb. per 25 running feet.

Spot Application: Apply in areas of heavy infestation or suspected harborages at the rate of ½ lb. per 100 sq. ft. Apply to hiding places near buildings, tree trunks, shrubs, outbuildings, using a Cyclone or similar spreader.

EPA Reg. No. 6754—69

EPA Est. No. 6754—GA—1

NET WEIGHT 50 POUNDS

NOTICE:

Because Dettelbach Pesticide Corporation has no control over storage, handling, and conditions of use, which are of critical importance, Dettelbach Pesticide Corporation makes no representation or warranty, either expressed or implied, for results due to misuse, improper handling or storage of this material. Nor does Dettelbach Pesticide Corporation assume any responsibility for injury to persons, crops, animals, soil or property arising out of misuse, improper handling or storage of this material.

Dettelbach Pesticide Corporation

4113 PEACHTREE ROAD, N.E. - ATLANTA, GEORGIA 30319

U.S. DEPARTMENT OF LABOR Occupational Safety and Health Administration	Form Approved OMB No. 44-R1387
MATERIAL SAFETY DATA SHEET	
Required under USDL Safety and Health Regulations for Ship Repairing, Shipbuilding, and Shipbreaking (29 CFR 1915, 1916, 1917)	

SECTION I	
MANUFACTURER'S NAME WHITMIRE RESEARCH LABORATORIES, INC.	EMERGENCY TELEPHONE NO. (314) 225-5371
ADDRESS (Number, Street, City, State, and ZIP Code) 3568 Tree Court Industrial Blvd., St. Louis, MO 63122	
CHEMICAL NAME AND SYNONYMS O,0-diethyl 0-(2-isopropyl-6-methyl-4-pyrimidinyl)	TRADE NAME AND SYNONYMS PT 260
CHEMICAL FAMILY Organic Phosphate Insecticide Phosphorothi-	FORMULA 1.0% Diazinon
date EPA Reg. No. 499-156-AA	

SECTION II - HAZARDOUS INGREDIENTS					
PAINTS, PRESERVATIVES, & SOLVENTS	%	TLV (Units)	ALLOYS AND METALLIC COATINGS	%	TLV (Units)
PIGMENTS			BASE METAL		
CATALYST			ALLOYS		
VEHICLE			METALLIC COATINGS		
SOLVENTS & Propellants	99.0	2238 mg/m ³	FILLER METAL PLUS COATING OR CORE FLUX		
ADDITIVES			OTHERS		
OTHERS					
HAZARDOUS MIXTURES OF OTHER LIQUIDS, SOLIDS, OR GASES				%	TLV (Units)
Diazinon [O,0-Diethyl 0-(2-isopropyl-6-methyl-4-pyrimidinyl)				1.0	0.1 mg/m ³
Phosphorothioate)					

SECTION III - PHYSICAL DATA			
BOILING POINT (°F.)	n/a	SPECIFIC GRAVITY (H ₂ O=1)	1.335
VAPOR PRESSURE (mm Hg.)	3620 mmHg	PERCENT VOLATILE BY VOLUME (%)	99%
VAPOR DENSITY (AIR=1)	n/a	EVAPORATION RATE (_____ = 1)	n/a
SOLUBILITY IN WATER	Insol.		
APPEARANCE AND ODOR Sprays as a strong mist with characteristic Diazinon odor.			

SECTION IV - FIRE AND EXPLOSION HAZARD DATA			
FLASH POINT (Method used) None (FIFRA Method 807.3)	FLAMMABLE LIMITS Nonflammable	LeI	UeI
EXTINGUISHING MEDIA			
SPECIAL FIRE FIGHTING PROCEDURES			
UNUSUAL FIRE AND EXPLOSION HAZARDS			

SECTION V - HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE 10 mg/M ³ (approx. sol'n method)
EFFECTS OF OVEREXPOSURE Discomfort or tightness in chest, difficulty in breathing, stomach pains, nausea, vomiting, diarrhea, cramps, headache, nervousness, weakness, nonactive pinpoint pupils or blurred vision. Symptoms may not occur until 1-8 hours after exposure.
EMERGENCY AND FIRST AID PROCEDURES Remove person from area where pesticide is present. Call physician. Atropine is antidote--consult physician for an emergency supply if competent personnel are available to administer atropine. Also, 2-PAM is antidotal and may be used in conjunction with Atropine. Artificial respiration may also be required.

SECTION VI - REACTIVITY DATA

STABILITY INDEFINITE when used according to directions	UNSTABLE		CONDITIONS TO AVOID Do not spray into open flame or onto very hot surfaces.
	STABLE	X	
INCOMPATIBILITY (Materials to avoid) NONE			
HAZARDOUS DECOMPOSITION PRODUCTS Thermal decomposition in open flame will result in halogen acids and carbon dioxide.			
HAZARDOUS POLYMERIZATION	MAY OCCUR		CONDITIONS TO AVOID
	WILL NOT OCCUR	X	

SECTION VII - SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED If container begins to leak (through puncture, etc.) allow it to discharge completely in well-ventilated area, then dispose in safe place. In case of spillage on skin, wash thoroughly with soap and water. Consult physician immediately if illness occurs.
WASTE DISPOSAL METHOD Aerosol cylinder is not refillable. Do not attempt to recharge. When cylinder is exhausted, discard in safe place. Do not throw in fire.

SECTION VIII - SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION (Specify type) None required--avoid breathing of spray mist.		
VENTILATION	LOCAL EXHAUST	SPECIAL
	MECHANICAL (General) Provide adequate ventilation of treatment area.	OTHER
PROTECTIVE GLOVES None required--avoid contact with skin.		EYE PROTECTION None required--avoid contact with eyes.
OTHER PROTECTIVE EQUIPMENT None required		

SECTION IX - SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING Keep out of reach of children. Contents under pressure. Do not puncture. Do not store near heat or open flame. Exposure to temperatures above 130°F may cause bursting.
OTHER PRECAUTIONS Wash thoroughly after using. Avoid contamination of food, utensils, and food preparation areas.

SECTION IV: Waste Management

These papers outline safety precautions to be taken to ensure proper management of toxic and hazardous hospital wastes.

STRATEGIES FOR MANAGING INFECTIOUS HOSPITAL WASTES

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Bethesda, Maryland 20205

ABSTRACT

The need to prudently manage hospital wastes considered to be hazardous or infectious is a growing concern today, within hospital circles as well as without. The general public has become more aware, more sophisticated and more vocal about its insistence that these issues be addressed appropriately. Administrators and managers in the hospital/biomedical research fields are beginning to realize the need for professional responses to the perceived and real concerns of this educated public.

Administrators have overall responsibilities, be they legal, moral or ethical, to ensure that appropriate waste management practices are followed by all personnel. Many resources are already available (e.g., epidemiologists, infectious control committees, microbiologists, lab directors, etc.) to assist in developing the best approach and in coordinating appropriate programs for their own institutes. There is no "best" system for all hospitals or biomedical research settings. Alternatives exist for handling infectious waste. Administrators need to know what some of these alternatives are and what options can be considered. The other chapters in this section present specific suggestions for managing chemical, toxic and radiological wastes. The focus of this chapter is on infectious materials, using experiences at the National Institutes of Health (NIH) as an example of a complex system, interdependent on many different organizational units.

The NIH is situated on a 300 acre campus in Bethesda, Maryland, and has more than sixty buildings dedicated to various biomedical research activities. Waste materials are generated at the rate of 25-30 tons each day, 6 tons of which are considered to be potentially infectious and are incinerated on-site in one of the incinerators. A significant portion of this waste is generated in the Clinical Center, a 14-story complex containing a 550-bed ambulatory care hospital, research laboratories, animal facilities and a myriad of services necessary to support these activities. This arrangement provides for a unique opportunity for patient care/research interactions within the various National Institutes of Health represented in this facility: Aging, Alcohol Abuse and Alcoholism, Allergy and Infectious Diseases, and Mental Health.

Infectious Materials

Although many different types of microorganisms are found in hospital and biomedical research environments, the microorganisms of greatest concern are those with potential for human infection and spread resulting from handling infectious body fluids or by direct contact with patients. Infection control procedures for access to patient rooms, for handling linens and gowns, and for disinfection/decontamination practices have been prescribed for many communicable diseases, based on risk assessments for these diseases.

As an example of the prudent practices developed for handling materials which represent moderate risks to hospital and laboratory workers, consider two blood-borne diseases. The threat of acquiring hepatitis B (and hepatitis nonA-nonB) is real for these occupational classes. The threat of contracting AIDS is also perceived to be real by persons who handle blood products and other body fluids. The virus responsible for hepatitis B can be found in human blood and blood products, urine, semen, cerebrospinal fluid and saliva obtained from persons infected with this virus. Infections have resulted from workers' exposure to the virus by droplet exposure of mucous membranes, parenteral inoculations (from needle sticks, broken glass or other punctures), or by contact exposure of broken skin with infectious materials. Personnel handling contaminated materials are advised to wear gloves. Consideration should be given to providing Heptavac immunizations for all persons at high risk (nursing staff as well as others). Nonimmunized individuals who report to the Occupational Medical Service that they would have been injured by needle "sticks" or similar puncture wounds are provided this vaccine therapy.

Immediate and proper spill clean-up is important because the virus may be present in dried blood or blood products for several days. Overt spills of blood (and other body fluids) should be covered with adsorbent paper and saturated with a suitable disinfectant, such as chlorine or iodine based compounds. All materials should be treated subsequently as potentially infectious.

The method of choice for primary decontamination of materials contaminated with infectious microorganisms is steam sterilization. Glass and plasticware, media, blood tubes, and other materials can easily be sterilized in this manner and then handled as general non-contaminated waste.

AIDS body fluids are perceived of as being at least equally hazardous as hepatitis virus-containing materials. In truth, there are no confirmed cases of hospital or laboratory acquired infections of AIDS, despite many reported incidents of overt

exposures (including needle sticks) to materials known to come from AIDS patients. The virus (HTLV3) which causes this syndrome does not appear to survive in dried blood products. Moreover, HTLV3 is easily inactivated experimentally by many common disinfectants, including alcohol, chlorine and iodine.

Various locations throughout the Clinical Center have been identified as primary generators of potentially infectious waste materials: patient care areas, surgical suites, autopsy areas, research laboratories, animal rooms, and clinical and pathological diagnostic laboratories. Activities in many of these areas also result in the generation of chemical and radioactive wastes. (Construction waste materials produced during renovations within the Clinical Center must also be evaluated for specific hazards, such as asbestos, and subsequently removed appropriately.)

Infectious (or potentially infectious) materials are identified, packaged, labeled, transported and disposed of in a way to minimize the exposure potential for all patients, employees and visitors. Waste materials must not pose deleterious environmental effects, as a public threat to health, as a public nuisance, or as potential contaminants to ground water supplies. For those wastes that are disposed of off-site, special care is given to those materials which may be perceived of as being infectious (i.e., red liquids are "always" blood) or which may contribute to other societal problems (e.g. syringes).

At the NIH, medical pathological wastes (MPW) are defined as all wastes containing or contaminated with potentially infectious agents or minimally contaminated with toxic chemicals. (Chemical and radioactive wastes are specifically handled through other mechanisms.) Examples of MPW include:

- All disposable clothing, towels, sorbent liners, and similar materials potentially contaminated with infectious agents or minimally contaminated with toxic chemicals.
- Clinical specimens (urine, feces, blood) that are processed in the diagnostic laboratories, or other body parts that may be handled in the associated research laboratories.
- Wastes from surgical and autopsy suites.
- All syringes and needles not contaminated with radioactive materials. (Radioactively-contaminated liquids, solids, and animal carcasses are handled separately.)

- All animal carcasses (except those contaminated with radioactive materials) and all potentially contaminated animal bedding.
- Disposable glass and plastic labware, and other materials, such as media, which may be contaminated with infectious materials, blood products or minimal amounts of toxic or carcinogenic chemicals.

General Packaging Instructions. Materials shipped to our on-site pathological incinerators are packaged in 3 mil thick plastic bags placed in cardboard boxes (2.6 cubic feet, 90 pound capacity). Wet materials are double bagged; each bag is sealed separately to minimize leakage. Each box is packaged to a maximum weight of 40 pounds. Fiberglass filament tape is used to seal the boxes; other tapes have not been found strong enough to maintain the integrity of the boxes during subsequent handling. Personnel who package the boxes affix an appropriate label identifying building location, type of material contained in the box and any special precautionary information. The purpose of this labeling is to allow housekeeping personnel to obtain additional information in the event of a spilled, broken or leaking box so that appropriate directions for subsequent decontamination/clean-up procedures can be given.

Patient Care Areas. In practice, all waste materials which come from patient rooms, treatment areas, and nursing stations are packaged in MPW boxes. Empty IV bottles (which have had their needles removed) are packaged and identified as non-contaminated glass. This allows for down-stream segregation to minimize the amount of glass going to the incinerators. Personnel are instructed on the proper disposal of chemicals (particularly flammables) and empty aerosol cans, which also result in incinerator damage if burned.

Sharps. Many different commercial "systems" currently are available for handling needles and syringes, but the underlying principles for handling "sharps" are the same. In contrast to recent past practices for clipping needles, clipping is now discouraged; this practice creates aerosols (resulting in hand as well as inhalation exposures). Clipping also increases the possibility for accidental punctures. Prudent practice calls for placing the uncapped intact needle and syringe into a leakproof, puncture resistant container. Suitable hard plastic containers are available for temporary secure storage in patient rooms, for inclusion on a patients' medication cart or for installation in a medical prep room. Care must be exercised while placing needles and syringes into these containers to minimize self-innoculation, particularly as the containers fill up. Some containers have a rubberized flange in the opening that will cause needles to

"hang-up." We recommend that when the containers are approximately 3/4 full, the opening be secured, taped and placed within an MPW box for safe transport to the incinerator. Incineration is one successful terminal treatment for needles and syringes, ensuring against their entering into landfill operations as intact and potentially infectious sharps materials. Encapsulation, maceration or other mechanical means for rendering these sharps materials unusable/unrecognizable/noninfectious may also be appropriate and should be evaluated as a part of any waste management program.

From an infection control perspective, broken glassware and other sharps materials only need to be treated as potentially infectious when contaminated with certain microorganisms. Unfortunately, in hospital and laboratory environments, the potential for contamination by infectious or hazardous agents is very high and all puncture wounds must be treated with concern. Sharps materials that have been decontaminated, generally by steam sterilization, are contained in glassware disposable boxes to minimize their physical hazards and treated as general waste. These containers are marked to alert all personnel that the boxes contain sharps.

Surgical Autopsy Areas. Body fluids typically are collected in disposable plastic suction bottles, which are sealed and placed upright in the corners of an MPW box, inside a 3 mil plastic bag. Other disposable materials (drapes, towels, etc.) are packaged in such a way as to ensure that the sealed containers are maintained in an upright position.

All tissues and surgical specimens are placed into plastic containers and delivered directly to the pathology department. These materials, plus materials from the autopsy suite, are packaged as MPW by the dieners. These individuals personally transport and load the boxes into the pathological incinerators.

Laboratory Wastes. Clinical and research laboratories can be sources of known or unknown microbial contaminants. Body fluids from (potentially) infectious patients are often manipulated in such a way (by centrifuging, vortex mixing, pipetting with mechanical devices, etc.) that aerosols are created or that splatters occur. The potential is relatively high for repeated exposure to infectious microorganisms, and laboratory personnel need to maintain a correspondingly high level of awareness of these hazards.

Potentially infectious waste materials are often referred to as "biohazards," drawing attention to the need for special handling (as distinct from general, chemical or radioactive wastes). Infectious laboratory wastes can be decontaminated by

suitable exposure to chemicals, by steam sterilization or by incineration. All three systems are acceptable. Chemical decontaminants are matched to the microorganisms being manipulated. Autoclaves are available in close proximity to the laboratory and are checked routinely for proper function. When infectious materials are removed from the laboratory for transportation to a remote autoclave or to the incinerator, proper packaging is done to minimize the chance for spread of disease-causing microorganisms and for possible "sharps" problems.

Increasing numbers of laboratories operate almost exclusively with pre-sterilized disposable glassware and plasticware. In some instances, the routine practice of autoclaving all used glassware, pipettes, culture tubes, plates, etc. leaving these laboratories has been discontinued. Laboratory personnel are instructed in the proper packaging of these contaminated materials as MPW.

Discarded and potentially infectious materials are sometimes collected in bright orange "biohazard bags" for subsequent steam sterilization. Biohazard bags are inherently a good idea, but are often misused. Calling them "autoclave bags" is a misnomer, for, once properly taped closed, these plastic bags effectively prohibit steam penetration, even under pressure, and thus prevent sterilization. A cup or so of water added to the bag before sealing will allow steam to be generated in the bag. Alternatively, the bag must be opened before autoclaving to ensure steam penetration. Most biohazard bags look the same after sterilization as before sterilization.* This is an important consideration, for housekeeping and other personnel may not be able to distinguish a bag that has been properly sterilized from one that has not. When autoclaves are located at a site other than the laboratory, non-autoclaved biohazard bags may inadvertently wind up in the same location as all other bagged trash. This is obviously inappropriate and a potentially serious problem. We recommend that sealed, intact biohazard bags (autoclaved or not) be sealed into 3 mil plastic bags and placed in a MPW box for subsequent incineration.

Laboratory activities occasionally involve the use of hazardous or toxic chemicals, such as antineoplastic drugs or carcinogens. At the NIH, bulk waste chemicals are disposed of using the services of a licensed contractor. Residual chemicals, as might be found inside pipettes, on disposable gloves or on plastic-backed adsorbent bench covers are disposed of as MPW.

*Some bags are now being marketed which undergo an ink color change after appropriate temperature/time/humidity conditions have been met.

(Pathological incinerators are typically operated in the 1000°C range, with a 2-second gas dwell time; considered to be suitable destruction conditions for these chemicals. Since the operation of incinerators is under the control of state environmental agencies, it is important to follow local applicable codes and regulations.)

Animal Room Wastes. Animal carcasses are treated as MPW, even though the animals may not have been exposed to (potentially) infectious microorganisms. In our circumstances, it is expeditious not to have to identify and segregate dead animals into different waste streams. The bedding from animals not considered to be "infectious," however, is not treated as MPW. (At other hospitals or biomedical research institutes it may be desirable to segregate animal carcasses or to include all animal bedding in one waste stream; economics, odor control or public perception are strong situational motivators.)

Animal care personnel charged with the responsibility of packaging these materials are aware of box weight limitations and fluid content. Double bagging is generally needed. Animal carcasses in labeled plastic bags may be placed inside a freezer designated for temporary storage. (In states which govern infectious wastes, there generally are specific time limits and temperature specifications for storing infectious waste materials before removal to an off-site incinerator facility.)

Management Facilities. When the hospital administrator decides to initiate a waste handling program, one individual (or a designated group) must be delegated responsibility for the program. In turn, the managers of appropriate service areas must be supported and encouraged. One strategy that has worked well is to gather together all those persons who have responsibilities for different aspects of the system and charge them with developing the mechanics for attaining the desired goals. A participating management approach generally will elicit ideas as well as concurrence on implementation.

Maintenance and support services personnel should be involved with developing the infectious and hazardous waste management programs. These persons may be exposed inadvertently to a variety of microbiological or chemical agents, for example while unclogging drains, servicing air handling systems, or repairing hospital or laboratory equipment. Often they are aware of potentially hazardous situations (or, conversely, may be totally unaware of others). Eliciting their involvement early on can result in a greater understanding of the issues, help identify areas for needed training, and greatly assist in the implementation of and compliance with the final program.

Maintenance and support personnel are also the persons involved with operating or servicing the autoclaves, incinerators, compactors and other equipment associated with the waste streams. Management must be assured that these persons are adequately trained, that they have appropriate equipment and that they are providing the necessary services.

Employee awareness programs must be initiated and maintained. Each functional group must understand why such a program is needed and what their role is in making the system work. Necessary training should be provided, for existing and new employees, on responsibilities, techniques, spill clean-up, accident reporting and possible medical surveillance (e.g. a "sharps" program).

Finally, if an "outside" contractor is engaged to handle the hospital's waste stream, management has other responsibilities. The contractor's operation, reputation, services and facilities must be understood thoroughly to ensure that the hospital's wastes are properly handled. Responsibility of the generator of hazardous waste does not end when the truck drives away from the loading dock.

SUMMARY

Hospitals, clinics, biomedical clinical and research laboratories, animal research facilities, and teaching institutions are recognizing their responsibilities for prudently managing their infectious wastes. Program development involves careful evaluation of the source within the institute that may be generating infectious waste materials and performing appropriate risk assessments to determine real and potential biohazards. Decontamination, packaging, "containerization" and transporting are procedures which need careful evaluation. Communication with employees is imperative for understanding and compliance, and can be accomplished through initial training and ongoing awareness programs. Finally, all activities involving infectious and hazardous materials should be critically reevaluated periodically.

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SHARPS MANAGEMENT

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ABSTRACT

This section discusses the occupational injury risks, hospital infection control risks and hazardous waste concerns as they relate to the mismanagement of "sharps" in the health care industry. Older and newer systems for managing sharps are discussed in some detail. The components of a comprehensive sharps management system are presented. The merits of such a system are highlighted and a system design is outlined. This section contains references to helpful state and federal publications as well as a list of private vendors currently providing sharps management services. The author gained experience and knowledge in this area as a result of his involvement with his hospital's safety committee.

GUIDELINES FOR DESIGNING A SHARPS MANAGEMENT SYSTEM

Materials management of hypodermic syringes, blood collection devices, scalples and other "sharps" can effectively reduce the number of puncture wounds suffered by health care personnel. In addition, such a management system should make it easier for a health care facility to comply with hazardous solid waste regulations.

For the purpose of this discussion, "sharps" is defined as those items or materials such as hypodermic syringes, needles, scalples, etc. that are utilized in a health care facility either as a disposable or non-disposable item which can cause a puncture wound or laceration (broken glass is included in this category). The term "health care facility" includes hospitals, ambulatory specialty clinics, surgical centers, public health centers and nursing homes. In this list I shall include veterinary hospitals and treatment facilities as well as research facilities in which sharps are utilized. The terms "hazardous wastes" and "infectious wastes" are as defined in the North Carolina Solid Waste Management Rules and Amendments (G.S. -130A-294, effective July 1, 1985).

In the many hospitals that I am familiar with, syringe related puncture wounds account for a large portion of the occupational injury classification known as the Hospital Acquired Penetrating Contact (HAPC). Because many puncture and laceration

injuries are caused by an assortment of sharps other than needle syringes, the term HAPC has gained popularity.

At some facilities, HAPC's account for 50% or more of the reported occupational injuries. The cost of these injuries may vary from \$150.00 to \$350.00 per incident. These figures include cost factors such as lost time away from the work site, time related personnel cost of employees involved in administering prophylaxis, additional laboratory costs, follow-up exams, form processing, insurance costs and possibly Workman's Compensation. A typical 350 bed hospital probably averages ten syringe related HAPCs per month. These injuries could translate into an annual burden of \$42,000.00. Causes of syringe related HAPC's vary. An analysis of these incidents at Durham County General Hospital revealed the causes (Table 1) and the category of personnel affected by HAPC's (Table 2):*

Table 1. Causes of Syringe Related HAPC's

Percent	Cause
44%	Careless technique in handling syringe
28%	Recapping/reinsertion of needle cap after injection
8%	Syringe hidden in linen, trash, etc.
12%	Needle clipper box-additional handling
8%	Unexpected movement by patient

Table 2. Hospital Personnel Incurring Injuries

Percent	Categories of Personnel
44%	Staff Nursing
18%	Special Services/Respiratory Specialists
7%	Student Nurses
7%	Laboratory
7%	Emergency Medical Services Personnel
7%	Pharmacy/I.V. Nursing
4%	Operating Room Personnel
4%	Laundry/Housekeeping Personnel

* Statistics based on injuries incurred prior to implementing a comprehensive sharps management system. Since implementing the sharps management program, the number of syringe related injuries has decreased by 50%.

A comprehensive sharps management system can be cost effective for any size hospital in curbing the cost of HAPCs. Such a system should address the problems of hidden sharps, handling of used syringe and managing sharps as a hazardous waste.

Hidden Sharps:

In hospitals, sharps are found in patient care and patient treatment areas, laboratories, pharmacies and medication carts. Because of improper disposal techniques, lack of written procedures, improper syringe destruction techniques, sharps can be found in waste containers, bed linens, trash shutes, etc., thereby causing injuries to housekeepers, laundry personnel, maintenance personnel, and other support staff. These people are the innocent victims. Contaminated sharps present the double hazard of inducing disease and inflicting injury. Hospital infection control concerns become complicated if the offending sharp was used in the treatment of a patient with an infectious disease. All sharps pose the hazard of physical injury through cuts or puncture wounds.

Used/Contaminated Syringes:

American hospitals rely heavily on disposable patient-care products. Most hypodermic syringes used in the health care industry today are disposable. To prevent these intact, reusable, contaminated syringes from falling into the hands of society's undesirables. North Carolina enacted a law that states in part:

It shall be unlawful for any firm, organization, corporation, hospital, medical clinic, their agent or employees to discard a hypodermic syringe or needle unless such instrument is first rendered inoperable for future use...." (G.S. 90-113 4A, 1977)

Most states have similar syringe destruction laws. The North Carolina statute does not specifically state how "rendering inoperable" should take place. An acceptable method which involves the mechanical clipping of the needle at the syringe hub gained popularity during the late seventies as a practical method of complying with the syringe destruction laws. Manufacturers responded to this need by offering special syringe melt down ovens, large mechanical chopper-grinder machines, hand operated syringe destroyers, and the hand operated needle cutter/clipper boxes. The small needle clippers are currently in use in the majority of health care facilities in North Carolina.

Studies have indicated that the destruction method of needle clipping is problematic and undesirable. This method requires additional handling of the contaminated syringe. The process is labor intensive and the cutters must constantly be sharpened, cleaned and replaced. Destroyed syringe parts and needles must be collected, boxed and transported to an autoclave, removed and eventually taken to a landfill or incinerator. Some facilities have the capability of incineration on site. This factor is advantageous because the costs of autoclaving and transportation to a disposal site are eliminated.

Nursing personnel, phlebotomy technicians and others who destroy syringe needles by clipping, risk exposure to infectious materials from splattered and aerosolized blood. It is important to note that the Center for Disease Control discourages this clipping/cutting method. A number of years ago the Center recommended that needles and syringes be left intact and that they be placed in rigid containers. Full containers should be disposed of in accordance with approved and accepted methods; i.e. incineration, autoclaving or landfilling.

Sharps: A Hazardous Waste:

Hospital generated sharps are a hazardous waste and are regulated by law. I encourage the reader to obtain a copy of the Environmental Protection Agency's Draft Manual for Infectious Waste Management-1982. This manual discusses environmentally acceptable techniques for infectious waste management (including sharps management). This manual provides citations of federal and state regulations as well as non-governmental guidelines applying to infectious waste management. For an updated version write to:

U.S Environmental Protection Agency
Office of Solid Waste
Washington, D.C. 20460

North Carolina runs its own Solid and Hazardous Waste Management Program. Anyone designing a sharps management system for his/her hospital should, in my opinion, have reader access to North Carolina's Solid Waste Management Rules and Amendments (July 1985). Copies may be obtained by writing to:

North Carolina Department of Human Resources
Division of Health Services
Environmental Health Section
Solid and Hazardous Waste Management Branch
Box 2091
Raleigh, North Carolina 27602

Sharps as a hazardous material must be managed properly from cradle to grave. If your hospital operates under an accreditation of the Joint Commission on Accreditation of Hospitals (JCAH), then you should be aware that this commission, through its standards promulgation process, encourages hospitals to identify the potential hazards of sharps, and to require special precautions to be taken in their handling.

In July of 1985, amendments to North Carolina's Solid Waste Management Rules will require specific treatment for a variety of infectious wastes prior to sanitary landfill disposal. The list of infectious wastes includes:

1. Microbiological Wastes
2. Pathological Wastes
3. Blood Products
4. Sharps

Sharps are a new entry into this list and I view this inclusion as a welcomed regulation. The state approved method for the treatment of sharps prior to landfill disposal is "multilution or incineration." From a regulatory standpoint, I should note that requirements for licensure and certification for hospitals by the North Carolina Department of Human Resources do not specifically address the management of sharps. Hospitals are urged to "sterilize all contaminated disposable supplies and wastes which are not incinerated prior to transferring them into a general waste disposal system." Nationally the regulations of health care infectious wastes (including sharps) varies considerably. A few examples follow:

<u>Minnesota:</u>	Land disposal of infectious wastes is prohibited.
<u>Kentucky:</u>	Hospitals must have an incinerator capable of destroying infectious wastes.
<u>Alabama:</u>	Infectious wastes must be incinerated on site.
<u>Tennessee:</u>	Hospital infectious wastes must be autoclaved or incinerated.
<u>New Hampshire:</u>	Health care wastes must be incinerated.
<u>Hawaii:</u>	Infectious wastes must be treated or otherwise rendered safe prior to disposal. Double bagging is considered a means of rendering an untreated waste safe.

SOLUTIONS

A comprehensive sharps management system in any health care facility will enable that facility to:

1. Reduce the incidence of occupational injuries caused by sharps.
2. Enhance the overall effectiveness of its infection control program.
3. Provide cradle to grave accountability of sharps utilized in the facility.
4. Ensure that the facility is in compliance with local and state regulations that require the rendering inoperable of syringes and needles prior to disposal.
5. Ensure compliance with local, state, and federal solid waste regulations.

The design of such a system should include mechanisms for:

1. Collection of contaminated wastes.
2. Treatment/detoxification of contaminated syringes.
3. Mutilation of syringes.
4. Disposal of all materials.
5. Written procedures that prohibit, in most situations, the recapping or resheathing of a contaminated syringe, needle, I.V. device or blood collection device.
6. Alternate work practices that minimize additional handling of contaminated sharps.

To be effective in reducing the incidence of HAPCs caused by sharps, the system should include an engineered feature known as the "sharps container." These containers should be tough, rigid, puncture proof, tamper proof and leak proof. The containers may vary in size depending on their usage, i.e. patient's room, medication cart, blood-gas machine, pharmacy I.V. make up area, operating room, Emergency Medical Service Ambulance, Radiology special procedure rooms, emergency rooms, etc. The containers can also be conveniently located on the walls in the corridor between the rooms for easy access by all. The majority of sharps used in hospitals are syringes and they vary in size from 1 cubic centimeter capacity to 60 cc capacity. Some hospital areas will utilize more of the larger syringes, i.e. cardiac care units, and consequently, their sharps containers will fill faster. It will be necessary to devise a system for emptying or replacement so that the containers never become completely filled. A filled or overflowing sharps container is useless and can become a source for HAPC's.

Any hospital or health care facility planning a sharps management program will need to develop a cost justification

program for approval. The development of this plan is the responsibility of the Infection Control Committee, Quality Assurance Committee or Safety Committee. To be effective in reducing overall losses, such a system must be utilized in all areas of the health care facility. Illustrative in-house and contract system costs are presented in the following examples:

In House Systems: 200 bed hospital
- \$15 - \$35 -for fabricated reusable metal containers
- \$1,500 - \$9,000 - Mutilation Machine*
- Salary of a full time employee responsible for managing the system.

Contract Systems: 350 bed hospital
- \$1,100 - \$2,100 monthly cost

The contractor provides reusable containers to the facility. Full containers are exchanged for clean, empty containers on a weekly or monthly schedule. The contractor processes the sharps at his plant, i.e. autoclaving, mutilation or incineration prior to landfilling. Contract systems are beneficial because:

1. Capital equipment purchases for incinerators or mutilation machines are not required.
2. Additional employees are not required.
3. Expenses due to equipment down-time or replacement cost are the responsibility of the contractor.
4. Competitive pricing lowers the cost to the facility.

Engineered/Marketed Systems: 350 bed hospital
-\$8,000 - \$26,000 in machine costs
-\$2 - \$70 in container costs

The vendor will sell or lease "one-time-use" disposable sharps containers or durable reusable sharps containers. (Disposable containers are usually undesirable.) The vendor will sell or lease a mutilation machine or autoclave type melt-down oven.*

A number of North Carolina hospitals have implemented a variety of sharps management systems. All of these "newer" systems are based on the sharps container. Whole disposal or disposing of an intact syringe is made easier when the sharps container is conveniently located near or at the syringe usage site. It is my opinion that the ideal system will have a container in every patient's room. If contaminated syringes must

*Facilities with approved incinerators do not need mutilation machines.

be carried out of the patient's room to a container located on a corridor wall or medication cart, it should be carried in a tray or other device. A system designer should develop written procedures that address the hazards of recapping and hand carrying contaminated syringes. Written procedures must be acceptable to staff and compatible with the system.

Facilities that have access to incinerators are at an advantage to others since incineration will at one time render syringes inoperable, detoxify the collected sharps and accomplish disposal. A popular sharps container utilized at some facilities is one that comes in a variety of sizes, can be autoclaved without meltdown and when incinerated produces little residue.

"Rendering inoperable of syringes..." is the law in North Carolina. If a system designer is unsure of the effectiveness of his system, I suggest that he contact the office of:

Mr. F.E. Epps, Chief
Regulatory Branch of the Division of
Mental Health, Retardation
Substances Abuse Services
North Carolina Department of Human
Resources

You may request a site inspection to ensure that your system satisfies compliance with the North Carolina Controlled Substances Act and Regulations.

SUMMARY

A sharps management system with sharps containers, chopper grinder machines or an incinerator may be purchased, leased or contracted with an outside firm. Some hospitals have built their own containers and mutilation machines. Some have entered into contracts with companies that provide containers, arrange for scheduled changes of containers and will process the collected contaminants at their own processing plant. If you intend to design a system or if you decide to contract out, I urge you to visit facilities that have implemented sharps management systems.

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INCINERATION OF CONTAMINATED WASTES

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ABSTRACT

Incineration at high temperature is a process whereby organic compounds (those composed primarily of carbon, hydrogen, oxygen, nitrogen) can be decomposed into effluent gases of carbon dioxide, water vapor, and sterile ash. The operation can take place on-site, resulting in substantial savings over shipment for burial in approved landfills.

Even though incineration offers several advantages as an alternative method of waste treatment, it is by no means a panacea. For example, there is an initial capital investment which can be extensive, suitable incinerator operator training must be provided, the system must be of an appropriate design for the particular waste stream, and operating licences must be obtained from the appropriate regulatory agencies.

INTRODUCTION

This chapter will deal with the entire incineration process by offering information concerning equipment design and selection, licensing, operational procedures, and effluent control.

A discussion of incineration would not be complete without a list of definitions (Environmental Control Products, Inc., n.d.):

BURN RATE- Total quantity of combined carbon and hydrogen that is converted to CO_2 and H_2O vapor, usually expressed in pounds per hour.

CHARGE RATE- Quantity of waste material loaded into an incinerator, but not necessarily burned. Usually expressed in pounds/hour.

CONTROLLED AIR- Controlling air flow to attain desired combustion rate.

ENDOTHERMIC- Chemical reaction that absorbs heat from its surroundings: $\text{C} + \text{H}_2\text{O}(\text{Steam}) = \text{CO} + \text{H}_2$.

EXCESS AIR- Controlled burning at other than stoichiometric requirements.

EXOTHERMIC- Chemical reaction that liberates heat to its surroundings: $\text{C} + \text{O}_2 = \text{CO}_2$ $\text{H}_2 + 1/2 \text{O}_2 = \text{H}_2\text{O}$

FIXED CARBON- The non-volatile portion of waste which must be burned at higher temperatures.

HEAT RELEASE- Total energy released from combustion, i.e. HEATING VALUE (BTU/lb) x BURN RATE (lb/hour). Expressed in BTU/hour.

HEAT VALUE- Net energy available from chemical combustion, expressed in BTU/lb.

MOISTURE- Both formed and contained which must be evaporated from the waste material by the heat released from the waste material.

PARTICULATE EMISSION- Fine solid matter suspended in combustion gases carried to the atmosphere. Usually expressed in GR/DSCF corrected to a common base, usually 12% CO₂.

PATHOGENIC- Waste material capable of causing² disease.

PATHOLOGICAL- Waste material relating to the study of the essential nature of disease and generally altered or caused by disease.

PROXIMATE ANALYSIS- Determination of volatile matter, fixed carbon, moisture and noncombustible(ash) matter in any given waste material.

PYROLYSIS- Chemical destruction of organic materials in the presence of heat and the absence of oxygen.

RETENTION TIME- Amount of time volatile matter is exposed to mixing, temperature, and excess air for final combustion.

STARVED AIR- Controlled burning at less than stoichiometric air requirements.

STOICHIOMETRIC- Theoretical air required for complete combustion to CO₂ and H₂O vapor.

STUFF AND BURN- where charging rate is greater than burning rate.

VOLATILE MATTER- That portion of waste material which can be liberated with the application of heat only. In controlled air incineration, the volatile matter is burned primarily in the combustion chamber.

TYPES OF WASTE

The incinerator design and charge rate will be a function of the type and the form of the waste to be burned. For example, hospital/institutional waste will be in liquid or solid form composed primarily of paper, plastics, animal/vegetable wastes, and pathological material. Each of these waste types have their own waste classification based on their heat content (Environmental Protection Agency, n.d.):

Type O- 8500 BTU/lb, TRASH. A mixture of highly combustible waste, such as paper, cardboard, wood and floor sweepings from commercial and industrial activities. May contain up to 10% by weight of petroleum waste, 10% moisture and 5% noncombustible solids.

Type 1- 6500 BTU/lb, RUBBISH. A Mixture of combustible and non combustible waste, such as paper, cardboard and floor sweepings from domestic, commercial and industrial activities. May contain up to 20% weight of restaurant waste, but little or no petrochemical wastes. Moisture content may be up to 25% with 10% noncombustible solids.

Type 2- 4300 BTU/lb, REFUSE. An evenly distributed mixture of rubbish and garbage as usually found in as received municipal waste. May contain up to 50% moisture and 7% noncombustible solids.

Type 3- 2500 BTU/lb, GARBAGE. Consists of animal and vegetable wastes from restaurants, cafeterias, hotels, hospitals, markets and similar installations. May contain up to 70% moisture and 5% noncombustible solids.

Type 4- 1000 BTU/lb, HUMAN AND ANIMAL REMAINS. Consists of carcasses, organs, and solid organic wastes from hospitals, laboratories, abattoirs, animal pounds and similar sources. May contain up to 85% moisture and 5% noncombustible solids.

Type 5- BY-PRODUCT WASTE. Gaseous, liquid or semi-liquid, such as tar, paints, solvents, sludges, fumes, etc., from industrial operations. BTU values must be determined for the individual materials to be destroyed.

Type 6- SOLID BY PRODUCT WASTE, such as rubber, plastics, wood waste, etc., from industrial operations. BTU values must be determined for the individual materials to be destroyed.

Normally, an incinerator will be rated at a charge rate for a particular amount of waste (e.g. 500 lb/hr- Type 1). By using the relationship of their respective heat contents, approximate charge rates for different types of wastes may be derived.

TYPES OF INCINERATORS

The advantages offered by high-temperature incineration are numerous. A properly operated unit can decompose even the most toxic organic compounds or pathogens. An 80-90% reduction in volume and weight of the initial waste is not uncommon. Significant savings of incineration over shipment for burial have been realized resulting in "pay back" periods of 2-3 years for the purchase and installation of an incinerator.

As mentioned in the abstract, incineration also entails several disadvantages. Initial capital cost can be high. A small unit (350-500 lb/hr) can cost in the vicinity of \$100,000. Licensing through the respective regulatory agencies can be both

extensive and expensive. Testing of the stack emissions, for example, may be required during the licensing review process. (In some jurisdictions a condition of licensing reciprocity may exist. That is, if a particular model has already been tested and approved, additional tests of that model may not be required.)

The staff of an incineration facility should have extensive training in proper operational characteristics. Secondary environmental impacts, such as the formation of acid gases during the incineration of halogenated hydrocarbons, must be assessed. Public reaction to incineration must be integrated into the equation. The public may equate any type of incineration process with the neighborhood "box-burner" which belches black smoke and bits of flaming cardboard from its stack. Negative reactions can be minimized by working with various neighborhood organizations or local conservation groups.

There are several types of incinerators that are commercially available. Some of the more common designs include multiple chambers, rotary kiln, liquid injection, and multiple hearths. Other available technologies include fluidized bed and molten salt units (which incorporate beds of sand or salt into which the waste is injected) and incineration via plasma or electric arc.

The chosen technology will depend on several characteristics including the types of waste to be incinerated. For example, a multiple chamber unit with controlled combustion air is often chosen for institutional/hospital waste streams. Due to the significant differences in waste types and forms that are handled by commercial disposal services, most of their technology is based on large rotary kiln units. Figures 1 and 2 depict these representative units.

The refractory material (the interior lining of the incinerator) must be chosen carefully. The Al_2O_3 content of the material requested will normally depend on the operating temperature and the composition of the waste stream (Caprio, et al., 1982). Refractory material is available in either brick form or as a castable.

Stress afforded to the refractory can be minimized by utilizing properly selected operational procedures. For example, thermal shock can be reduced by avoiding quick heating and cooling of the unit. Some longitudinal cracking will normally occur but should close as the temperature increases. The lining must be visually checked for spallation or slag formation, which can be caused by chemical or physical interaction with the waste and/or heat.

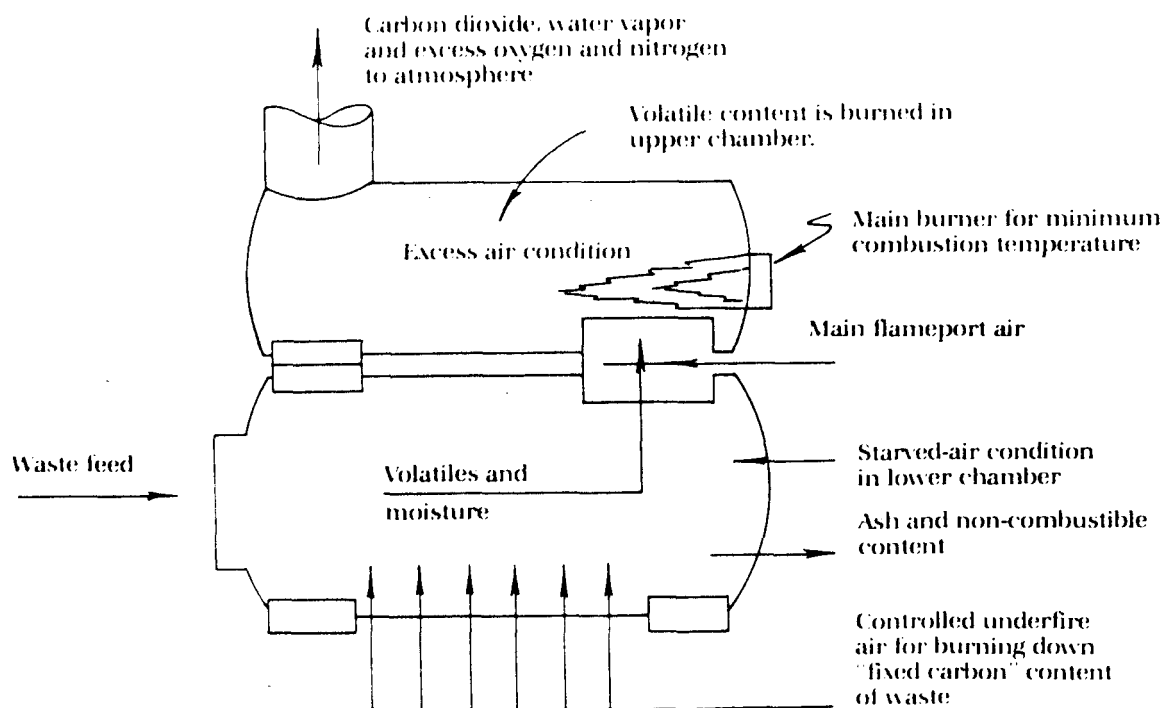
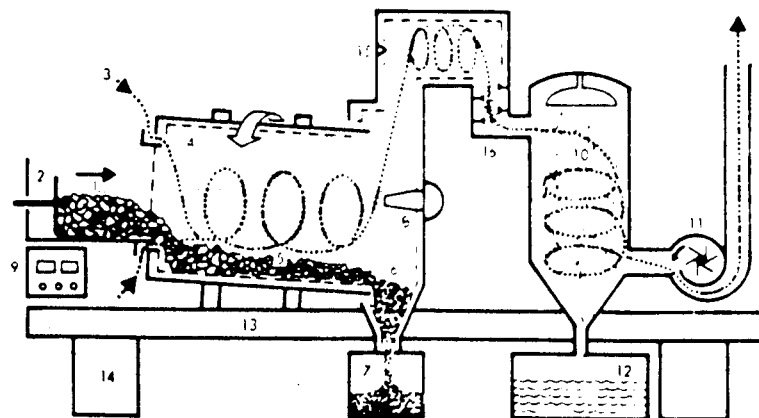


Figure 1. Dual-Chamber Controlled Air Incinerator
 From: Environmental Control Products, Inc. (n.d.)
 CONTROLLED AIR INCINERATION, [Pamphlet]:2.



(1) Waste to incinerator	(9) Self-compensating instrumentation-controls
(2) Auto-cycle feeding system: feed hopper, pneumatic feeder, slide gates	(10) Wet-scrubber package: stainless steel, corrosion-free wet scrubber, gas quench
(3) Combustion air in	(11) Exhaust fan and stack
(4) Refractory-lined, rotating cylinder	(12) Recycle water, fly ash sludge collector
(5) Tumble-burning action	(13) Support frame
(6) Incombustible ash	(14) Support piers
(7) Ash bin	(15) Afterburner chamber
(8) Auto-control package: programmed pilot burner	(16) Precooler

Figure 2. Rotary Kiln Incinerator

From: Sittig, M. (1979) INCINERATION OF INDUSTRIAL HAZARDOUS WASTES AND SLUDGES, Noyes Data Corporation, Park Ridge, N.J.: 296.

Another important aspect of the incineration process is the means by which the wastes are to be loaded. From an occupational standpoint, an automated system is the desirable since it minimizes the potential exposure to chemical vapors and/or excess heat. Several automatic loading models exist, including one loader based on a hydraulic ram which batch-loads the waste into the combustion chamber. Continuous feed units are also available.

There are systems available which will pump liquids directly into the incinerator for destruction and/or use an auxiliary fuel. The associated pumps and nozzles must be chosen to ensure compatibility with the chemical characteristics of the waste.

Removal of the ash must also be considered. If the unit is to be in continuous operation, an automatic ash removal system should be installed. There are two principle types of ash removal methods. One incorporates a water pit into which the ash falls. This pit is cleaned via a drag line conveyor system or a hydraulic scoop. An alternative to dealing with the resultant sludge is a dry system which utilizes an hydraulic ram. In a controlled air system, both of these must be operated as airtight as possible to maintain controlled air characteristics and minimize extraneous emissions.

Large incinerators that are in continuous operation often make use of the great amount of heat that is produced. This may be as simple as pre-heating combustion air by pulling it through a shroud surrounding the outer hot skin of the incinerator. Or, it may be more complex, as in the incorporation of a waste heat boiler to generate heat for space heating. In any case, the possible use of this resource should be considered.

LICENSING

The licensing should begin in the very early stages of design. The regulatory agencies responsible for air quality, hazardous waste, and, if appropriate, radioactive material, must be notified to initiate the application. The air quality and/or hazardous waste groups of such agencies will have information about manufacturers and incinerator models that have previously been approved in the area.

The application for an air quality permit will require knowledge of the types and characteristics of auxiliary fuel to be used. The licensing agencies will be interested in the overall design of the proposed unit, projected waste types and charge rates, operating temperatures, and air velocity through the chamber. Other interests will center on applicable air pollution

control equipment such as scrubbers or filter banks. Depending on the agency's historical data with a particular vendor, stack testing may or may not be required. A typical panel for stack emissions may include analyses for several different inorganics, total particulates, halogens, halogen gases, and/or PCB's.

Persons responsible for facilities which meet the "generator" definition set forth by the U.S. Environmental Protection Agency should be familiar with requirements under the Resource Conservation and Recovery Act (RCRA) Vol. 47, No. 122 of the Federal Register (Table 1) which stipulates design criteria and operating procedures for a hazardous waste incineration facility (U.S. Environmental Protection Agency, 1982).

The incineration of low-level radioactive waste will require a license from the state radiation protection group or, if the state is not an agreement state, a license directly from the U.S. Nuclear Regulatory Commission (NRC). Application for such a permit should include information concerning the radioisotopes to be incinerated, including activity of each, handling procedures for the waste material (and the resultant ash), and operational characteristics of the incinerator including unit design and its location in relation to air intake ducts. Calculations of emitted activity per cubic centimeter of air in relation to the maximum permissible concentrations set forth by the NRC must also be included. A facility's health physicist or radiation safety officer should be responsible for submitting this application.

OPERATION

Proper operation of an incinerator is certainly a key element of a successful waste disposal program. Having determined the types of waste to be incinerated, as well as the chemicals or infectious agents that are to be destroyed, appropriate operating parameters may be established. Paramount to this is the proper selection of temperature. As portrayed in Figure 3, improper temperature selection can lead to formation of new compounds as the initial waste is being destroyed.

The autoignition, or decomposition, temperature is the point at which a compound will begin to decompose exclusive of an external flame. This characteristic has been used in a model to predict proper operating temperature for 99.99% destruction at one second retention (residence) time ($T_{99.99}$) and at a retention time of two seconds. Other requirements for the calculation include hydrogen-carbon ratios, number of carbon double bonds, number of nitrogens, and degree of halogenation (Table 2) (Lee, et al., 1979).

Table 1. Resource Conservation and Recovery Act.

Section	Jan. 23, 1981 regulation	Amended regulation
264.340	Exempted wastes: (1) Listed ignitables and (2) those failing the test for ignitability, when shown to contain no Appendix VIII substances.	Exempted wastes: (1) Listed ignitables, corrosives and/or selected reactivities and (2) those failing the tests for ignitability, corrosivity and/or selected reactivity characteristics, when shown to contain no or insignificant levels of Appendix VIII substances.
264.343(b)	Performance Standard for HCl Emissions If: Waste input exceeds 0.5% chloride. Then: Remove 99% of stack gas HCl.	Performance Standard for HCl Emissions: If: Stack emissions exceed 1.8 kg HCl/hr, Then: Control emissions so that they do not exceed the larger of the following: (1) 1.8 kg HCl/hr, or (2) 1% of the HCl in the stack gas.
264.343(c)	Performance Standard for Particulate Emissions: Emissions may not exceed 180 mg/DSCM when corrected to 12% carbon dioxide.	Performance Standard for Particulate Emissions: Emissions may not exceed 180 mg/DSCM when corrected

Table 1. Resource Conservation and Recovery Act. (Cont'd.)

Section	Jan. 23, 1981 regulation	Amended regulation
		to 50% excess air or as otherwise specified in the permit.
264.344	No provisions for permits to new incinerators.	Allows for four-phase permit for new incinerators: Phase 1: "Shake-down" phase. Phase 2: Trial burn. Phase 3: "Follow-up" phase. Phase 4: Permanent operation phase.
264.345	Air Feed Rate to be designated as an operation requirement	Indicator of Combustion Gas Velocity to be designated as an operating requirement.
122.27	1. New facilities must have Final RCRA permit prior to construction. 2. Requirement to monitor Hazardous Combustion By-Products during trial burn. 3. Waste Analysis requirements for trial burn plan	1. New facilities submit Part B of the application and required information for trial burn plan simultaneously. Permit is issued after opportunity for public hearing. 2. Deleted. 3. Language Clarification

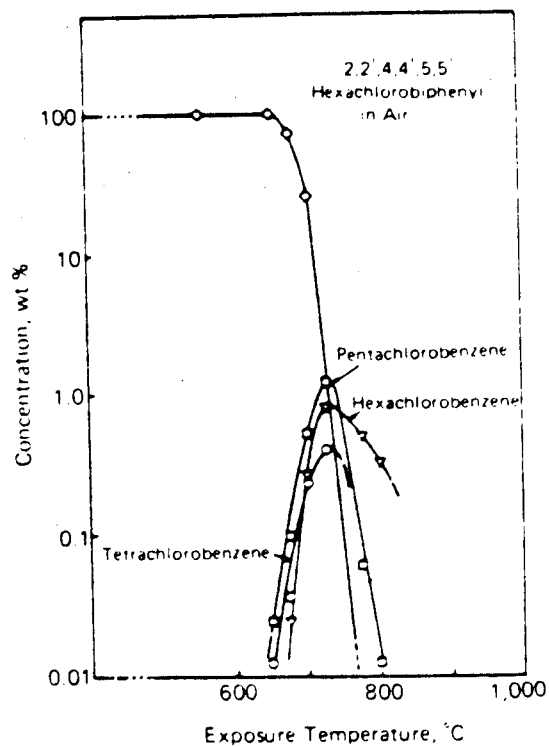


Figure 3. Decomposition of Hexachlorobiphenyl
From: Dillon, A. (1981) HAZARDOUS WASTE INCINERATION ENGINEERING, Noyes Data Corporation, Park Ridge, N.J.: 79.

Table 2. Destruction Temperatures for Selected Compounds

Compound	Autoignition Temp. (°F)	T99.99 @ 1 sec. (°F)	T99.99 @ 2 sec. (°F)
Benzene	1044	1350	1321
Acrolein	453	1018	973
Ethanol	793	1306	1256
Acrylonitrile	898	1342	1296

From: Lee K-C., Hansen J., Macauley D. (1979) Predictive model of the time-temperature requirements for thermal destruction of dilute organic vapors. PROCEEDINGS OF 1979 ANNUAL MEETING OF THE AIR POLLUTION CONTROL ASSOCIATION.

Prior to loading, an incinerator should be allowed to pre-heat to a minimum operating temperature. This temperature will be a function of the chemicals in the waste stream. If the unit is loaded cold and then fired, the chemicals in the waste will tend to volatilize out the stack rather than be destroyed. This pre-burn period may last a matter of hours depending on such unit characteristics as burner size (heat input) and chamber volume.

Once the minimum operating temperature has been reached, unit loading can begin. This may be via a liquid injection system or a hydraulic ram batch loader. The charge rate should be a function of the charge weight and the waste type. Inspection of the stack, either visually or with monitors, will offer information as to the suitability of the rate. If smoke is visible, the charge rate should be modified. (This may also be indicative of problems with the combustion air fans, butterfly valves, etc.) After the last charge of a burn period, the unit should be allowed to "burn-down." This will help in ensuring that the last loads, usually pathological material, are decomposed and/or detoxified.

Each incinerator manufacturer will have a preventative maintenance program. An overall effective program should include, among others:

- Regular inspection of refractory and outer skin
- Regular ash removal
- Cleaning of underfire air ports (controlled air units)
- Inspection of all electrical circuits and lubricated parts

EFFLUENTS

The environmental effects from the operation of an incinerator should be of utmost concern. A unit which has been properly designed and incorporates correct operating procedures will have minimal detrimental affects.

A license to incinerate low-level radioactive waste will require monitoring radioisotopic emissions. Based upon the ALARA concept (As Low As Reasonably Achievable), the results, in micro-curies per cubic centimeter of air, should be one-tenth (0.1) of the applicable MPC (Maximal Permissible Concentration). The concentrations should be measured at the boundary of the restricted area, whether it be at the top of the stack or at the site perimeter fence.

Tritium (H-3) and carbon-14 (C-14) are the radioisotopes most often used in biomedical research. High temperature incineration of organics tagged with these isotopes will result in the emission of tritiated water vapor ($^3\text{H}_2\text{O}$) and carbon-14 labelled

carbon dioxide ($^{14}\text{CO}_2$). At proper operating temperatures, it is safe to assume that 100% of the activity of these radioisotopes will be emitted in this manner, leaving only background activity in the ash bed. Other radioisotopes commonly used in medicine (e.g. the iodines, phosphorus-32, chromium-51) will, to some extent, remain in the bed. As a result of their short half-lives, however, they can be safely stored for decay and then incinerated for detoxification of the tagged chemical.

The ash-bed, as well as the refractory, should be monitored periodically. If the ash analyses result in a significant percentage of radioactivity below the MPC for nonrestricted water, it may be possible to deposit the ash in a noncontrolled (sanitary) landfill.

Chemical analyses of the ash bed should also be performed. Complete inorganic and organic spectra will offer insights as to the contaminants that are left in the ash. Proper selection of temperature and operating procedures will ensure negligible amounts of organic material, leading to the possibility of disposal in a noncontrolled landfill. Until complete analyses are made, the person responsible for ash removal should be protected from potential hazards.

REFERENCES

1. Environmental Control Products, Inc. (n.d.) CONTROLLED AIR INCINERATION, [Pamphlet, 16 pp.].
2. Ibid.
3. Caprio James A., Wolfe H. Edward. (1982) Refractories for hazardous waste incineration - an overview. PROCEEDINGS OF THE 1982 NATIONAL WASTE PROCESSING CONFERENCE: 139.
4. U. S. Environmental Protection Agency. (1982) The hazardous waste management system. FEDERAL REGISTER 47 (122): 27520-27535.
5. Lee K-C., Hansen J., Macauley D. (1979) Predictive model of the time-temperature requirements for thermal destruction of dilute organic vapors. PROCEEDINGS OF 1979 ANNUAL MEETING OF THE AIR POLLUTION CONTROL ASSOCIATION.

APPENDIX

APPENDIX

HEALTH CARE PROVIDERS QUESTIONNAIRE ON RISKS
IN THE USE AND MANAGEMENT OF TOXIC AND
HAZARDOUS SUBSTANCES

1. Have you or any of your associates been injured or contracted an illness due to exposure to toxic or hazardous substances?

If so, what were the symptoms? What caused them? What procedures have been implemented to reduce those health risks?

2. Do you believe you and your colleagues are adequately informed of the risks and of the proper handling of the toxic and hazardous substances associated with your work?

If not, for which substances or problems would you like to have more information?

3. Is there a place(s) in your facility where information is maintained and readily available to any individual on the toxic and hazardous substances used or produced? (Explain how information of this nature is made available to the different people involved.)

-2-

4. If the proposed toxic and hazardous substance compendium about risks and proper risk reduction procedures were available to you, would you use it?

How many others at your facility would be likely to use it also?

What types of training sessions or workshops would be useful to you and your staff?

5. Are there any other problems or questions you have on the safe management of toxic and hazardous substances? If so, please explain.
6. If any of you have developed or know of information that would be particularly helpful if it were included in this compendium, please send us a copy or provide us the information so we can obtain a copy.

Thank you for your assistance. We hope to have the compendium completed by early 1985.

As soon as possible, please return the completed questionnaire to:

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